Bull Run Water Supply
Habitat Conservation Plan

Annual Compliance Report 2020—Year 11

Final · July 2021

Portland Water Bureau
From Forest to Faucet

City of Portland, Oregon 1851

Under penalty of law, I certify that, to the best of my knowledge, after appropriate inquiries of all relevant persons involved in the preparation of this report, the information submitted is true, accurate, and complete.

7/22/2021

Liane Davis, Environmental Compliance Manager, PWB Resource Protection Date

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Abbreviations

cfs	cubic feet per second
DO	dissolved oxygen
EDT	Ecosystem Diagnosis and Treatment
ESA	Endangered Species Act
HCP	Habitat Conservation Plan
JOM	juvenile outmigrants
LCR	Lower Columbia River
LW	large wood
MSL	mean sea level
NMFS	National Marine Fisheries Service
O&M	operations and maintenance
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
PGE	Portland General Electric
PHP	Portland Hydroelectric Project
PWB	Portland Water Bureau
RM	river mile
TDG	total dissolved gas
TMP	Temperature Management Plan
TMDL	total maximum daily load
USGS	US Geological Survey
7DADM	seven-day average of daily maximum temperature

1. Executive Summary

For 2020, the Portland Water Bureau (PWB) met the terms and conditions of every HCP conservation measure with the exception of downstream water temperature targets for the lower Bull Run River. For 22 days in October, the temperature of the river exceeded the HCP temperature target. PWB presented the 2020 water temperature information to the Oregon Department of Environmental Quality, the National Marine Fisheries Service, and the Oregon Department of Fish and Wildlife. PWB will continue to monitor water temperatures in the lower Bull Run River in 2021 and will work with the agencies, starting in the late spring, on operational measures to improve performance of the system for temperature control.

The Bull Run Water Supply Habitat Conservation Plan (HCP) is a 50-year plan to protect and improve aquatic habitat while continuing to manage the Bull Run River watershed as a water supply for the City of Portland (City), Oregon. The Portland Water Bureau (PWB) created the HCP, with technical assistance from the Sandy River Basin Partners, to minimize and mitigate the effects of covered activities associated with the Bull Run water supply operations on listed and unlisted Endangered Species Act (ESA) species and their associated habitat. The primary focus of the HCP is protection for ESA-listed anadromous fish under the jurisdiction of the National Marine Fisheries Service (NMFS), but the plan also includes other species. In 2009, NMFS issued an Incidental Take Permit to the City pursuant to Section 10(a)(1)(B) of the Endangered Species Act and signed an Implementing Agreement with the City. The HCP and each of its provisions are incorporated into those agreements.

In addition, in 2008 the Oregon Department of Environmental Quality (ODEQ) approved PWB's Temperature Management Plan for the Lower Bull Run River (Appendix G of the HCP). This plan addresses temperature requirements for the lower Bull Run River that are articulated in the Sandy River Basin Total Maximum Daily Load (TMDL) report.

The HCP includes 49 conservation measures to protect and improve habitat and to avoid or minimize the impacts of the Bull Run water supply system. Annual reports from PWB are required to document compliance with the conservation measures, monitoring requirements, research efforts, and adaptive management actions that are implemented.

The eleventh year of the HCP was 2020, referred to as Year 11 throughout this document. This is the eleventh Annual Compliance Report.

Changing circumstances and conditions have required modifications to some of the original HCP measures. The changed measures were implemented with target amounts or locations that accounted for other measures that could not be implemented (for example, canceling a large wood [LW] project in one location and increasing the number of large wood pieces in a second location). These changes are noted in this report.

The PWB met the terms and conditions of every HCP conservation measure for 2020, with the exception of downstream water temperature targets. For 22 days, the temperature of the Bull Run River exceeded the HCP temperature target. PWB presented the 2020 water temperature information to the Oregon Department of Environmental Quality, the National Marine Fisheries Service, and the Oregon Department of Fish and Wildlife. PWB will continue to monitor water temperatures in the lower Bull Run River in 2021 and to work with ODEQ, starting in the spring, on operational measures to improve performance of the system for temperature control.

2. Introduction

2.1 Habitat Conservation Plan Background

In April 2009, the National Marine Fisheries Service (NMFS) signed a Permit for Incidental Take of Threatened Species number 13812, granting the City of Portland (City) authorization to operate its Bull Run water supply subject to the provisions of the implementing agreement for the Bull Run Water Supply Habitat Conservation Plan (HCP). The Incidental Take Permit covers four anadromous fish species listed under the Endangered Species Act (ESA) of 1974—Lower Columbia River (LCR) Chinook Salmon *(Oncorhynchus tshawytscha)*, Columbia River Chum Salmon *(O. keta)*, LCR Coho Salmon *(O. kisutch)*, LCR steelhead *(O. mykiss)*—and Pacific Eulachon *(Thaleichthys pacificus)*.

The Bull Run HCP includes 49 habitat conservation measures that are expected to minimize and mitigate, to the maximum extent practicable, the effects of take on the covered fish and wildlife. The measures are designed to improve habitat conditions for the fish and 18 additional wildlife species in the Bull Run subbasin and the Sandy River Basin, watersheds that are part of the lower Columbia River Basin in northwest Oregon. The Sandy River Basin was included in the plan in order to fully address the Incidental Take Permit requirements.

Measures in the Bull Run include modifying water supply infrastructure, implementing seasonal flow regimes and downramping rates, placing gravel and large wood, establishing fish passage in certain streams, removing invasive species, and defining operational standards to avoid or minimize the effects of operations on the covered species. The measures in the Sandy River Basin, called offsite measures, include large wood and log jam placement, channel redesign and reconstruction, establishing fish passage in certain streams, establishing easements and making improvements in riparian zones, and acquiring land parcels and water rights.

The HCP measures are being implemented and monitored over the course of 50 years. Measures in some reaches are being implemented early in the term of the HCP to provide the greatest improvements over time. Not every measure was implemented in the first year, however. Other measures slated to be implemented later in the HCP time frame are mentioned by name in this report but are not extensively discussed. By necessity, the terms of some measures have changed in response to changes in the Sandy River watershed. PWB has maintained full records of measure adjustment terms, including correspondence with NMFS documenting approval of the changes. Correspondence is summarized in this compliance report appendix each year.

A key element of the HCP involves improving water temperature conditions for spawning and rearing salmonid fish. Compliance with this objective also fulfills the temperature objectives for the lower Bull Run River that are articulated in the Oregon

Department of Environmental Quality's (ODEQ's) Sandy River Basin Total Maximum Daily Load (TMDL) report (ODEQ 2005). PWB's Temperature Management Plan for the Lower Bull Run River, approved by ODEQ in 2008, is Appendix G of PWB's HCP.

2.2 Annual Report Organization

This report is organized to provide the status of work and planned accomplishments for HCP monitoring, the research efforts, and PWB's adaptive management program. The monitoring section is divided into compliance and effectiveness monitoring. Within each of these monitoring subsections, information is provided for the Bull Run Watershed measures and for the offsite measures in the Sandy River Basin, respectively. Measures that share similar objectives (such as large wood placement or obtaining riparian easements) are grouped together. The introductory subsections titled Measure Commitments are taken directly from the HCP and are characterized by a font that is different from the rest of the report text.

The HCP outlines a specific program of monitoring, research, and adaptive management to evaluate habitat improvements resulting from the measures. The monitoring component includes both compliance and effectiveness monitoring. This eleventh yearly report of accomplishments includes compliance monitoring information in Section 4.1, effectiveness monitoring information in Section 4.2, and a summary of the planned research in Section 4.3. Reports describing the monitoring, research, and results in detail are available as Appendices A through D.

Table 12, beginning on page 57, provides summary information for the status of each measure. The table outlines the measurable habitat objective, the method of compliance monitoring described in the HCP, the years in which the measure is planned to be implemented, and a description of the status. Table 12 also indicates where the effectiveness monitoring reports and the research reports are relevant to measures in this annual report. Measures that are not relevant to the current reporting year are shown with a gray background. Measures that are due to be started in future years are blank in the "Status" column.

3. HCP Monitoring, Research, and Adaptive Management Programs

3.1 Monitoring Program

The monitoring program for the HCP is designed to document compliance and verify progress toward meeting the goals and objectives outlined in Chapter 6 of the HCP. The monitoring program comprises both compliance and effectiveness monitoring. Compliance monitoring tracks progress implementing the HCP measures. Compliance monitoring reports focus on the work completed and planned for the following calendar year. Effectiveness monitoring, described in detail in Appendix A, is provided for those measures for which the habitat outcomes are somewhat uncertain. Effectiveness monitoring data will enable an assessment of whether the measurable habitat objectives have been met.

3.2 Research Program

The research program for the HCP focuses on four components in the Bull Run River Watershed and one component in the larger Sandy River Basin. In the Bull Run Watershed, PWB is studying the placement of spawning gravel, the concentrations of total dissolved gases at certain locations, and the abundance of spawning Chinook adults. For the Sandy River Basin, PWB is collaborating with other organizations doing research to measure the number of juvenile salmonid outmigrants at the reach and basin levels. See Appendices B–C for detailed reports on the research and results.

3.3 Adaptive Management Program

Adaptive management is an approach that involves monitoring the outcomes of a project and, on the basis of the monitoring results, improving the way the project is managed. PWB anticipates that, over the course of its 50-year HCP, scientific understanding of the issues relating to salmonid habitat will improve and some conditions will change such that some reconsideration and adaptation of its approach will be appropriate. The adaptive management program provides for ongoing evaluation of individual measures as well as milestones for evaluating the HCP as a whole. A key measure for adaptive management is the Habitat Fund, described in Section 4.4.

4. Monitoring Measures Status and Accomplishments

4.1 Compliance Monitoring

Most of the HCP measures pose very little uncertainty as to whether implementing the measures will meet the objectives. For these measures, PWB is conducting compliance monitoring to track implementation and document completion.

4.1.1 Bull Run Measures

PWB is using established United States Geological Survey (USGS) sites on the lower Bull Run River and Little Sandy River to monitor river flow and water temperature. River flow compliance will be measured at USGS Gage No. 14140000 (at river mile [RM] 4.7 on the Bull Run River). This gage will also be used to determine compliance with the downramping rate. Compliance with temperature measures will be based on the temperature data recorded at USGS Gage No. 14140020 on the lower Bull Run River (at RM 3.8, the Larson's Bridge site) and at USGS Gage No. 14141500 on the Little Sandy River (at RM 1.95, the Little Sandy Dam site), as shown in Figure 1.

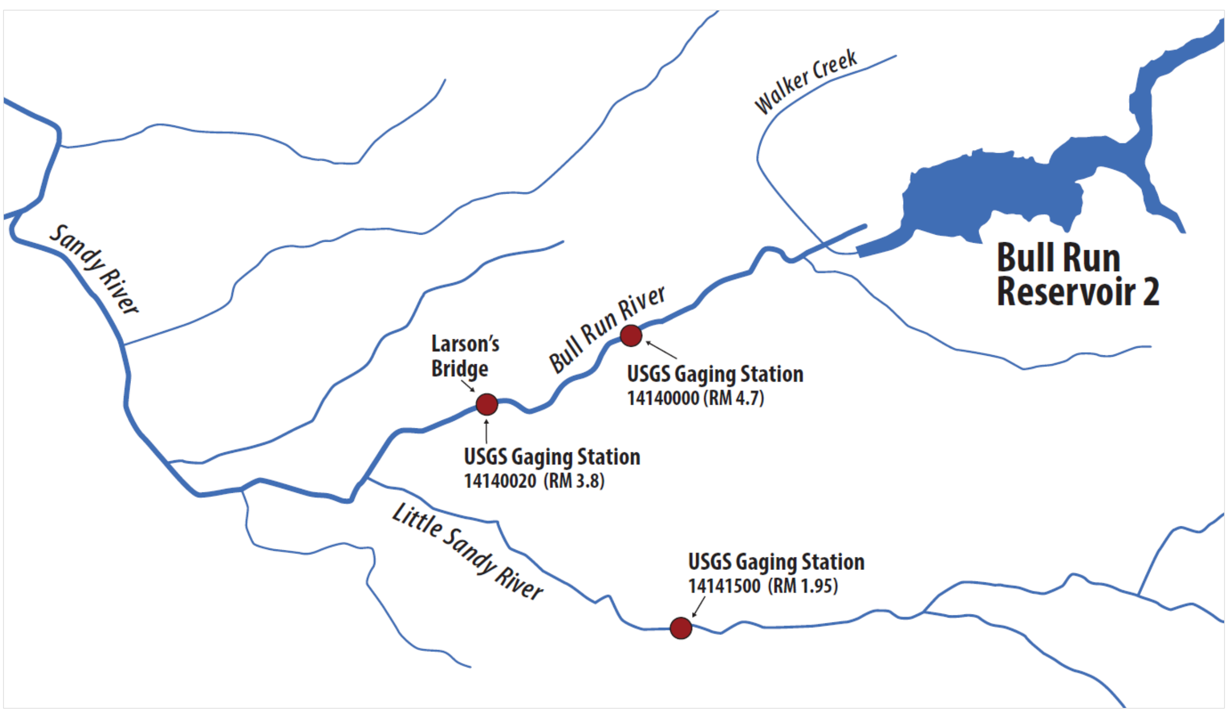

Figure 1. USGS gaging stations for compliance monitoring

Measure F-1—Minimum Instream Flow, Normal Water Years

Location: Bull Run Watershed

Benefits: Bull Run River flow

Contact: Kristin Anderson, Hydrologist, PWB Resource Protection

Primary Objective

Measure F-1 describes minimum instream flows to improve fish habitat conditions in the lower Bull Run River during normal water years. The measure includes guaranteed minimum flow amounts and other criteria that will maintain flow levels for spawning, rearing, and migrating salmonids and other aquatic species.

Measure Commitments

Measure F–1—Minimum Instream Flows, Normal Water Years: For HCP Years 1–50, the Bull Run water supply will be operated during normal water years to achieve the guaranteed flows in the lower Bull Run River specified in Table 1 (expressed in mean daily flows in cubic feet per second, cfs).

Table 1. Flow commitments for the lower Bull Run River during normal water years, measured at USGS Gage No. 14140000, RM 4.7

Time period	Guaranteed minimum flow (cfs)	Required percent of inflow	Maximum required flow (cfs)
January 1–June 15	120	n/a[a]	n/a
June 16–June 30	Gradually decrease flows over 15 days from minimum of 120 cfs to a minimum of 35 cfs. If reservoir drawdown begins before June 30, decrease flows at no more than 2 inches/hour to reach the 20–40 cfs operating range; see below.		
July 1–September 30	Vary flow from 20 cfs to 40 cfs to manage downstream water temperature[b]		
October 1–October 31	70	50%	400
November 1–November 30	150	40%	400
December 1–December 31	120	n/a	n/a

[a] n/a = not applicable

[b] See Measure T-1.

For the period from June 16 to June 30, the guaranteed minimum flow of 120 cfs will be decreased by 5 cfs per day until the minimum of 35 cfs is achieved at Gage No. 14140000.

Variable flows will be implemented in summer (July through September) of normal water years. Water temperature is a key management concern during this season, and the reservoirs will be operated to take advantage of the limited amount of cold water that can be stored. Releases from the reservoirs will vary with weather conditions to better manage use of the available cold water. During mild weather, when temperatures in the river are naturally lower, less cold water will be released from the reservoirs. During warm weather, when cold water from the reservoirs is needed to moderate river temperatures, more cold water will be released. The resulting average summer flow in normal water years is expected to be 35 cfs.

Flow releases in October and November are defined as a percentage of reservoir inflow, with both upper and lower bounds as shown in Table 1. PWB will provide a "floor" or minimum flow levels for the lower Bull Run River. PWB will also cap the maximum flow level in October and November to allow the reservoir to refill to reduce the potential for unacceptable turbidity. The percentage of inflow released is higher in October than in November, but the total amount of water released will be higher in November because (1) the floor for the November minimum flow is higher than the floor for October, and (2) inflow is generally higher in November than October.

Basing water release on a percentage of inflow will ensure that fall flow in the lower river is determined by flow into the reservoirs, not by the amount of water stored in the reservoirs or the amount diverted for municipal supply. Reservoir storage and diversions are both affected by water demand. Inflow is not affected by water demand.

PWB will control streamflow releases below Dam 2 at Headworks (RM 6.0 on the Bull Run River), and the lower Bull Run River flow will be measured at USGS Gage No. 14140000 (RM 4.7). For purposes of determining streamflow releases in October and November, reservoir inflow will be measured and totaled for four USGS Gages (No. 14138850, Bull Run River at RM 14.8; No. 14138870, Fir Creek at RM 0.6; No. 14138900, North Fork Bull Run River at approximately RM 0.2; and No. 14139800, South Fork Bull Run River at RM 0.6). The daily mean flows of the four gages will be added and then multiplied by 1.2 to account for the ungaged area of reservoir inflows in the Bull Run Watershed.

PWB staff will determine the week's reservoir inflows once a week and determine the following week's flow target based upon the inflow data. The first determination of reservoir inflow levels will occur prior to October 1. The flow releases to meet the targets will be implemented starting on October 1. Flow release targets will be set each week through the end of November.

Through the term of the HCP, the flow releases in the lower Bull Run River may exceed the guaranteed minimum flows in Table 1 if the reservoir inflows exceed demands for drinking water and the guaranteed minimum flows for fish.

The minimum flow requirements may not be met during the days that the Chinook surveys occur. Flows will be held to less than 150 cfs, as measured at USGS Gage No. 14140000, to allow safe surveying. The surveys are expected to occur approximately once per week from August through November. See Appendix F of the HCP for more details on the Chinook survey procedures.

Status of Work for Calendar Year 2020

PWB met the minimum instream flow requirements of HCP Measure F-1 in 2020. Guaranteed minimum flows for normal water years were used as the flow targets for the entire year.

During October and November, guaranteed minimum flows were based on a percentage of total inflow to the Bull Run reservoirs during the previous week. Table 2 summarizes the dates and flows used to derive these calculations.

Table 2. Dates, inflow, and flow targets for October and November 2020

Flow target period		Index period		Average inflow (cfs) during index period	Flow target (cfs)
From	To	From	To		
1-Oct	6-Oct	22-Sep	28-Sep	170	85
7-Oct	13-Oct	29-Sep	5-Oct	85	70
14-Oct	20-Oct	6-Oct	12-Oct	518	259
21-Oct	27-Oct	13-Oct	19-Oct	956	400
28-Oct	31-Oct	20-Oct	26-Oct	408	204
1-Nov	3-Nov	20-Oct	26-Oct	408	163
4-Nov	10-Nov	27-Oct	2-Nov	259	150
11-Nov	17-Nov	3-Nov	9-Nov	763	305
18-Nov	24-Nov	10-Nov	16-Nov	1640	400
25-Nov	30-Nov	17-Nov	23-Nov	1172	400

Releases from Bull Run Reservoir 2 were reduced on October 15, 21, and 28 and November 11, 2020, to allow PWB fish biologists to conduct spawning surveys safely in the lower Bull Run. On these days, the mean daily flow at USGS Gage No. 14140000 was less than the guaranteed minimum level, a reduction in stream flow that is allowed under the terms of the HCP measure. Lower Bull Run River flows at USGS Gage No. 14140000 are depicted in Figure 2.

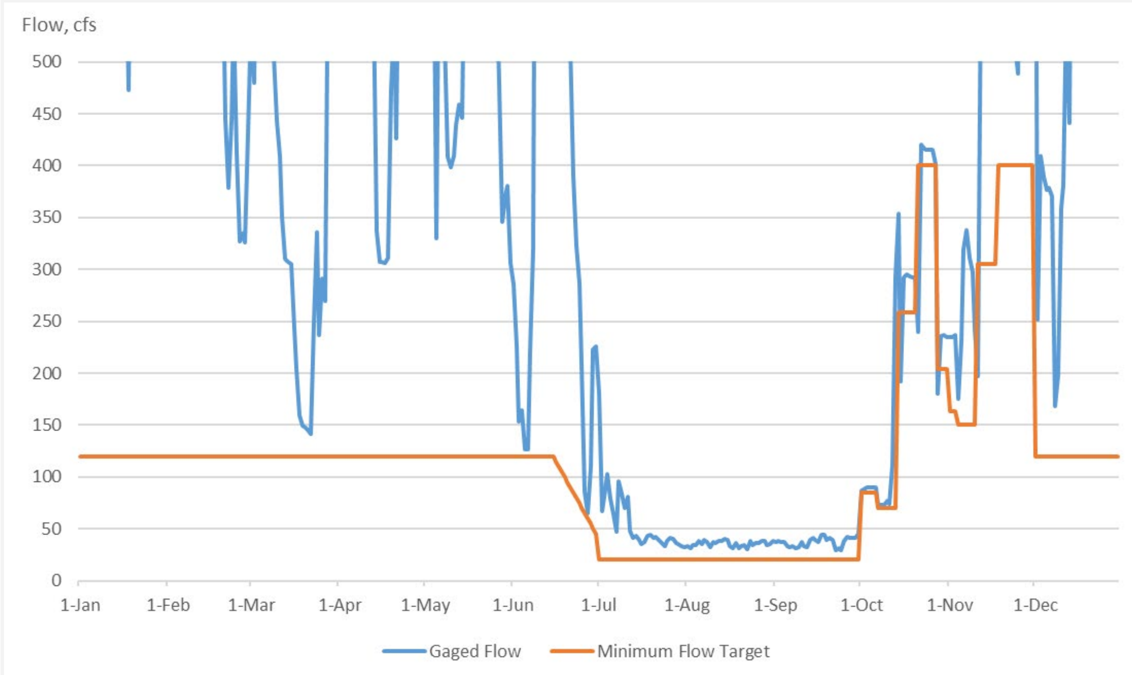

Figure 2. Lower Bull Run River minimum and actual flows[a] in 2020

[a] Flows exceeding 500 cfs are not shown.

Planned Accomplishments for Calendar Year 2021

PWB will continue to set the minimum flow levels early each day so that the daily averages meet or exceed the HCP minimum flow targets. Flow levels will be monitored in 2021 and compared to the guaranteed minimum flows. Normal-year or critical-year flow criteria will be applied as appropriate.

Measure F-2—Minimum Instream Flows, Water Years with Critical Seasons

Location: Bull Run Watershed

Benefits: Bull Run River flow

Contact: Kristin Anderson, Hydrologist, PWB Resource Protection

Primary Objective

Measure F-2 describes minimum instream flows that will be used during water years with critical seasons. These minimum flows will be used to achieve the guaranteed flows in the lower Bull Run River.

Measure Commitments

Measure F-2—Minimum Instream Flows, Water Years With Critical Seasons: During HCP Years 1-50, for any years that have a critical spring or fall season, the Bull Run water supply will be operated to achieve the guaranteed flows in the lower Bull Run River specified in Tables 3 and 4 (in mean daily flow in cfs). Fall flows in Table 3 will not be implemented more frequently than two years in a row and will not be implemented four years after a previous season of critical fall flows has been implemented (to avoid affecting the same age cohort twice). If a year does not have a critical spring or fall season, all flows will be the normal water year flows described in Measure F-1.

The triggers for a critical spring or fall season are defined in Table 3.

Table 3. Critical spring and fall season triggers

Critical Season	Trigger
Spring	Drawdown occurs prior to June 15
Fall	August and September inflows within lowest 10% of historical record (1940 to current HCP Year)

The response to a critical spring season is outlined in Table 4.

Table 4. Flow commitments for the lower Bull Run River during water years with critical spring seasons

Time period	Guaranteed minimum flow[a] (cfs)	
June 1–June 30	30	If critical spring season trigger is met, decrease flow after drawdown begins, but no earlier than June 1. Maintain downramping rate described in Measure F-3, from 120 cfs to 30 cfs.

[a] Measured at USGS Gage No. 14140000 (RM 4.7)

In any year of the HCP when a critical spring season has been triggered, there may be additional rain that temporarily raises reservoir inflow levels above outflow levels. PWB may elect, in such circumstances, to raise the flow of the Bull Run River higher than the critical-period guaranteed minimums indicated in Table 4. Also, PWB may elect to release more flow than the guaranteed minimum to the lower Bull Run River during critical spring seasons to meet water temperature objectives as described in Measures T-1 and T-2.

The trigger for the critical fall season is based on whether the mean daily flow for the August and September inflows to the Bull Run reservoirs are within the lowest 10 percent of historical flows for that time period. Throughout HCP Years 1-50, the 10th-percentile flow level will be updated annually to include new years of record.

The response to a critical fall season is outlined in Table 5.

Table 5. Flow commitments for the lower Bull Run River during water years with critical fall seasons[a]

Time period	Guaranteed minimum flow[a] (cfs)	Required percent of inflow (cfs)	Maximum required flow (cfs)
October 1-October 15	20	If critical fall season trigger is met, continue to vary flow from 20 to 40 cfs to manage downstream water temperature	
October 16-October 31	30	50%	250
November 1-November 15	30	40%	250
November 16-November 30	70	40%	350
December 1-May 31	120	n/a	n/a

[a] Measured at USGS Gage No. 14140000 (RM 4.7)

The percentage of inflow and maximum flow requirements might not be met during the days that the Chinook surveys occur. Flows will be held to less than 150 cfs, as measured at USGS Gage No. 14140000, to allow safe surveying. The surveys are expected to occur approximately once a week from August through November. See Appendix B for more details on the Chinook survey procedures.

PWB will control streamflow releases at Headworks (RM 5.9 on the Bull Run River), and the lower Bull Run River flow will be measured at USGS Gage No. 14140000 (RM 4.7). For purposes of determining streamflow releases in October and November, reservoir inflow will be measured and totaled for four USGS Gages (No. 14138850, Bull Run River at RM 14.8; No. 14138870, Fir Creek at RM 0.6; No. 14138900, North Fork Bull Run River at approximately RM 0.2; and No. 14139800, South Fork Bull Run River at RM 0.6). The daily mean flows of the four gages will be added and then multiplied by 1.2 to account for the ungaged area of reservoir inflows in the Bull Run Watershed.

PWB staff will determine the previous week's reservoir inflows once each week and establish the next week's flow release target based on that inflow data. The first determination of streamflow level will occur prior to October 1. The flow releases to meet the targets will be implemented starting on October 1. Additional flow release targets will be set each week through the end of November.

Status of Work for Calendar Year 2020

The critical spring trigger was not met in 2020. Naturally occurring drawdown commenced on July 11, 2020. Downstream flows were maintained at or above flows outlined in Measure F-1.

The lowest 10 percent of total reservoir inflow during August and September from 1940 through 2019 was 3.52 billion gallons. Total reservoir inflow during August and September 2020 was 3.81 billion gallons; therefore, critical fall conditions did not occur. Lower Bull Run River flows at USGS Gage No. 14140000 are depicted in Figure 2.

Planned Accomplishments for Calendar Year 2021

The critical spring and fall triggers will be assessed in 2021. If one or both triggers are met, PWB will implement the appropriate guaranteed critical-year minimum flows per the conditions of the HCP.

Measure F-3—Flow Downramping

Location: Bull Run Watershed

Benefits: Bull Run River flow

Contact: Glenn Pratt, Hydroelectric Project Manager, Portland Bureau of Hydroelectric Power

Primary Objective

PWB is committing to a low downramping rate to reduce effects on covered fish in the lower Bull Run River and the Sandy River.

Measure Commitments

Measure F-3—Flow Downramping: For HCP Years 1-50, PWB will release flow into the lower Bull Run River, below Dam 2 as a result of hydropower operation, at a maximum downramping rate of no more than 2 inches/hour (0.17 feet/hour), as measured at USGS Gage No. 14140000 (RM 4.7). PWB staff will monitor recordings at USGS Gage No. 14140000 to ensure that the decreases adhere to this downramping rate.

This maximum downramping rate will not apply to events beyond the control of system operators, such as unexpected power grid interruptions, downed power lines, equipment failures, emergency responses at Headworks as required to comply with federal Safe Drinking Water Act standards, the mandatory annual testing of the powerhouse, and other circumstances that preclude the use of the North Tunnel or Diversion Pool at PWB's water supply Headworks. The maximum downramping rate will also not apply when naturally occurring high flows, as measured at USGS Gage No. 14138850 (Bull Run RM 14.8), decrease by more than 2 inches/hour.

Status of Work for Calendar Year 2020

PWB was in compliance with Measure F-3 in 2020.

Downward-stage fluctuations in the lower Bull Run River, as measured at USGS Gage No. 14140000, were maintained at or below a rate of 2 inches/hour for 99.67 percent of the time in 2020. Downramping exceedances occurred for 29 hours, or 0.33 percent of total operating hours during the monitoring year.

The effects analysis outlined in the HCP was based on predicted flow exceedances of 0.4 percent of total operating hours per year—a level of downramping flow exceedances that was determined to have minimal effects on covered fish species in the plan.

While downramping exceedances occurred for 29 hours in 2020, 24 of 29 hours of the exceedances were excluded from the fluctuation limit as allowed by Measure F-3. Even though the exceedances were allowed, PWB analyzed the flow data to determine why the exceedances occurred and to improve future operations. Accounting for each hour of the allowed downramping exceedances follows:

- 12 hours were associated with the excessive flow rates coming into both Reservoir 1 and Reservoir 2 due to extreme precipitation from December 20 to December 22,

2020. During this time, both powerhouses were running at maximum capacity (P1 = 24 MWh production, and P2 = 12 MWh production). During this three-day period, flows at both reservoirs were spilling over both spillways despite the maximum production at both powerhouses. At this time, flows would fluctuate beyond the ability of the powerhouses to modulate and control them.

- Four hours were associated with the failure of the Howell-Bunger valve to maintain the flow rate of P2 when the powerhouse was taken out of service (June 14, June 20, October 28, and December 18).
- Eight hours (January 3 and December 22) were associated with the disruption of service to the hydroelectric plants as a result of trees falling into the high-voltage line and causing the plants to trip off-line.
- Four hours (January 27 and October 14) were associated with operator failure to manage flow rates between Reservoir 2 and Diversion Pool flows to the Bull Run River. One hour (January 27) was due to an error on Eugene Water & Electric Board's part. Three hours (October 14) were due to Headworks operator error.
- One hour (December 23) was associated with an emergency flow decrease order from Operations to the Portland Hydroelectric Project to decrease flows from Powerhouse 2 to the Diversion Pool due to an ongoing turbidity event in Reservoir 2.

When these allowed exemptions are factored into the year's output, PWB was compliant with this measure of the HCP during all hours.

Downramping data for the 2020 calendar year is maintained in City of Portland Water Bureau files at J:\Engineering\Hydro Power\Hydro Restricted\ACTIVE PHP FILES\Morning Reports\PHP 2 Inch Per Hour\2020.

Planned Accomplishments for Calendar Year 2021

Flow downramping will continue to be monitored in 2021.

Measure T-2—Post-infrastructure Temperature Management

Location: Bull Run Watershed

Benefits: Bull Run water temperature

Contact: Kristin Anderson, Hydrologist, PWB Resource Protection

Primary Objective

PWB has altered its water supply infrastructure and its water supply operations to reduce water temperatures in the lower Bull Run River. PWB's strategy relies on sharing the available cold water in the Bull Run reservoirs for drinking water and fish flow needs. PWB stores cold water in the reservoirs in spring and early summer when overall temperatures are lower and will release the water throughout the summer and early fall when river temperatures are warmer. The multilevel intakes already existing at Dam 1 are used for this purpose. With the multilevel intakes at Dam 2, PWB's target is to maintain the seven-day moving average of the maximum daily water temperature (7DADM) of the lower Bull Run River below either the numeric stream temperature criteria or the seven-day moving average of the maximum water temperature of the Little Sandy River, whichever is greater, with additional air temperature and calendar exceptions. Compliance with this measure fulfills the objectives of PWB's Temperature Management Plan (TMP) for the Lower Bull Run River (Appendix G of the HCP).

Measure Commitments

Measure T-2—Post-infrastructure Temperature Management: Within HCP Years 1-5, PWB will design, permit, and complete two significant changes to Bull Run water supply infrastructure to implement this conservation measure:

The Dam 2 intake towers will be modified to allow taking water from the reservoir at different levels.

The spillway rock weir in the Bull Run River immediately downstream of the Dam 2 spillway will be modified to allow rapid movement of flow through the spillway stilling basin.

After the infrastructure changes are made to the Dam 2 intake towers and the spillway rock weir, PWB will manage flow to meet Oregon state water quality standards in the lower Bull Run River, as established in ODEQ's Sandy River Basin TMDL (ODEQ, 2005) and the ODEQ-approved Temperature Management Plan. PWB will use the Little Sandy River water temperature (measured at USGS Gage No. 14141500) as a surrogate for the natural thermal potential of the lower Bull Run River. Water temperature compliance will be measured at Larson's Bridge on the main stem Bull Run River (USGS site 14140020). All water temperatures will be expressed as the seven-day moving average of the daily maximum temperature (Table 6).

Per the Sandy River Basin TMDL, Bull Run River water temperature target will be maintained

- at or below the appropriate biologically based numeric temperature criteria shown in Table 6 when the Little Sandy River temperature is below the criteria

Table 6. Appropriate numeric temperature criteria

River reach	Time period	Habitat use	Numeric criterion (seven-day average maximum)
River mile 0 to 5.3	June 16 to August 14	Salmonid rearing	16°C
	August 15 to June 15	Salmonid spawning	13°C
River mile 5.3 to 5.8	June 16 to October 14	Salmonid rearing	16°C
	October 15 to June 15	Salmonid spawning	13°C

Source: ODEQ 2005

or

- at or below the Little Sandy River temperature (as adjusted, see below) when the Little Sandy River temperature is above the numeric criteria.

Also, per the TMDL, the Bull Run water temperature target will be adjusted above the actual measured Little Sandy temperatures as follows:

- Between August 16 and October 15, allowances will be made for a 1.0°C departure above the Little Sandy temperature.
- If the seven-day moving average of daily maximum air temperature is above 27°C, the lower Bull Run water temperature target will be the lower Little Sandy River water temperature plus 1°C.
- If the seven-day moving average of daily maximum air temperature is above 28°C, the lower Bull Run water temperature target will be the lower Little Sandy River water temperature plus 1.5°C.

The ODEQ temperature standards (OAR 340-041-0028[12][c]) provide an additional exception if the maximum daily air temperature exceeds the 90th percentile of the seven-day average of the daily maximum air temperature calculated in a yearly series over the historical record. If this situation occurs in the lower Bull Run River, the numeric criteria and natural condition criteria (Little Sandy water temperatures as adjusted above) would not apply.

Daily maximum air temperatures will be recorded at the Water Bureau's Headworks facility below Dam 2 (approx. RM 6).

The Bull Run water temperature criteria also will not apply to events beyond the control of the water system operators, such as unexpected power grid interruptions, downed power lines, equipment failures, loss of computer contact with the Dam 2 intake towers, emergency responses at Headworks as required to ensure compliance with federal Safe Drinking Water Act standards, the mandatory annual testing of the protection devices at the powerhouse, and other circumstances that preclude the use of the intake towers or diversion pool at PWB's water supply Headworks.

Status of Work for Calendar Year 2020

Infrastructure changes (the addition of multilevel water intake gates on the north tower at Bull Run Reservoir 2) were completed in 2014, and the multilevel intakes were placed into operation for temperature management. 2020 was the seventh year of using the multilevel intakes for downstream temperature management. From the spring through the fall, PWB continued to use its flow calculator model for determining flow releases on a twice-daily basis using data from previous years to estimate in-stream heating under various conditions.

The bottom gates of the Bull Run Reservoir 2 North Tower were closed on February 28 to ensure that the coldest possible water was captured at the bottom of the reservoir. However, cold water was not well isolated until thermal stratification became strong in July. Weak stratification started as early as April during a dry and sunny period. Heavy precipitation in May and June weakened stratification as high rates of flow passed through the reservoir. As a result, the temperature of the bottom of the reservoir increased at a higher rate in the spring than occurs when the reservoir is well stratified. Bottom temperatures at the end of June were 9.2°C, 0.5°C to 2.3°C warmer than those in 2014–2019.

PWB communicated the water temperature information to ODEQ, NMFS, and ODFW throughout 2020. Those agencies directed PWB to continue to monitor water temperatures in the lower Bull Run River and to work with them, starting in May of each year, on operational measures to improve performance of the system for temperature control.

The beginning of the temperature management period was marked by rainy conditions. The earliest instances of releasing water at rates above the minimum flow requirements to manage temperatures occurred in late June. Drawdown began on July 11. Neither critical spring nor critical fall conditions were triggered, and therefore normal flow commitments represented the baseline flows during the entire temperature management period in 2020.

The lower Bull Run seven-day average of daily maximum (7DADM) temperatures stayed below the moving temperature target through most of the summer management period, early June through the beginning of October (Figure 3).

Starting October 1, the bottom of Reservoir 2 warmed at an accelerated rate, driven by increased rates of release required in HCP Measure F-1 and marking the depletion of remaining cold water at the bottom of the reservoir. By mid-October, stratification of the reservoir was lost. The loss of cold water with which to manage downstream temperatures resulted in the lower Bull Run 7DADM exceeding temperature targets October 6–27. Cooling ambient temperatures and cool tributary flows to the reservoir allowed for downstream temperatures to return to levels below the temperature targets at the end of October.

Water temperature targets for the lower Bull Run were exceeded for 22 days at Larson's Bridge. During this time, the highest 7DADM temperature during this period was 14.8°C, a departure of 1.8°C above the target. Water temperatures were often cooler than that for the Bull Run River downstream of the Little Sandy confluence (see green line in graph). Those data were taken from PWB data loggers.

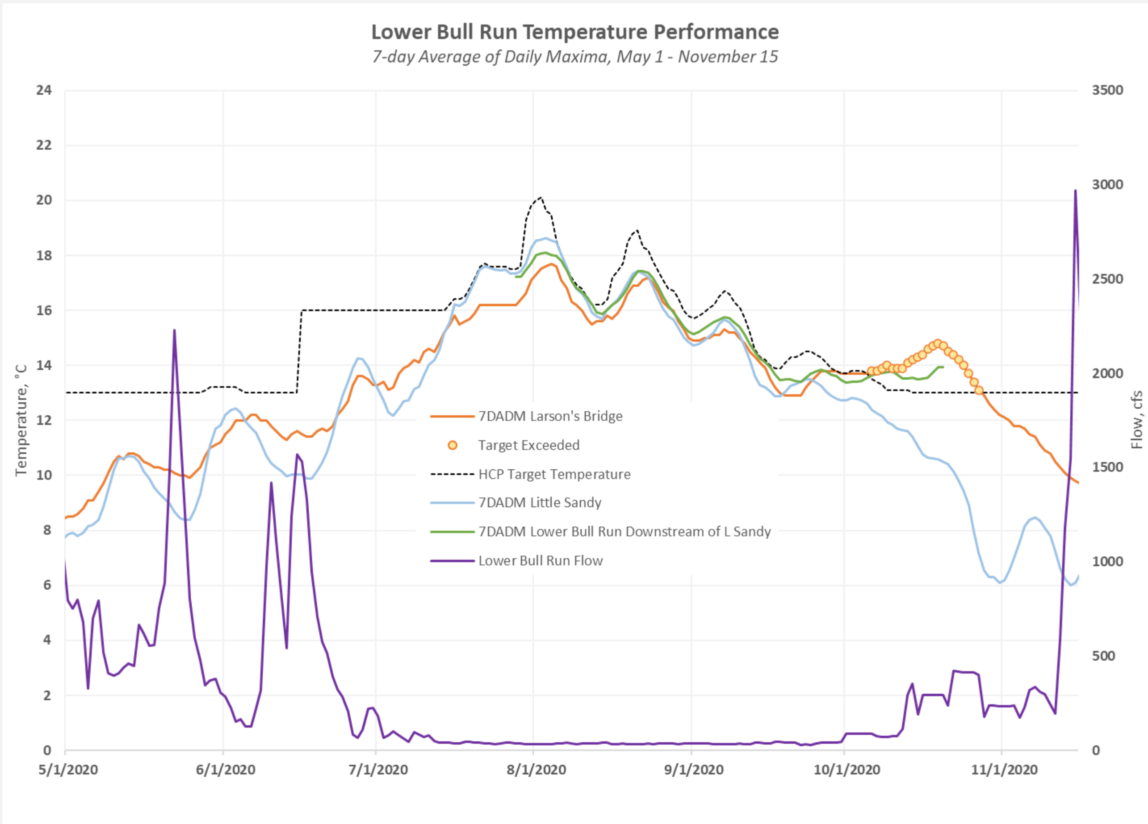

Figure 3. Seven-day moving average of daily maximum water temperature in the lower Bull Run River [a] for 2020

[a] Temperatures are from Larson's Bridge (USGS Gage No. 14140020) and Little Sandy River (USGS Gage No. 14141500). Target temperature combines numeric criteria, Little Sandy temperature, air temperature, and calendar exceptions. The modified target temperature represents the joint decision by PWB and regulators to preserve the cold-water resource for later critical periods.

Consideration of Air Temperature Exclusions

On four days in 2020 (July 26–27 and August 15–16), the 90th-percentile air temperature was forecast to be exceeded but was not. For all days that include dates in which the 90th-percentile air temperature is exceeded in its seven-day average (i.e., from those days to six days after those dates), the temperature target does not have to be met.

The 90th-percentile air temperature exclusions do not help PWB with water supply planning. Twice-daily decisions about optimal downstream releases occur prior to peak daily air temperatures from which exclusions are determined. This proactive management approach is key for managing water temperatures, and forecast conditions cannot be relied upon to determine exceptions. These exclusions, therefore, do not help PWB plan for water releases or savings.

Planned Accomplishments for Calendar Year 2021

PWB will manage flow releases from Headworks to maintain the seven-day average of daily maximum temperatures at Larson's Bridge according to Measure T-2, Post-Infrastructure Temperature Management. The eighth year operating the new multilevel intakes at Bull Run Dam 2 will be 2021. PWB will incorporate knowledge from the first seven years of operating with the new multilevel intakes to optimize operations in 2021.

Measure R-1—Reservoir Operations

Location: Bull Run Watershed

Benefits: Avoids or minimizes Cutthroat and Rainbow Trout mortality

Contact: Kristin Anderson, Hydrologist, PWB Resource Protection

Primary Objective

PWB is continuing to manage the reservoirs to ensure compliance with federal Safe Drinking Water Act standards and to avoid or minimize mortality of Cutthroat and Rainbow Trout.

Measure Commitments

Measure R-1—Reservoir Operations: For HCP Years 1-50, PWB will operate the two Bull Run reservoirs to avoid or minimize mortality of Cutthroat and Rainbow Trout. The operating criteria for the reservoirs will be the following:

1. When PWB is operating its hydroelectric powerhouses at the two Bull Run dams during the winter, the reservoir surface elevations will not normally vary outside of the upper two feet of the reservoirs' normal full pool range (except as noted in items 2 and 3 below). For Bull Run Reservoir No. 1, the elevation range is 1,034 to 1,036 feet above mean sea level (MSL). For Reservoir 2, the range is 858 to 860 feet above MSL.
2. PWB will lower the surface elevation of the two reservoirs beyond the upper two feet of the normal full pool level only for water supply or quality reasons, for downstream fish habitat reasons, for dam safety, or for repairs or maintenance to the dam or hydropower project facilities.
3. PWB will operate the two reservoirs as needed to maintain required streamflows and water temperatures in the lower Bull Run River for covered species.
4. During the summer drawdown season, Reservoir 1 may be lowered to approximately elevation 970 feet above MSL, and Reservoir 2 may be lowered to approximately 832 feet above MSL as needed for water supply purposes.
5. At the end of each drawdown season, the two Bull Run reservoirs will be filled as rainfall, streamflow, and required downstream releases permit.
6. The spillway gates on Bull Run Dam No. 1 will be lowered onto the spillway crest in the spring to store additional water for use in the summer months. After the risk of major flooding has passed and any habitat maintenance work has been completed in the upper reaches of Bull Run Reservoir No. 1 (see Measure R-3, Reed Canarygrass Removal), the water surface level in that reservoir will be raised to a summer supply full pool level of 1045 feet.
7. PWB will use four-cycle engines on its boats to minimize reservoir water pollution.

Status of Work for Calendar Year 2020

The Bull Run reservoirs were operated to meet the requirements of Measure R-1 in 2020. Graphs of the daily surface elevations of each reservoir are shown in Figures 4 and 5.

Reservoir 1 was operated within two feet of the spillway elevation (1,036.0 feet above MSL) from January through March with a few brief, storm-induced levels above 1,036.0 feet. The spillway gates were lowered (closed) on April 1, and Reservoir 1 slowly filled to a maximum of 1,044.9 feet on June 25. Water levels stayed at 1,044.4 feet or above through July 12, after which Reservoir 1 started drawing down consistently through the summer. Reservoir 1 reached a minimum elevation of 983.0 feet on October 9, then refilled to 1023.8 feet on October 21. Another shorter period of drawdown followed due to high fish flow releases and drier conditions, and Reservoir 1 refilled to 1,034.0 feet on November 12 (within two feet of spillway elevation 1,036.0 feet).

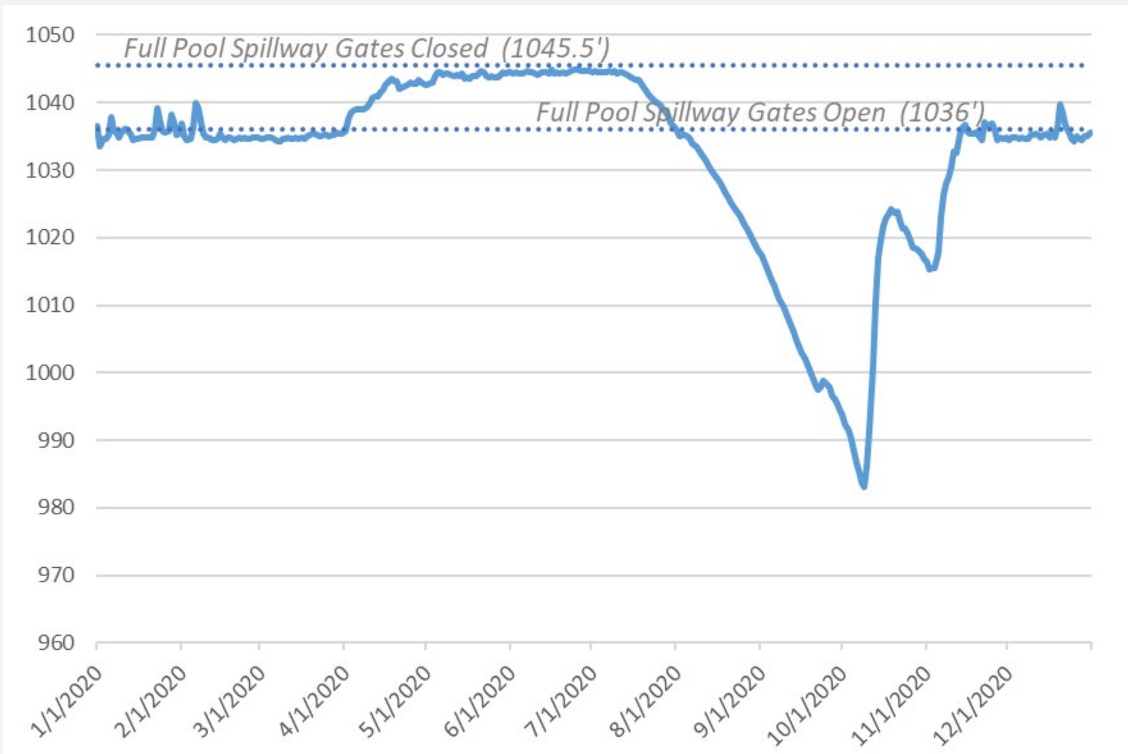

Figure 4. Reservoir 1 elevations[a] during 2020

[a] Reservoir elevations were recorded at midnight at USGS Gage No. 14139000 in feet above MSL. Reservoir elevations are also tracked via PWB's SCADA system.

Reservoir 2 was operated within two feet of spillway elevation (860 feet) until August 4, with several brief storm-caused increases above 860 feet throughout the year. From August through November 2020, Reservoir 2's levels were at times slightly lower than 858 feet. This was done to better accomplish weekly downstream fish surveys. Reservoir 2 reached its minimum elevation for 2020 of 860.0 feet on November 23. Powerhouse 1 went offline on November 22 due to a mechanical issue, and flow from Reservoir 1 to Reservoir 2 ceased for a period of time, during which Reservoir 2 drew down to this minimum level.

PWB used only four-cycle engines on all powered boats operated on the Bull Run reservoirs.

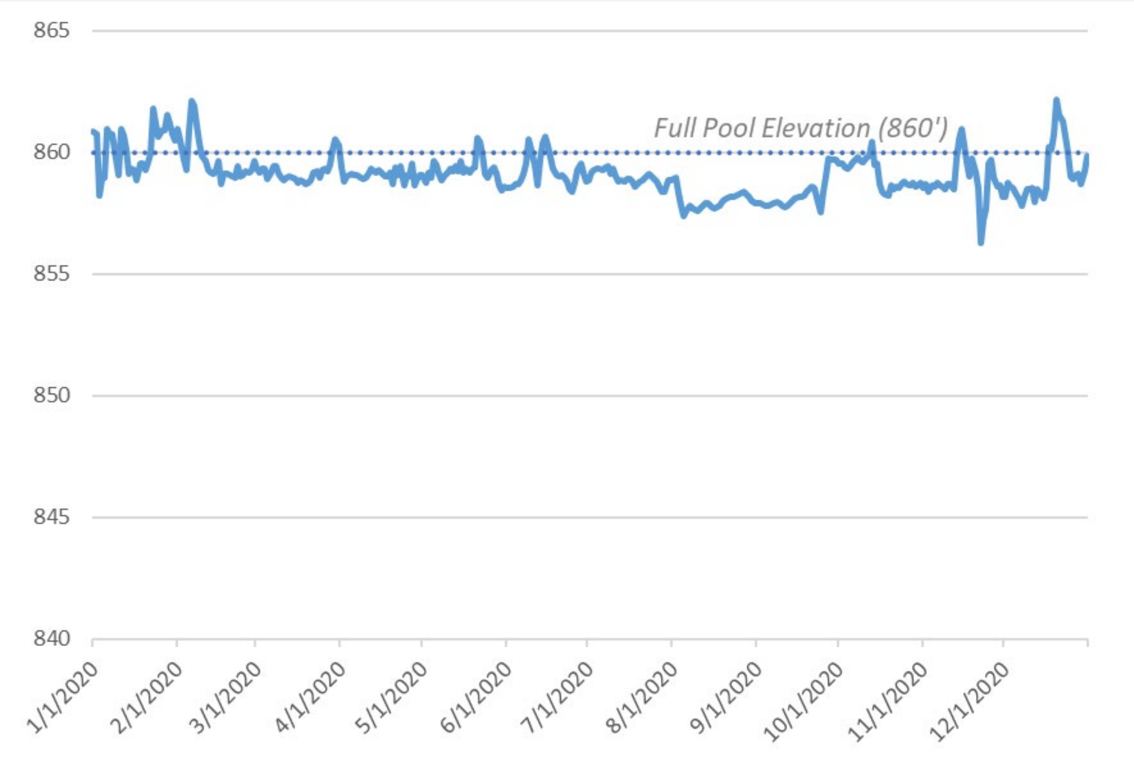

Figure 5. Reservoir 2 elevations[a] during 2020

[a] Reservoir elevations were recorded at midnight at USGS Gage No. 14139900 in mean feet above MSL. Reservoir elevations are also tracked via PWB's SCADA system.

Figure 6. Reservoir 1 and Dam 1 during a drawdown period

Planned Accomplishments for Calendar Year 2021

Reservoir elevations will be managed in 2021 according to the commitments of this measure. All boats operated on the Bull Run reservoirs will be powered by four-cycle engines or human power.

Measure R-3—Reed Canarygrass Removal

Location: Bull Run Watershed

Benefits: Improve terrestrial habitat for wildlife

Contact: Angie Kimpo, Vegetation Stewardship Program Manager, PWB Resource Protection

Primary Objective

To improve breeding and rearing habitat for western toads and red-legged frogs at areas along the upper end of Bull Run Reservoir 1 that PWB has identified as important for reproduction and egg incubation. Since the initiation of the measure in 2010, only western toad breeding has been observed in the upper reservoir areas. Monitoring results have been focused on habitat conditions for that species.

Measure Commitments

Measure R-3—Reed Canarygrass Removal: For HCP Years 1–50, PWB will cut and rake reed canarygrass away from designated areas along the north bank of the upper end of Bull Run Reservoir 1. PWB will access the site by boat from the reservoir and by trail. Power tools will be used for cutting the grass. Neither heavy equipment nor additional road access will be needed. The cutting will occur just before the summer season lowering of the spillway gates on Dam 1, which will flood the shallow area of the reservoir.

Status of Work for Calendar Year 2020

The cutting and removal of reed canarygrass are not having the desired outcome for toads. To date, the removal of reed canarygrass has not been shown to benefit toads because adult toads are mostly avoiding the treated areas.

Information collected during the past four breeding seasons (2016–2019) has shown that adult toads are breeding annually and laying most eggs in areas that have structure. The structure the adults are using is live and dead reed canarygrass attached to the reservoir bottom, and flotsam, especially partially submerged logs, bark, and sticks. Flotsam accumulates at the shoreline of the primary breeding area each winter via back-eddy flows. After eggs hatch, tadpoles aggregate on the structures.

In 2020, toad breeding was monitored from mid-May to mid-June. Surveys were conducted incrementally during the breeding season when breeding area water temperatures were 14°C. During monitoring, data on the location, onset, magnitude, duration, and outcomes of breeding were recorded. Appendix D in this report provides more information on the monitoring effort.

In 2020, areas along the upper portion of the Bull Run Reservoir 1 were not treated for the first time since 2010. Data collected during the prior four years (2016–2019) indicated that adult toads preferred to lay eggs in areas with structure such as logs, bark, and sticks.

Surveys indicated toads bred very late in 2020. Unlike the previous five years, in which most egg laying occurred in May, most egg laying in 2020 occurred in June. Only an estimated eight females laid eggs through the completion of the survey. This is significantly less than other years, in which 20–30 pairs were surveyed.

Planned Accomplishments for Calendar Year 2021

Figure 7. Adult western toad located during 2020 survey

The main goal of this conservation measure is to make the primary breeding area more closely resemble habitat at other toad breeding sites on the west slope of the Cascades where reed canarygrass has not invaded. But this approach has not worked and has not benefited toad breeding. PWB believes that by focusing on monitoring and seeking to achieve successful recruitment of young toads into the adult population, the effort goes beyond the original objective of Measure R-3 (cutting and removing grass).

For this year and future years, PWB will continue annual monitoring of toad breeding at Reservoir 1. Through monitoring, PWB seeks either to (1) determine that toad breeding at the site is self-sustaining, or (2) find a way to improve productivity.

Measure H-1—Spawning Gravel Placement

Location: Bull Run Watershed

Benefits: Improve instream habitat

Contact: Burke Strobel, Fish Biologist, PWB Resource Protection

Primary Objective

PWB is replenishing spawning gravel and mimicking natural supply and accumulation in the lower Bull Run River. The three selected sites provide the best combinations of access for delivery of gravel to the river and proximity to known spawning areas.

Measure Commitments

Measure H-1—Spawning Gravel Placement: PWB will augment spawning gravel in the lower Bull Run River and monitor the effects of the gravel placements. A total of 1,200 cubic yards of gravel will be placed in the river annually during HCP Years 1–5; 600 cubic yards will be placed annually for the remainder of the HCP term (HCP Years 6–50). The gravel will consist of a spawning matrix composed of medium to very coarse material (0.5 to 4 inches) that has been washed or sorted to remove fine sediment. PWB will purchase gravel from companies with current valid permits for the mining or removal of gravel. PWB will only purchase gravel that comes from areas outside of river floodplains.

Gravel will be placed in the river downstream of PWB's water supply intakes. Equal amounts will be placed at three locations:

- 1,200 feet downstream of the Plunge Pool at RM 5.7
- 450 feet downstream of USGS Gage No. 1414000 at RM 4.7
- 600 feet downstream of Larson's Bridge at RM 4.0

Spawning gravel placement will occur in December after the primary fall Chinook Salmon spawning period and before steelhead spawning starts in the spring.

Gravel placements will continue as described above unless

- the lower Bull Run River does not experience high enough flows to distribute the gravel at the three placement locations

or

- the gravel placement is determined to be ineffective for creating spawning habitat for the covered species.

If either of these two conditions arises, PWB will work with the NMFS to modify implementation of the measure as needed.

The effectiveness of the placed spawning gravel was not assessed in 2020. The HCP called for monitoring spawning gravel surface area on an annual basis for HCP Years 1–10 (2010–2019) and then once every five years after Year 10. The effectiveness of spawning gravel placements will be evaluated again in 2024.

Status of Work for Calendar Year 2020

PWB met the requirements of the HCP measure. PWB successfully placed 600 cubic yards of spawning gravel in the lower Bull Run River in January 2020, at three specified locations. Using trucks with conveyor belts, PWB placed a total of 200 cubic yards of gravel into the river at each location in late January 2020 (Figure 8). The gravel was obtained from a gravel quarry located near Estacada, Oregon, from an old alluvial terrace above the Clackamas River. The material complies with the specifications described in the measure.

Conveyor trucks were able to throw gravel to the middle of the Bull Run River, where it later was moved downstream by high flows. River flows during implementation of the project ranged from approximately 2,140 cfs to approximately 4,140 cfs. No gravel was placed in pools.

Gravel placement did not result in accumulations great enough to hinder the movement of fish at any of the three sites. Higher flows of 6,450 cfs on February 7 redistributed most of the placed gravel.

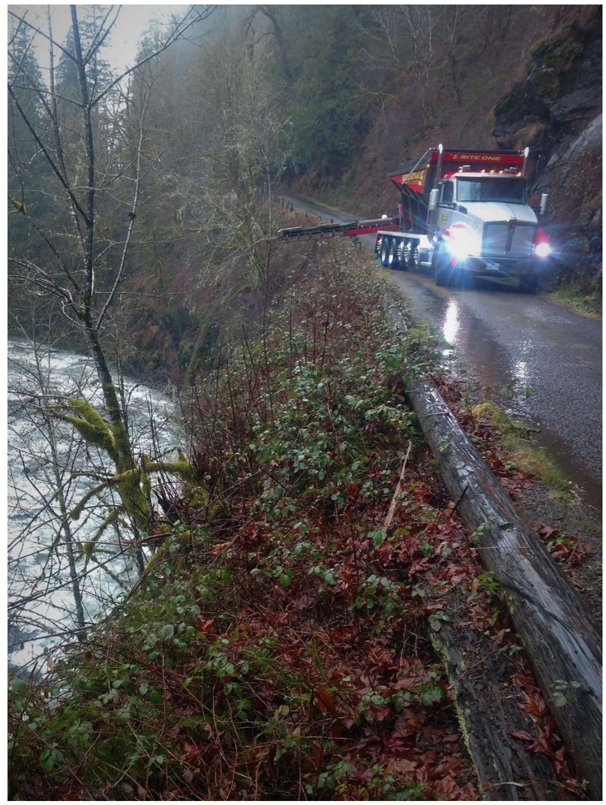

Figure 8. Placing gravel in the Bull Run River in 2020

Planned Accomplishments for Calendar Year 2021

Spawning gravel will be placed in the lower Bull Run River in early 2021. The placement methods will be similar to those used in previous years. A total of 600 cubic yards of spawning gravel will be placed, as called for in Measure H-1, in HCP Years 6–50.

Measure H-2—Riparian Land Protection

Location: Bull Run Watershed

Benefits: Improve riparian and instream habitat

Contact: Liane Davis, Environmental Compliance Manager, PWB Resource Protection

Primary Objective

City-owned lands along the lower Bull Run River are capable of providing riparian habitat at a level comparable to unmanaged late-seral forest. PWB will continue managing these lands for the duration of the HCP so that their value to instream habitat will be maintained and, in some cases, improved.

Measure Commitments

Measure H-2—Riparian Land Protection: For HCP Years 1-50, City-owned lands adjacent to the lower Bull Run River will be managed for the conservation of riparian habitat. PWB will not cut trees within 200 feet of the river's average high-water level on City-owned lands for the term of the HCP. A tree, as defined here, is any coniferous species with a minimum average diameter at breast height of 12 inches. Exceptions will include selective tree cutting to construct, maintain, and operate water supply and

Figure 9. Protection of riparian forest on the Lower Bull Run River

treatment facilities, water monitoring facilities, power lines, roads, and bridges. PWB will also remove trees if they threaten PWB facilities, pose a significant risk to human safety, or when PWB and NMFS determine selective cutting is desirable for the purpose of maintaining or improving riparian habitat. If trees are removed, PWB will assess the site to determine whether an appropriate riparian species could be planted where the tree (or trees) was removed and will replant trees where feasible. The planted trees will be species that do not grow as tall as the removed trees. See also Measures W-1 and W-2.

Status of Work for Calendar Year 2020

PWB met the requirements of Measure H-2. PWB did not cut trees within 200 feet of Bull Run River's average high-water level on City-owned lands in 2020. PWB also managed invasive species on lower Bull Run River riparian land.

Planned Accomplishments for Calendar Year 2021

PWB will continue to monitor activities within 200 feet of the Bull Run River.

Measure O&M-1—Bull Run Infrastructure Operations and Maintenance

Location: Bull Run Watershed

Benefits: Avoid or minimize effects of operations and maintenance activities on covered lands

Contact: Liane Davis, Environmental Compliance Manager, PWB Resource Protection

Primary Objective

PWB will implement the Bull Run Infrastructure Operations and Maintenance (O&M) measure to address the potential impacts of maintaining and operating its water supply facilities in the watershed.

Measure Commitments

Measure O&M-1—Bull Run Infrastructure Operations and Maintenance: For HCP Years 1-50, PWB will take the following actions to avoid or minimize effects on species covered or addressed in the HCP in the Bull Run Watershed:

Covered Lands

- PWB will prevent paint and debris from falling in the river during bridge and conduit maintenance at all active stream crossings.
- PWB will avoid or minimize erosion during repair and maintenance of all water supply infrastructure.
- Water drained from the conduits will be dechlorinated and routed through energy dissipaters prior to releases in the nearest waterway.
- PWB will not use insecticides on covered lands. PWB will allow Bonneville Power Administration (BPA) to use the herbicide Garlon 3A in a limited manner on the BPA transmission line easement on City land (see Section 8.7 of the HCP for more information). PWB will avoid or minimize use of other herbicides on covered lands except as necessary to control invasive plants. Plans for herbicide use that might affect habitat for covered species will be provided to NMFS for preapproval.
- PWB will use fertilizers on lands, if necessary, to encourage plant establishment and growth after projects that cause ground disturbance (e.g., as part of hydroseeding).
- PWB will remove trees in riparian areas if they threaten PWB facilities or pose a significant risk to human safety. PWB will plant replacement trees in the same approximate locations if trees of greater than 12 inches diameter at breast height are cut.

Sandy River Station

- Within HCP Years 1-10, PWB will evaluate stormwater drainage at Sandy River Station and improve facilities if needed.

Status of Work for Calendar Year 2020

Covered Lands

PWB followed all of the commitments stated in Measure O&M-1.

Sandy River Station

PWB evaluated the stormwater drainage system for Sandy River Station (SRS) in April 2018 and reported those results in the 2018 HCP Annual Compliance Report.

The stormwater drainage system evaluation has now been completed, and PWB will continue with quarterly inspections and maintenance activities to ensure proper operation.

Planned Accomplishments for Calendar Year 2021

PWB will continue to monitor the commitments stated in Measure O&M-1.

Measure O&M-2—Bull Run Spill Prevention

Location: Bull Run Watershed

Benefits: Avoid or minimize effects of operations and maintenance activities on covered lands

Contact: Liane Davis, Environmental Compliance Manager, PWB Resource Protection

Primary Objective

PWB will implement the Bull Run Spill Prevention measure to address the potential impacts of maintaining and operating its water supply facilities in the watershed.

Measure Commitments

Measure O&M-2—Bull Run Spill Prevention: For HCP Years 1–50, PWB will implement the following actions to avoid or minimize spill effects on the species covered or addressed in the HCP in the Bull Run River and Sandy River:

Headworks

- Fuel and chlorine deliveries will be escorted by a pilot car via paved roads.
- Secondary containment will be provided for the fuel tanks.
- Containment basins will be inspected and pumped out as needed.

Sandy River Station

- Secondary containment systems will be provided for the fuel tanks and pumps to contain any leaks. Containment basins will be inspected and pumped out as needed.
- Within Years 1–5 of the HCP, PWB will evaluate the feasibility of moving existing fuel tanks and pumps out of the Sandy River floodplain. This feasibility analysis will be done in conjunction with a PWB capital improvement project.

Status of Work for Calendar Year 2020

PWB complied with all of the commitments in Measure O&M-2 in 2020.

Planned Accomplishments for Calendar Year 2021

PWB will continue to adhere to the commitments in Measure O&M-2.

4.1.2 Offsite Measures

PWB is implementing conservation measures on land in various locations throughout the Sandy River Basin. The measures are grouped by type: riparian easements and improvements, acquisition of water rights, fish passage, carcass placement, large wood and log jam placement, channel restoration, and terrestrial wildlife habitat conservation.

4.1.2.1 Riparian Easements and Improvements

From the HCP, PWB committed to obtaining easements from willing landowners for a total of 373 acres of riparian lands. The initial easement targets were 166, 99, and 108 acres for the lower, middle, and upper Sandy River watershed, respectively (Table 7). For adaptive management reasons, PWB made slight changes to the easement targets. PWB was to obtain the total target acreage by Year 15 of the HCP (2024). Acreage targets are indicated in the table below. The actual acreage obtained for easement targets in the lower, middle, and upper Sandy River watersheds are 168, 76, and 51 acres, respectively. These acquired easements have enabled PWB to meet and exceed the targeted habitat benefits of the conservation easement measures (see 2019 HCP Annual Compliance Report).

When applicable, the measurable habitat objectives define a number of acres for riparian easements. The intent is for the easements to provide a minimum of a 100-foot-wide buffer from the top of the mean high-water level in the specified reach.

Table 7. Easement acre targets and acres obtained for HCP implementation, year 10 (2019)

Measure code	Reaches	HCP years	Easement acre targets	Total acres obtained
Lower Sandy Watershed				
H-11	Sandy 1	2010–2014	0	–
H-12	Sandy 2	2010–2014	143	145
H-13	Gordon 1A, 1B	2010–2014	23	23
		Subtotal	166	168
Middle Sandy Watershed				
H-14	Sandy 3	2020–2024	7	17
H-15	Cedar 2 & 3	2015–2019	49	25
H-16	Alder 1A & 2	2010–2014	43	0
—[a]	Lower Bull Run River	2012	0	34
		Subtotal	99	76
Upper Sandy Watershed				
—[b]	Sandy 7		0	49
H-18	Sandy 8	2020–2024	25	2
H-19	Salmon 1	2015–2019	23	0
H-20	Salmon 2	2020–2024	36	0
H-21	Salmon 3	2020–2024	12	0
H-22	Boulder 1	2010–2014	0	0
H-28	Zigzag 1A & 1B	2020–2024	12	0
		Subtotal	108	51
	Grand Total		**373**	**295**

[a] No associated HCP measure. PWB acquired land around the lower Bull Run River, as authorized by NMFS, on September 16, 2011 (see summary in Appendix F, Item 3 of the 2011 report).

[b] No associated HCP measure. PWB acquired an easement in Sandy 7, as authorized by NMFS, on February 13, 2017 (see summary in Appendix I, Item 12 of the 2017 report).

Riparian Easements and Improvements

Location: Lower Sandy River, middle Sandy River, and upper Sandy River watersheds

Benefits: Improve riparian and instream habitat

Contact: Angie Kimpo, Vegetation Stewardship Program Manager, PWB Resource Protection

Primary Objective

PWB has identified habitat conservation measures that will improve riparian-zone conditions. The land easements will improve a minimum of 100 feet of riparian forest on either side of the active channel width of the river or creeks. The conservation measures include silvicultural practices (e.g., selective thinning and tree planting) to improve the riparian zones. The acreage totals for the land protection easements are calculated by multiplying the lineal distance of the stream by the amount of riparian forest protected by the easement.

Measure Commitments

A general measure description is provided for measures H-11 through H-16, H-18 through H-22, and H-28. The general description does not include specific acreages. Acreages are marked as “XX” in the description. Specific acreages for each easement area are listed in Table 8.

Within HCP Years 1-5, PWB will acquire 100-foot-wide land protection easements from willing private landowners for at least XX acres, which will comprise the total number of lineal feet x 100 feet of riparian width on either side of the Sandy River in the named reaches. At a minimum, the easements will be maintained for the term of the HCP. PWB will also consider, on a voluntary and case-by-case basis, obtaining easements with durations longer than the term of the HCP and greater than 100 feet wide. The HCP funding for purchasing and maintaining each easement will be limited to what is defined in Chapter 11 of the HCP for that measure. The easement areas will be managed to support forest of ≥70 percent conifer trees (by canopy cover) where site conditions are conducive to the growth of conifers. Deciduous trees will be selectively thinned, and the easement will be replanted with conifers. If the easement area is not conducive to the growth of conifers, the area will be managed to support the growth of native hardwood species. Management of the easements will also include control of invasive plant species.

Status of Work for Calendar Year 2020

PWB has finalized easements for 295 acres (Table 8). The last easements were obtained in 2019 and those accomplishments were summarized in the 2019 HCP Annual Compliance Report. PWB is ahead of schedule for acquiring conservation easements in the Sandy River Basin and has completed all easement acquisition related to this measure.

For all easements or acquired riparian buffer areas, canopy cover is estimated both prior to work onsite and after planting in five-year increments to determine progress toward canopy cover goals.

Table 8 summarizes the location, acreage total, and condition of the canopy cover for the easements that PWB has obtained to date.

PWB is obligated to treat all easement areas so that the canopy cover meets or exceeds 70 percent conifer trees, or native hardwood species as the site conditions dictate, over the term of the HCP. The canopy cover for the Mench, Metro Kingfisher, Metro Hyman, and Clackamas easements exceed the ≥70 percent criterion stated in the HCP. PWB will continue to track the canopy cover for all easements.

Figure 10. Looking across the lower Sandy at the Cornwall easement

Table 8. Location, amount, and estimate of conifer canopy cover for easements, HCP year 11 (2020)

Reach/ property owner	Year acquired	Number of easements	Acres	Initial canopy cover estimate[a]	Five-year canopy cover estimate
Gordon 1A & 1B		**2**	**23 Total**		
Maunder	2011		3	45%	45%
Bonner	2012		20	48%	56%
Sandy 2		**1**	**145 Total**		
Metro Kingfisher	2014		25	71%	65%
Metro Cornwall	2014		13	64%	61%
Metro Diack	2014		35	53%	48%
Hyman	2014		2	82%	83%
Metro Partridge	2014		16	40%	37%
Camp Collins	2013	1	54	60%	61%
Cedar 2 & 3		**2**	**25 Total**		
Lowy	2015		9	30%	32%
Harrison	2015		16	61%	66%
Lower Bull Run			**34 Total**		
City of Portland	2013		34	52%	64%
Sandy 3		**1**	**17 Total**		
Rayne	2011		17	28%	45%
Sandy 7		3	**49 Total**		
Clackamas County	2017		29	79%	n/a[b]
Conlin	2019		9	65%	n/a[b]
Denney	2019		11	69%	n/a[b]
Sandy 8	2011	1	**2 Total**		
Mench	2011		2	92%	96%

Abbreviation: TNC is The Nature Conservancy

[a] Conifer canopy cover data are collected approximately within the first year of easement acquisition and every five years after that.

[b] Five-year canopy cover estimates for Sandy 7 will be conducted later in 2021.

Planned Accomplishments for Future Years

PWB has completed enough easement acquisition. To support that assertion, PWB looked at the projected habitat and fish benefits associated with the original HCP conservation easements and compared that to the projections for the actual easements acquired through 2019. The projected fish benefits associated with this easement program meet or greatly exceed the projections from the original HCP. All of this information is summarized in Appendix A of the 2019 Annual Compliance Report.

PWB does not plan to pursue additional easements but will continue to actively manage conservation easements and monitor canopy cover to document HCP compliance.

Figure 11. PWB-purchased easement in the middle Sandy River Gorge

Measures H-23 and H-24—Salmon 2 Miller Quarry Acquisition and Restoration

Location: Salmon River watershed

Benefits: Improve riparian and instream habitat

Contact: Liane Davis, Environmental Compliance Manager, PWB Resource Protection

Primary Objectives

Acquire the Miller Quarry parcel on the Salmon River and implement measures to improve riparian-zone conditions.

Measure Commitments

H-23: Within HCP Years 6-10, the 40-acre Miller Quarry parcel in reach Salmon 2 will be purchased. The restoration commitments are described in Measure H-24.

H-24: Within HCP Years 11-15, PWB will remove riprap along 0.25 miles of riverfront of the Miller Quarry parcel to reconnect floodplain and side-channel habitat. Approximately 1,000 feet of new side channel will be opened. 160 pieces of large wood (LW) will be placed in the side channel to create approximately eight log jams. Approximately four acres of riparian zone will be amended with soil and then replanted with suitable riparian species.

Planned Accomplishments for Future Years

PWB worked on acquiring the Miller Quarry property since 2011. The steps that PWB took were described in the 2016 Annual Compliance Report.

PWB was unable to complete the purchase and, subsequently, the restoration of the Miller Quarry property on the Salmon River due to an unwilling property owner.

For Measures H-23 and H-24, there were projected habitat and fish benefits as described in the HCP. PWB will make up for the loss of projected habitat and fish benefits from this measure with the implementation of other conservation measures. This plan is described in detail in Appendix A of the 2019 Annual Compliance Report.

NMFS and ODEQ reviewed the accomplishments of all HCP conservation measures to date, as described in Appendix A of the 2019 Annual Compliance Report. PWB will not implement Measures H-23 and H-24.

4.1.2.2 Water Rights

Measure F-5—Cedar Creek Purchase Water Right

Location: Cedar Creek in Sandy River Basin

Benefits: Improve instream habitat

Contact: Hassan Basagic, Watershed GIS Specialist, PWB Resource Protection

Primary Objective

Cedar Creek is a populated watershed with numerous privately owned parcels and associated water rights for rural residential and agricultural purposes. The creek has elevated water temperatures in late summer, partially due to water withdrawals. PWB will acquire water rights to improve water quality and base flows in Cedar Creek for steelhead, Coho, and Cutthroat Trout.

Measure Commitments

Measure F-5—Cedar Creek Purchase Water Rights: Within the first 10 years of the HCP term, PWB will acquire approximately 50 percent of the current certificated surface water rights that affect summer flows on Cedar Creek. These water rights will be acquired from willing sellers and will be converted to instream use for at least the term of the HCP.

Planned Accomplishments for Future Years

In previous annual compliance reports, PWB documented the history of action taken for this conservation measure. PWB has found no willing sellers of certificated surface water rights in the Cedar Creek drainage. PWB was not be able to implement this measure.

For this measure, there were small projected habitat and fish benefits as described in the HCP. PWB will make up for the loss of projected habitat and fish benefits from this measure with the implementation of other conservation measures. PWB's plan for this is described in detail in Appendix A of the 2019 Annual Compliance Report.

NMFS and ODEQ reviewed the accomplishments of all HCP conservation measures to date, as described in Appendix A of the 2019 Annual Compliance Report. PWB does not anticipate additional efforts to implement Measure F-5.

4.1.2.3 Large Wood Placement

Measure H-4—Sandy 2 Log Jams and Measure H-27—Zigzag Channel Design

Location: Sandy River

Benefits: Improve instream habitat

Contact: Burke Strobel, Fish Biologist, PWB Resource Protection

Primary Objective

PWB's large wood measures are being implemented to help restore key habitat for fish. The large wood additions for Measure H-4, for example, will increase habitat complexity, providing benefits such as pools and cover for migrating, spawning, and rearing fish in the Sandy River reach 2. Restoring side channel flow for Measure H-4 and removing berms for Measure H-27 will reconnect rivers with their riparian zones.

Section 4.2.1 of this report describes the effectiveness monitoring methods for these measures.

Measure Commitments

The commitments for Measure H-4 have been changed from what was described in the HCP to incorporate benefits from another measure, H-9, which will not be implemented, and to move H-4 benefits planned for Sandy 1 to Sandy 2. Within HCP Years 6–10, PWB will work with willing landowners to place a minimum of 530 key logs into the Sandy River in a way that restores flow to at least 2,100 lineal feet of side channel. PWB will also increase off-channel habitat in the reach by 8,164 square feet. Large wood will be placed avoiding federal land, land without landowner permission, and land where the preexisting large wood quantity is already adequate. Large wood quantities were chosen to achieve placement densities of approximately 75 pieces per mile on average for the originally planned treatment reach, Sandy 2.

Within HCP Years 11–15, PWB will work with willing landowners to modify Zigzag 1A to create more natural channel conditions. Approximately one half mile of new side channel will be created, and an additional half mile of existing side channel will be improved. A minimum of 270 pieces of large wood (LW) will be placed in the side channel and mainstem of Zigzag 1A.

Individual LW pieces will be sound conifer logs with a small-end diameter of at least 12 inches and a length of at least 30 feet. The key pieces will be placed to collect other additional woody debris. If available, large root wads will also be selected for placement. Artificial anchoring of the wood will be used only when wood movement cannot be tolerated. Anchoring will be used only if the large wood might move downstream and damage road culverts, bridges, private property, or other streamside improvements. It is desirable for the stream to redistribute the placed large wood to some extent as long as damage is avoided. Methods and timing for LW placement will be determined in consultation with NMFS and the ODFW.

The LW placements will be maintained for 15 years. Year 1 of the maintenance will be the calendar year following the wood placement.

Effectiveness monitoring is described in Section 4.2.1 of this report.

Status of Work for Calendar Year 2020

H-4—Sandy 1 and 2 Log Jams

Construction relating to Measure H-4 was completed in 2018 and that work was described in the 2019 Annual Compliance Report. Project revegetation efforts continued in 2020 and work focused on maintaining plantings. PWB evaluated its efforts to create compensatory wetlands at the project site and determined that it would have great difficulty creating enough wetland surface area to fully compensate for wetlands converted to open water by the project. The planned compensatory wetlands would also have been susceptible to lateral migrations of the activated side channel and related changes to site hydrology. PWB will continue to establish wetlands where possible at the project site. However, PWB also fully mitigated for lost wetlands at the project site in 2020 through the Oregon Department of State Lands’ Payment-in-Lieu program.

Figure 12. Zigzag Large 1A channel design, 2019

Figure 13. Zigzag Large 1A channel design, 2020

H-27—Zigzag 1A Channel Design

Measure H-27 was constructed and completed in 2019 and those project activities were described in the 2019 Annual Compliance Report.

Further adjustments were made to the project in 2020 to improve its performance. The entrances of side channels at the six locations where berms were removed were excavated deeper to allow surface flow during the summer (Figure 13).

Planned Accomplishments for Calendar Year 2021

H-4—Sandy 1 and 2 Log Jams

PWB plans to complete revegetation for this measure, focusing on further establishing plantings and suppressing invasive weeds. All plantings will be maintained for an additional two years after the completion of revegetation.

4.1.2.4 Terrestrial Wildlife Habitat Conservation

Measures W-1, W-2, and W-3—Minimum Impacts to Spotted Owls, Bald Eagles, and Fishers

Location: Sandy River Basin

Benefits: Avoid disturbance of species' habitat

Contact: Liane Davis, Environmental Compliance Manager, PWB Resource Protection

Primary Objectives

The objective for Measures W-1 and W-2 is to avoid or minimize the periodic, temporary disturbance of habitat that might result from the routine operation, maintenance, and repair of water supply facility from implementation of HCP measures.

Although fishers have not been found in the Sandy River Basin, PWB developed Measure W-3 as a contingency habitat measure to avoid or minimize impacts to fishers during the performance of covered activities in the basin.

Measure W-1 Commitments

Measure W–1—Minimize Impacts to Nesting Spotted Owls: For the term of the HCP, PWB will take steps to avoid or minimize impacts to nesting spotted owls on all covered lands. The terms of the measure are described on page 7–66 to 7–69 of the HCP.

Measure W-2 Commitments

Measure W–2—Minimize Impacts to Bald Eagles: For the term of the HCP, PWB will take steps to avoid or minimize impacts to bald eagles on all covered lands. The terms of the measure are described on page 7–69 to 7–74 of the HCP.

Measure W-3 Commitment

Measure W–3—Minimize Impacts to Fishers: If the fisher is found to occur within 30 miles of the Bull Run Watershed or the locations of any unfinished HCP measures, PWB will meet with US Fish and Wildlife Service (USFWS) to discuss whether any steps need to be taken to avoid or minimize impacts to fishers during the performance of the covered activities.

Status of Work for Calendar Year 2020

For Measures W-1, W-2, and W-3, PWB avoided or minimized impacts to spotted owls and bald eagles for all City projects in 2020.

Fishers have not been found to occur anywhere near the Bull Run Watershed, and therefore, no avoidance or minimization actions were necessary.

Planned Accomplishments for Calendar Year 2021

PWB will continue to evaluate potential impacts to spotted owls and bald eagles when considering City projects. PWB will continue to be vigilant about any information related to fishers and will consider such information during the performance of covered activities.

4.1.3 Monitoring for Clean Water Act 401 Certification Conditions

As part of HCP Measure T-2—Post-infrastructure Temperature Management—PWB completed a project to modify a water intake tower at Bull Run Dam 2 to allow withdrawal of water from the reservoir at different levels. PWB has a noncapacity license amendment with the Federal Energy Regulatory Commission (FERC) for the tower modifications. According to Section 401 of the Clean Water Act (CWA) and as part of the condition of the amended hydroelectric project license from FERC, the Oregon Department of Environmental Quality (ODEQ) reviewed the impacts of the proposed Bull Run Dam 2 Tower project on water-quality parameters that might be affected by construction on the intake tower. The five water-quality standards that might be affected by work in Bull Run Reservoir 2 are listed in Table 9 with the language from the Oregon Administrative Rule that describes the standard.

Table 9. Water quality parameters to monitor for CWA Section 401 Certification

Water quality parameter	Potential impact description in Oregon Administrative Rule
Nuisance phytoplankton growth	Changes in reservoir circulation may lead to changes in nutrient concentrations, which in turn may lead to algal blooms.
Creation of taste, odors, toxic conditions	Taste and odor or toxic conditions can occur from nuisance algal blooms.
Dissolved oxygen (DO)	Changes in water circulation in reservoir may alter dissolved oxygen concentration, especially at depth with change in residence time deep in reservoir; algal bloom respiration and decay may also consume DO.
pH	Algal blooms may cause spikes in pH values.
Temperature	Changes in withdrawal depth may result in temperature changes downstream.

PWB monitored water quality parameters for five consecutive years (2014–2018), as directed in the Section 401 certification. The monitored water quality parameters showed either no differences from the baseline conditions or slight changes, or still require future monitoring beyond the time frame conditions of the Section 401 certification. The previous monitoring results are summarized in the 2018 HCP Compliance Report. PWB will continue to monitor downstream water temperature for the lower Bull Run River and report to ODEQ and NMFS via direct conversations, biweekly reports during the summer and early fall, and the annual compliance reports for Habitat Conservation Plan activities.

4.2 Effectiveness Monitoring

PWB is conducting effectiveness monitoring for some of the HCP conservation measures. Those measures include large wood placement/log jam creation, side-channel development, river mouth reestablishment, and floodplain reconnection. For these measures, there is some degree of uncertainty about the biological effectiveness.[1] All effectiveness monitoring is conducted to test the hypothesis that at least 80 percent of the projected changes in the key habitat variables will occur in each stream reach.

Effectiveness monitoring activity does not occur every year for all of the measures listed in the paragraph above. This annual compliance report just describes the effectiveness monitoring that occurred in 2020 which was done for Measure H-17 Cedar 2 and 3 LW Placement and Measure H-27 Zigzag 1A Channel Design.

PWB is using the habitat variable ratings from the Ecosystem Diagnosis and Treatment (EDT) model and has provided estimated improvements from HCP measures in Appendix E of the HCP. For a detailed description of effectiveness monitoring for offsite in-channel conservation measures, including sampling methods and assessment procedures, see Appendix F of the HCP.

4.2.1 Large Wood and Log Jam Placement

Measures H-17 and H-27—Large Wood Placement

Location: Cedar Creek and Zigzag River in the Sandy River Basin

Benefits: In-stream habitat

Contact: Burke Strobel, Fish Biologist, PWB Resource Protection

Primary Objective

PWB's large wood measures are being implemented to help restore key habitat for fish. The large wood additions will increase habitat complexity, providing benefits such as pools and cover for migrating, spawning, and rearing fish in Cedar Creek reaches 2 and 3 and Zigzag River reach 1A.

Measure Commitments

Within HCP Years 6–10, PWB will work with willing landowners to place a minimum of 600 key logs into Cedar Creek reaches 2 and 3.

Within HCP Years 11–15, PWB will work with willing landowners to modify Zigzag 1A to create more natural channel conditions. Approximately one half mile of new side channel will be created, and an additional half mile of existing side channel will be

[1] In some cases, the City does not plan to conduct effectiveness monitoring because the outcomes are already known and are well-supported by the available scientific literature.

improved. A minimum of 270 pieces of large wood will be placed in the side channel and mainstem of Zigzag 1A.

Measurable Habitat Objectives

The measurable habitat objectives for the large wood measures share the common objective of achieving 80 percent of the predicted increase in pieces of large wood within 15 years of implementation. Additional habitat objectives include the following: come within 80 percent of the predicted increase in beaver pond and pool habitat in Cedar Creek reaches 2 and 3; and attain 80 percent of the predicted decrease in artificial confinement and increase in pools in the Zigzag River reach 1A within 15 years of implementation.

Effectiveness Monitoring Method

To test whether the habitat variable ratings in the current EDT database are representative of preproject conditions, and to determine whether the projected increases in habitat ratings are an accurate representation of postproject conditions, PWB is implementing the following monitoring methodology:

- Conduct baseline habitat surveys in both the project reaches and in upstream control reaches, where no habitat enhancement projects are planned.
- Conduct postproject habitat surveys in both the project reaches and in upstream control reaches.
- Compare the baseline and postproject survey results for project and control reaches. Evaluate effectiveness by comparing observed changes with the measurable habitat objectives after adjusting for background changes observed in control reaches.

Status of Work for Calendar Year 2020

PWB fully complied with the effectiveness monitoring as required by the HCP for Measures H-17 and H-27 in 2020. Posttreatment monitoring began for Measure H-27 and continued for Measure H-17. The specific monitoring accomplishments are referenced by measure name (e.g., Cedar 2 and 3 LW Placement) in Appendix A of this report.

Planned Accomplishments for Calendar Year 2021

The collection of posttreatment data for effectiveness monitoring will continue in 2021 for two HCP conservation measures: Measure H-27 Zigzag 1A Channel Design and Measure H-3 Little Sandy 1 and 2 LW Placement. Post-treatment habitat surveys will follow protocols identical to those used in previous years.

4.3 Research Program

4.3.1 Bull Run Research

4.3.1.1 Total Dissolved Gas

PWB has evaluated the structures, valves, and turbines in the Bull Run water supply system since 2005 to determine whether any facilities would exceed the state standard for total dissolved gas (TDG). For the state standard, the concentration of TDG relative to atmospheric pressure at a sample collection point may not exceed 110 percent of saturation except when stream flow exceeds the 10-year, seven-day average flood (7Q10). No additional TDG data were collected in 2020, but TDG research to date is summarized annually, regardless of data collected.

PWB has measured TDG levels in excess of 110 percent at river flows below the 7Q10 flow on three occasions in the past. On all three occasions, the water with high TDG levels had not yet had a chance to mix with the low-TDG water from Powerhouse 2. The average saturation level for TDG in the river was calculated to be less than 110 percent.

The detailed account of the TDG evaluation protocol is available in Appendix F of the HCP.

Because desirable flow conditions did not occur in 2020, there were no TDG monitoring measurements. Consequently, there is no TDG monitoring appendix in this year's annual compliance report.

Bull Run Adult Chinook Population

In conjunction with other agencies in the Sandy River Basin, PWB has partially funded research of the status of fish listed under the Endangered Species Act. The results of the research will be evaluated along with the results of PWB's effectiveness monitoring to determine PWB's adaptive management response over time.

PWB collects adult Chinook Salmon information for the lower Bull Run River. PWB conducts annual surveys of the lower river from RM 0 to RM 6.0 to count adult spring and fall Chinook Salmon from August through mid-December. Surveys are conducted on a weekly basis, provided instream flows allow for safe navigation of the river channel. Overall, PWB anticipates funding 20 years of surveys over the 50-year term of the HCP.

PWB conducted this annual survey of the Bull Run Chinook population as planned in 2020, but fire danger in early September and high flows in mid-November prevented scheduled surveys from being conducted on three occasions. The peak adult Chinook count and minimum escapement[2] estimate, as well as cumulative redd count in 2020, were the highest ever recorded since 2007 for both spring and fall Chinook.

A detailed description of the Bull Run Adult Chinook Population Research protocol is available in Appendix F of the HCP. The results of the current year's survey are available in Appendix B of this report.

Additional surveys were conducted on three occasions—in June, July, and August—following different protocols from those described in HCP Appendix F. The additional surveys were snorkel counts to evaluate the effectiveness of a weir near the mouth of the Bull Run River operated by ODFW to collect returning adult hatchery Chinook Salmon. A maximum of 31 hatchery adult Chinook were observed while snorkeling the Bull Run River during the summer. These Chinook probably entered before installation of the ODFW weir. No effort was made to remove them because of the small number and high risk of impacting wild adults.

4.3.2 Sandy River Basin Research

4.3.2.1 Sandy River Basin Juvenile Outmigrants

Although the HCP is habitat based and not focused on the specific population responses of the species, information about juvenile outmigrants (JOMs) is needed to obtain a complete picture of the condition and change in freshwater productivity through time. The results of the JOM research will be evaluated with other monitoring results to determine PWB's adaptive management response over time.

PWB will provide funds for collecting JOM information in the Sandy River Basin. This money will be leveraged with other funds to create a coordinated monitoring program. Twelve sites in the basin will be monitored and will serve as an index for the entire basin.

PWB and its partners' efforts to monitor JOM production were heavily impacted by the COVID-19 pandemic in 2020. Only five streams were monitored in 2020, three less than planned: Bull Run River, Little Sandy River, Gordon Creek, Beaver Creek, and Cedar Creek. Population estimates were calculated for steelhead and Coho smolts in all five streams and fork-length distributions, condition factors, and emigration patterns were analyzed. The ages of smolts from Clear Fork Sandy, Zigzag River, Still Creek, Little Sandy River, Bull Run River, Gordon Creek, and Beaver Creek from 2019 were calculated by aging fish using fish scale samples; those ages were added to age distribution information for all trap sites derived from fish scales collected between 2009 and 2018.

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[2] Escapement is the number of fish that avoid or escape all harvest and return to spawn in their home streams.

Steelhead and Coho smolts from different streams in the Sandy River Basin showed significant differences in weighted mean fork length of smolts. Low-elevation streams had longer Coho smolts than high-elevation streams, but there was no clear relationship between stream elevation and fork length for steelhead smolts.

Steelhead and Coho smolts from different streams in the Sandy River Basin also showed significant differences in mean condition factors. Condition factors negatively correlated weakly with fork length.

Steelhead smolts emigrated earlier, on average, than Coho smolts in most streams. Steelhead emigrated earlier from low-elevation than from higher-elevation streams, while Coho showed no geographic pattern.

High-elevation streams had a larger proportion of older-age steelhead and Coho smolts. Length-at-age calculations revealed that steelhead smolt fork lengths are shorter on average for a given age in higher-elevation streams than in low-elevation streams, as is seen in Coho, but this fact is masked by their older average age.

PWB's specific commitments and the approach to JOM research are outlined in Appendix F of the HCP. The results of this research are presented in Appendix C of this report.

4.4 Adaptive Management Program

The Bull Run HCP defined adaptive management along two concurrent tracks: adaptive responses for individual measures and decision milestones for addressing the effectiveness of the HCP as a whole. Through monitoring, PWB will evaluate its progress on implementation as well as effectiveness of the measures. Should monitoring results indicate, PWB will use its adaptive management program to change its approach.

If monitoring results indicate that a measure cannot be implemented, that an instream measure has not met its measurable objective, or that factors outside PWB's control have reduced the habitat benefits of a measure by more than 20 percent, then PWB will implement adaptive management. The adaptive management response includes several factors: consultation with NMFS, site surveys, and rerunning the EDT model to characterize baseline watershed conditions.

If, after taking these steps, PWB and NMFS reach the conclusion that an additional or substitute measure is necessary, PWB will follow the guidelines outlined in Chapter 9 (Section 9.4.3) of the HCP in its approach. Costs for implementing additional measures after the original measure has been implemented will be paid from the adaptive management section of the Habitat Fund. See the description of the Habitat Fund measure, below.

Measure H-30—Habitat Fund

Location: Covered lands

Benefits: Assists in meeting HCP objectives

Contact: Liane Davis, Environmental Compliance Manager, PWB Resource Protection

The adaptive management portion of the Habitat Fund will be used to implement additional projects if one or more of the offsite measures does not meet its objectives. The Sandy River Basin Partners' portion of the fund will be used to implement additional habitat projects that help compensate for water system impacts not fully addressed by other projects. The details of the Habitat Fund measure are presented in Chapters 7 and 11 of the HCP.

Primary Objective

The Habitat Fund enables adaptive management and allows PWB to address water system impacts that may not otherwise be addressed, respond to unknown future opportunities, and contribute to partnership projects.

Measure Commitments

PWB will provide money to create a Habitat Fund of $9 million. A $5-million portion of the Habitat Fund is available in four increments prior to HCP Year 20 and is dedicated to partnership projects. The increments are described in Chapters 9 and 11 of the HCP (see also Figure 11-1 of the HCP). The remaining $4 million is dedicated to adaptive management needs but will be used for additional partnership projects if not needed for adaptive management (see Chapters 9 and 11). Projects will be selected in consultation with the HCP Implementation Committee (see Chapter 9) and will be guided by the Sandy River Basin Restoration Strategy. PWB and NMFS will make the final project selection decisions.

Of the $5 million, PWB will specifically dedicate $1.7 million toward habitat enhancement projects on the Salmon River to be implemented jointly by the Sandy River Basin Partners and with additional funds from the Partners and/or from grants. If partnership funds cannot be obtained to implement these projects, PWB funds will be used for other projects in the Sandy River Basin.

Based on an informal agreement in October 2004, PWB will also work with the Partners to provide resources from the $5-million portion of the Habitat Fund to (1) participate in basin-wide efforts to control invasive plants that threaten riparian habitat, and (2) build the organizational capacity of the Partners to implement the basin-wide Restoration Strategy, including outreach.

Status of Work through June 2021

PWB was in full compliance with Measure H-30—Habitat Fund.

Through June 2021, PWB committed to fund one project for building funding capacity for the Sandy River Basin Partners, four projects to do scale analysis, one culvert replacement project in the Salmon River Basin, and ten restoration projects for the upper

Sandy River, the Salmon River, Lost Creek, and Still Creek, which are priority restoration areas for the Partners. PWB committed a total of $1,454,077 through June 2021. See Table 10 for a summary of past projects.

PWB intends to commit a total of $207,483 of Habitat Fund dollars through June 2022 to projects implemented by Sandy River Basin Partners. See Table 11 for projects from July 2021 through June 2022.

Table 10. Past projects funded through the HCP Habitat Fund

Number	Project partner	Amount	Duration	Purpose
Grant Agreement 32000035	Oregon Trout	$25,000	2009	Build the capacity of the Sandy River Basin Partners in obtaining additional funding to help implement the Partners' restoration strategy.
Grant Agreement 182484	Freshwater Trust	$50,000	July 2009 through June 2010	Partially fund implementation of the Sandy River Basin Short-Term Restoration Strategy, and partially fund stream restoration measures in the Salmon River and the Salmon River subbasin.
Grant Agreement 30001899	Freshwater Trust	$50,000	July 2010 through June 2011	Partially fund design and construction of habitat restoration projects to reconnect isolated habitat, restore habitat complexity, and monitor project impacts in the Salmon River subbasin.
Grant Agreement 32000592	Freshwater Trust	$50,000	July 2011 through June 2012	Fund design and construction of habitat restoration projects to reconnect isolated habitat and restore habitat complexity in the Salmon River subbasin.
Grant Agreement 30002765	Freshwater Trust	$70,780	Summer of 2012	Fund the purchase and installation of a culvert on side-channel 18 of the Salmon River.
Grant Agreement 32001021	Freshwater Trust	$127,500	July 2014 through June 2015	Fund the design and construction of habitat restoration projects on the Salmon River and Still Creek.
Intergovernmental Agreement 30004381	Oregon Department of Fish and Wildlife	$12,105	July 2014 through June 2015	Complete a scale analysis of juvenile Coho Salmon and steelhead smolts to determine age structure and freshwater productivity.

Table 10. Past projects funded through the HCP Habitat Fund

Number	Project partner	Amount	Duration	Purpose
Grant Agreement 32001148	Freshwater Trust	$100,000	July 2015 through June 2016	Fund the design and construction of habitat restoration projects in Still Creek.
30005230	Freshwater Trust	$96,458	July 2016 through June 2017	Fund the design and construction of habitat restoration projects on the Salmon River and Still Creek.
32001339	Sandy River Basin Watershed Council	$145,000	July 2016 through June 2017	Restoration work on the upper Sandy River.
Intergovernmental Agreement 30004381	Oregon Department of Fish and Wildlife	$6,385	July 2016 through June 2017	Complete a scale analysis of juvenile Coho Salmon and steelhead smolts to determine age structure and freshwater productivity.
32001489	Freshwater Trust	$148,398	July 2017 through June 2018	Restoration work on the Salmon River and Still Creek.
32001768	Freshwater Trust	$150,000	July 2018 through June 2019	Restoration work in the Salmon River and Lost Creek.
30006124	Oregon Department of Fish and Wildlife	$7,485	July 2018 through June 2019	Scale analysis of juvenile Coho Salmon and steelhead smolts to determine age structure and freshwater productivity.
32001884	Freshwater Trust	$125,000	July 2019 through June 2020	Restoration work in the Salmon River and the Zigzag River.
32001963	Sandy River Watershed Council	$125,000	July 2019 through June 2020	Restoration work on Sandy–Salmon confluence.
30006124	Oregon Department of Fish and Wildlife	$7,483	July 2019 through June 2020	Scale analysis.
32002118	Freshwater Trust	$150,000	July 2020 through June 2021	Restoration work on the Salmon River, Lost Creek, and the main Sandy River.
30006124	Oregon Department of Fish and Wildlife	$7,483	July 2020 through June 2021	Scale analysis.
Subtotal for past projects		$1,454,077		

Planned Accomplishments through June 2022

PWB has approved two projects from Sandy River Basin Partners to be implemented between July 1, 2021 and June 30, 2022. PWB intends to provide funding to The Freshwater Trust to support construction of habitat restoration projects on the upper Sandy River. PWB will also continue to fund ODFW for scale analysis associated with Sandy Basin smolt trapping. Table 11 shows the projects planned to be funded through the HCP Habitat Fund.

Table 11. Planned projects to be funded through the HCP Habitat Fund

Number	Project Partner	Amount	Duration	Purpose
Not yet assigned	Freshwater Trust	$200,000	July 2021 through June 2022	Restoration work for the upper Sandy River.
30006124	Oregon Department of Fish and Wildlife Service	$7,483	July 2021 through June 30, 2022	Scale analysis.
Subtotal for planned projects		$207,483		

Table 12. Summary of all measures

This table includes all of the HCP measures. Measures that are not relevant to this reporting year are shaded with a gray background. The Status column shows the activity for the measure in 2020 (HCP Year 11), whether the measure has been completed or removed from the HCP, and other relevant information. If the Status column is blank, the measure is yet to be implemented. In some cases, the status description includes a reference to an appendix where more detailed measure information is available.

Bull Run Measures—Compliance

#	Measure	Measurable habitat objective	Compliance monitoring	Years	Status
F-1	**Minimum Instream Flow, Normal Water Years**	Provide instream flows	Record hourly flows at USGS Gage No. 1414000	2010–59	Ongoing measure. Measure was in full compliance for 2020.
F-2	**Minimum Instream Flows, Water Years with Critical Seasons**	Provide instream flows	Record hourly flows at USGS Gage No. 1414000	2010–59	Ongoing measure. Measure was in full compliance for 2020.
F-3	**Flow Downramping**	Maintain downramping rate at or below 2 inches/hour	Record hourly flows at USGS Gage No. 14140000	2010–59	Ongoing measure. Measure was in full compliance in 2020.
F-4	**Little Sandy Flow Agreement**	Avoid conflicts with natural instream flows	Document completion of flow agreement	2010–14	Measure was completed in 2014. Confirmed by NMFS December 4, 2014 (see Appendix H, Item 9).
T-1	**Pre-infrastructure Temperature Management**	Maintain water temperatures at or below 21°C at Larson's Bridge	Record water temperatures hourly for the lower Bull Run River and Little Sandy River	2010–13	Measure was in full compliance for 2010–2013. Measure was completed in 2013.

Bull Run Measures—Compliance

#	Measure	Measurable habitat objective	Compliance monitoring	Years	Status
T-2	**Post-infrastructure Temperature Management**	Maintain water temperatures at their natural thermal potential	Record water temperatures hourly for the lower Bull Run River and Little Sandy River	2014–59	Ongoing measure. All infrastructure changes for the measure were completed by 2014. PWB did not meet some water temperature targets in 2020.
P-1	**Walker Creek Fish Passage**	Provide year-round upstream and downstream passage for steelhead and Coho	Document passage conditions compared with NMFS design criteria	2010–14	Measure was completed in 2010.
R-1	**Reservoir Operations**	Avoid or minimize mortality of Cutthroat and Rainbow Trout	Document reservoir surface elevations	2010–59	Ongoing measure. Measure was in full compliance for 2020.
R-2	**Cutthroat Trout Rescue**	Prevent mortality of Cutthroat Trout in spillway canal	Document any fish mortality that occurs in the canal and/or during handling (prior to release)	2010–59	Measure was implemented from 2010–2012. Benefits to Cutthroat Trout were very low. The measure was cancelled in 2013. Change authorized by NMFS, April 26, 2013 (see Appendix H, Item 7 in the 2013 report).
R-3	**Reed Canarygrass Removal**	Improve one-third acre of habitat for western toad and red-legged frog through annual removal of reed canarygrass	Provide photo documentation of sites after reed canarygrass removal	2010–59	Ongoing measure. Measure was altered in 2020 based on monitoring data. Appendix D summarizes 2020 monitoring conducted to determine whether the measure is having the desired outcomes.

Bull Run Measures—Compliance

#	Measure	Measurable habitat objective	Compliance monitoring	Years	Status
H-1	**Spawning Gravel Placement**	Supply spawning gravel in amounts equivalent to natural accumulation	Survey the lower Bull Run River (RM 0.0–RM 6.0) annually in Years 1–10 and every five years thereafter Document the amount of gravel placed, the placement locations, and amount of gravel usable for spawning by fish in annual report as described in Appendix F of the HCP	2010–59	Ongoing measure. Measure was in full compliance for 2020.
H-2	**Riparian Land Protection**	Preserve the riparian forest on City land along the lower Bull Run River	Survey riparian forest condition during annual spawning and gravel surveys; document results in annual report	2010–59	Ongoing measure. Measure was in full compliance for 2020.
O&M-1	**Bull Run Infrastructure Operations and Maintenance**	Avoid or minimize the effects of operations and maintenance activities on covered lands in the Bull Run Watershed	Document any releases of sediment or debris to the reservoirs, the lower Bull Run River, or any tributary streams Document changes in stormwater facilities at Sandy River Station, if needed Document tree planting and success of revegetation efforts	2010–59	Ongoing measure. Measure was in full compliance for 2020.
O&M-2	**Bull Run Spill Prevention**	Avoid or minimize effects of spills from water supply operations on covered species in the Bull Run River and the Sandy River below the confluence with the Bull Run	Document any spills to the reservoirs, the lower Bull Run River, or to any tributary streams	2010–59	Ongoing measure. Measure was in full compliance for 2020.

Offsite Measures—Compliance

#	Measure	Measurable habitat objective	Compliance monitoring	Years	Status
Riparian easements and improvements					
H-11	**Sandy 1 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 11 acres (with 100-foot buffer widths) within 15 years	Complete an aerial photograph analysis or site survey to determine whether planting is needed Repeat the analysis every five years for the term of the HCP to verify that initial planting has succeeded and/or if replanting is warranted Document date riparian easement is completed and when site potential forest is established	2010–14	Measure will not be implemented. Acreage target was moved to Measure H-12 Sandy 2 Riparian Easement and Improvement. Change authorized by NMFS on January 5, 2012 (see Appendix G, Item 5 in the 2012 report).
H-12	**Sandy 2 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 62 acres (with 100-foot buffer widths) within 15 years	Same as above	2010–14	Measure was completed in 2014. All easement acreage targets have been met for the lower Sandy River Basin. Canopy cover monitoring is ongoing.
H-13	**Gordon 1A and 1B Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 78 acres within 15 years of establishment of easement Fifteen acres are added to this measure to compensate for the acreage anticipated from Boulder 1 Riparian Easement and Improvement (H-22)	Same as above	2010–14	Twenty-three acres of easement area obtained in Gordon Creek (20 acres in 2012; three acres in 2011). 70 acres moved to Sandy 2 Riparian Easement and Improvement. Change authorized by NMFS on September 25, 2012 (see Appendix G, Item 6 in the 2012 report). Measure was completed in 2014. All easement acreage targets have been met for the lower Sandy River Basin. Canopy cover monitoring is ongoing.

Offsite Measures—Compliance

#	Measure	Measurable habitat objective	Compliance monitoring	Years	Status
H-14	**Sandy 3 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately seven acres (with 100-foot buffer widths) within 15 years of establishment of easement	Same as above	2020–24	Measure was completed in 2012. Canopy cover monitoring is ongoing.
H-15	**Cedar 2 and 3 Riparian Easement and Improvement**	Establish riparian forest of >70% site potential trees (by canopy cover) for approximately 49 acres (with 100-foot buffer widths) within 15 years of establishment of easement	Same as above	2015–19	Twenty-five acres of easement area obtained in Cedar Creek in 2015. Measure was completed in 2015. Canopy cover monitoring is ongoing.
H-16	**Alder 1A and 2 Riparian Easement and Improvement**	Establish riparian forest of >70% site potential trees (by canopy cover) for approximately 43 acres (with 100-foot buffer widths) within 15 years of establishment of easement	Same as above	2010–14	PWB is not pursuing easement acreage in Alder Creek due to unwillingness of private landowners to participate in program. PWB is obtaining easements in reaches Sandy 7 and 8 to compensate for the acreage that could not be obtained in Alder Creek. Change authorized by NMFS, July 12, 2013, and February 13, 2017 (see Appendix I, Items 11 and 12 in the 2017 report).

Offsite Measures—Compliance

#	Measure	Measurable habitat objective	Compliance monitoring	Years	Status
	Sandy 7 Riparian Easement and Improvement	Establish riparian forest of ≥70% site potential trees (by canopy cover, with 100-foot buffer widths) within 15 years of establishment of easement	Same as above		Twenty-nine acres of easement acquired in 2017. Change authorized by NMFS on February 13, 2017. Permission given to acquire easements on Sandy 7, 8 in lieu of Salmon 1, 2, 3 (see Appendix I, Item 12 in the 2017 report).
H-18	**Sandy 8 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 25 acres (with 100-foot buffer widths) within 15 years of establishment of easement	Same as above	2020–24	Nineteen acres of easement from two landowners acquired in 2019. Easement acres in lieu of Measure H-16. Canopy cover monitoring is ongoing.
H-19	**Salmon 1 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 23 acres (with 100-foot buffer widths) within 15 years of establishment of easement	Same as above	2015–19	This measure will not be implemented. PWB is pursuing easements in Sandy 7, 8 to compensate for the acreage that could not be obtained in Salmon 1, 2, or 3. Change authorized by NMFS, February 13, 2017 (see Appendix I, Item 12, in the 2017 report).
H-20	**Salmon 2 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 36 acres (with 100-foot buffer widths) within 15 years. of establishment of easement	Same as above	2020–24	Measure will not be implemented. PWB acquired enough easement area through 2019. The HCP easement program accomplishments are described in Appendix A of the 2019 Annual Compliance Report.

Offsite Measures—Compliance

#	Measure	Measurable habitat objective	Compliance monitoring	Years	Status
H-21	**Salmon 3 Riparian Easement and Improvement**	Establish riparian forest of ≥70% site potential trees (by canopy cover) for approximately 12 acres (with 100-foot buffer widths) within 15 years of establishment of easement	Same as above	2020–24	Measure will not be implemented. PWB acquired enough easement area through 2019. The HCP easement program accomplishments are described in Appendix A of the 2019 Annual Compliance Report.
H-22	**Boulder 1 Riparian Easement and Improvement**	Establish riparian forest of >70% site potential trees (by canopy cover) for approximately 15 acres (with 100-foot buffer widths) within 15 years of establishment of easement	Same as above	2010–14	This measure will not be implemented. PWB has obtained easements in Gordon Creek and the lower Sandy River to compensate for the acreage that could not be obtained in Boulder Creek. Change authorized by NMFS, May 11, 2011 (see Appendix F, Item 1, in the 2011 report).
H-28	**Zigzag 1A/1B Riparian Easement and Improvement**	Establish riparian forest of >70% site potential trees (by canopy cover) for approximately 12 acres (with 100-foot buffer widths) within 15 years of establishment of easement	Same as above	2020–24	Measure will not be implemented. PWB acquired enough easement area through 2019. The HCP easement program accomplishments are described in Appendix A of the 2019 Annual Compliance Report.

Offsite Measures—Compliance					
#	**Measure**	**Measurable habitat objective**	**Compliance monitoring**	**Years**	**Status**
H-23	**Salmon 2 Miller Quarry Acquisition**	Negotiate a sales agreement for the Miller Quarry property	Document purchase of the site in annual report Complete an aerial photograph analysis or site survey to determine whether planting is needed Repeat the analysis every five years for the term of the HCP to verify that initial planting has succeeded and/or if replanting is warranted Document date riparian easement is completed and when site potential forest is established	2015–19	PWB will not implement the measure due to an unwilling landowner. There were small projected habitat and fish benefits as described in the HCP. PWB will make up for the loss of projected habitat and fish benefits from this measure with the implementation of other conservation measures. PWB's plan for this is described in detail in Appendix A of the 2019 Annual Compliance Report.
H-24	**Salmon 2 Miller Quarry Restoration**	Establish riparian forest of >70% site potential trees (by canopy cover) for approximately 40 acres (with 100-foot buffer widths) within 15 years of acquisition	Document purchase of the site in annual report Complete an aerial photograph analysis or site survey to determine whether planting is needed Repeat the analysis every five years for the term of the HCP to verify that initial planting has succeeded and/or if replanting is warranted Document date riparian easement is completed and when site potential forest is established	2015–19	See status description for Measure H-23.

Offsite Measures—Compliance					
#	**Measure**	**Measurable habitat objective**	**Compliance monitoring**	**Years**	**Status**
Water rights					
F-5	**Cedar Creek Purchase Water Rights**	During HCP Years 1–10, purchase approximately 50% of the current surface water rights that affect summer flows	Document the rights purchased and the estimated amount of additional flow for fish	2010–19	Measure cannot be implemented due to unwilling seller. There were small projected habitat and fish benefits as described in the HCP. PWB will make up for the loss of habitat and fish benefits from this measure with the implementation of other conservation measures. PWB's plan for this is described in Appendix A of the 2019 Annual Compliance Report.
Fish passage					
P-2	**Alder 1 Fish Passage**	Provide year-round upstream and downstream passage for steelhead	Document passage conditions compared with NMFS design criteria once every three years after project implementation	2010–14	Measure was completed in 2013.
P-3	**Alder 1A Fish Passage**	Provide upstream and downstream passage for native fish during the months of water diversion operation	Same as above	2010–14	Measure was completed in 2014.
P-4	**Cedar Creek 1 Fish Passage**	Provide up to $3.7 million dollars to fund fish passage improvements on Cedar Creek	Same as above	2010–14	Measure was completed in 2014.

Offsite Measures—Compliance

#	Measure	Measurable habitat objective	Compliance monitoring	Years	Status
Carcass placement					
H-25	**Salmon 2 Carcass Placement**	Place 1,800 salmon carcasses in one season	Document number of carcasses, release sites, and year of implementation	2015–19	Measure was completed in the Zigzag and upper Sandy Rivers in 2013. Change authorized by NMFS, December 3, 2013 (see Appendix H, Item 8 in the 2013 report). Measure was completed early.
H-29	**Zigzag 1A, 1B, and 1C Carcass Placement**	Place 1,800 salmon carcasses in one season	Same as above	2020–24	Measure was completed in the Zigzag and upper Sandy Rivers in 2014. Change authorized by NMFS, December 3, 2013 (see Appendix H, Item 8 in the 2013 report). Measure was completed early.
Large wood					
H-3	**Little Sandy 1 and 2 LW Placement**	Place 50 key pieces of LW and achieve 80% of predicted woody debris levels within 15 years of placement	Monitor number of pieces of wood in the stream as described in HCP Appendix F	2015–19	Measure was completed in 2014, earlier than specified in the HCP.
H-4	**Sandy 2 Log Jams**	Place two engineered log jams and other large wood in reach Sandy 2, totaling 530 pieces. Increase off-channel habitat by 8,164 square feet. 80% of predicted woody debris levels will be attained within 15 years of placement	Same as above	2015–19	Measure was completed in 2018. Measure incorporates benefit increases to offset those of canceled Measure H-9. Change authorized by NMFS, April 14, 2015 (see Appendix H, Item 10 in the 2015 report).

Offsite Measures—Compliance					
#	**Measure**	**Measurable habitat objective**	**Compliance monitoring**	**Years**	**Status**
H-5	**Gordon 1A and 1B LW Placement**	Place 300 key pieces of LW in reaches Gordon 1A and 1B and achieve 80% of predicted woody debris levels within 15 years of placement An additional 65 key pieces of LW will be placed in reaches Gordon 1A and 1B to compensate for the wood that was not placed in Boulder 0 and 1	Same as above	2010–14	Measure was completed in 2012.
H-6	**Trout 1A LW Placement**	Place 25 key pieces of LW and achieve 80% of predicted woody debris levels within 15 years of placement	Same as above	2010–14	Measure was completed in 2012.
H-7	**Trout 2A LW Placement**	Place 20 key pieces of LW in reach Trout 2A and achieve 80% of predicted woody debris levels within 15 years of placement	Same as above	2010–14	Measure will not be implemented. Large wood placements planned for this measure have been added to Trout 1A LW Placement project instead. Change authorized by NMFS, March 15, 2012 (see Appendix G, Item 4 in the 2012 report).
H-17	**Cedar 2 and 3 LW Placement**	Place 600 key pieces of LW in reaches Cedar 2 and 3 and achieve 80% of predicted woody debris levels within 15 years of placement	Same as above	2015–19	Measure was completed in 2016. Only 470 pieces of LW were placed because of limited landowner permissions.

Offsite Measures—Compliance					
#	**Measure**	**Measurable habitat objective**	**Compliance monitoring**	**Years**	**Status**
H-26	**Boulder 0 and 1 LW Placement**	Place 65 key pieces of LW in reaches Boulder 0 and 1 and achieve 80% of predicted woody debris levels within 15 years of placement	Same as above	2010–14	Measure will not be implemented. Large wood placements planned for this measure have been added to Gordon 1A and 1B LW Placement instead. Change authorized by NMFS, August 16, 2011 (see Appendix F, Item 2 in the 2011 report).
Channel restoration					
H-8	**Sandy 1 Reestablishment of River Mouth**	Create one additional mile of stream by reconnecting with original river mouth	Document reestablishment of the historical Sandy River mouth	2015–19	The measure was completed in 2013, approximately five years ahead of schedule.
H-9	**Sandy 1 Channel Reconstruction**	Open one-third river miles of side-channel habitat Place 25 logs in side channel	Tag all side-channel logs at the time of placement for later identification Once every three years, resurvey the stream to document seasonal flooding of the side-channel habitat and determine how many pieces of LW are still within the side channel	2015–19	Measure will not be implemented. Large wood placements planned for this measure have been added to Measure H-4 Sandy 2 Log Jams instead. Change authorized by NMFS, April 14, 2015 (see Appendix H, Item 10 in the 2015 compliance report).
H-10	**Sandy 1 Turtle Survey and Relocation**	Avoid direct impacts to western painted turtles and northwestern pond turtles	Document surveys of potential turtle habitat. Document all turtle relocations (species, number, locations, and dates) Note: Measure H-10 is only necessary for projects conducted in the Sandy River delta.	2015–19	Measure was completed in 2013 in conjunction with Measure H-8.

Offsite Measures—Compliance

#	Measure	Measurable habitat objective	Compliance monitoring	Years	Status
H-27	**Zigzag 1A Channel Design**	Open or improve one mile of side channel habitat for steelhead, Coho, and spring Chinook Place 270 pieces of LW in reach Zigzag 1A	Tag all pieces of LW at the time of placement for later identification Once every three years, resurvey the stream to determine how many pieces of LW are still within the side channel	2020–24	Measure was implemented in 2019. Modifications were made to the project in 2020.
Terrestrial wildlife habitat conservation					
W-1	**Minimize Impacts to Spotted Owls**	Avoid disturbance of active nesting habitat	Survey protocols for owls, eagles, and fishers will be developed with the appropriate agencies, as necessary.	2010–59	Ongoing measure. Measure was in full compliance in 2020.
W-2	**Minimize Impacts to Bald Eagles**	Avoid disturbance of active winter night roosts or nests	Survey protocols for owls, eagles, and fishers will be developed with the appropriate agencies, as necessary.	2010–59	Ongoing measure. Measure was in full compliance in 2020.
W-3	**Minimize Impacts to Fishers**	Avoid disturbance of fisher habitat	Survey protocols for owls, eagles, and fishers will be developed with the appropriate agencies, as necessary.	2010–59	Ongoing measure. Measure was in full compliance in 2020.

Monitoring for Clean Water Act Section 401 Certification

Topic	Monitoring protocol and analysis	Results reporting	Duration	Status and report location
Monitoring for CWA Section 401 Certification	Monitor for five required water-quality parameters	Include with annual compliance report	For the first five years of operation of the modified Bull Run Dam 2 Tower	Baseline data collection period was August 2012–December 2013. Monitoring occurred through 2018, as directed by ODEQ. Monitoring for lower Bull Run River water temperatures continues as described by Measure T-2.

Offsite Measures—Effectiveness					
#	**Measure**	**Measurable habitat objective**	**Effectiveness monitoring**	**Years**	**Status**
Large wood					
H-5	**Gordon 1A and 1B LW Placement**	Achieve 80% of predicted increase in pieces of LW within 15 years of implementation	Conduct habitat surveys per monitoring protocol	2010–14	Measure was completed in 2013. Effectiveness monitoring will continue through 2025. See Appendix A.
H-6	**Trout 1A LW Placement**	Achieve 80% of predicted increase in pieces of LW within 15 years of implementation	Conduct habitat surveys per monitoring protocol	2010–14	Measure was completed in 2013. Effectiveness monitoring will continue through 2025. See Appendix A.
H-7	**Trout 2A LW Placement**	Achieve 80% of predicted increase in pieces of LW within 15 years of implementation	Conduct habitat surveys per monitoring protocol	2010–14	Measure will not be implemented and associated effectiveness monitoring has been cancelled. Change approved by NMFS March 15, 2012 (see Appendix G, Item 4 in the 2012 report).
H-3	**Little Sandy 1 and 2 LW Placement**	Achieve 80% of predicted increase in pieces of LW within 15 years of implementation Achieve 80% of predicted increase in backwater pools, pools, and pool-tail habitat within 15 years of implementation Achieve 80% of predicted increase in percentage of total habitat that is large-cobble riffles within 15 years of implementation	Conduct habitat surveys per monitoring protocol	2015–19	Measure was completed in 2014. Effectiveness monitoring will continue through 2027.

Offsite Measures—Effectiveness					
#	**Measure**	**Measurable habitat objective**	**Effectiveness monitoring**	**Years**	**Status**
H-26	**Boulder 0 and 1 LW Placement**	Achieve 80% of predicted increase in pieces of LW within 15 years of implementation	Conduct habitat surveys per monitoring protocol	2010–15	Measure will not be implemented and associated effectiveness monitoring has been cancelled. Change authorized by NMFS, August 16, 2011 (see Appendix F, Item 2 in the 2011 report).
H-4	**Sandy 2 Log Jam Placements**	Achieve 80% of predicted increase in pieces of LW within 15 years of implementation Achieve 80% of predicted increase in off-channel habitat within 15 years of implementation	Conduct habitat surveys per monitoring protocol	2015–19	Measure was completed in 2018. Effectiveness monitoring was initiated in 2015 and will continue through 2031.
H-17	**Cedar 2 and 3 LW Placement**	Achieve 80% of predicted increase in pieces of LW within 15 years of implementation Achieve 80% of predicted increase in percentage of off-channel, beaver pond and pool habitat within 15 years of implementation	Conduct habitat surveys per monitoring protocol	2015–19	Measure completed in 2016. Effectiveness monitoring was initiated in 2014 and will continue through 2029.
Channel restoration					
H-9	**Sandy 1 Channel Reconstruction**	Achieve 80% of predicted increase in percentage of off-channel habitat within 15 years of implementation	Every three years, resurvey the site to determine whether the gradient control structure is maintaining flow in the side channel and the river	2015–19	Measure will not be implemented. Associated effective monitoring has been cancelled. Fish production anticipated from this measure will be offset by enhanced habitat restoration efforts in Sandy 2. Change authorized by NMFS, April 14, 2015 (see Appendix H, Item 10, in the 2015 compliance report).

Offsite Measures—Effectiveness					
#	**Measure**	**Measurable habitat objective**	**Effectiveness monitoring**	**Years**	**Status**
H-24	**Salmon 2 Miller Quarry Restoration**	Achieve 80% of predicted improvements in off-channel habitat within 15 years of implementation	Once every three years after measure implementation, survey opened floodplain area and side channels	2020–24	Measure will not be implemented. See Status description for Measure H-23.
H-27	**Zigzag 1A Channel Design**	Achieve 80% of predicted habitat improvements within 15 years of implementation	Conduct habitat surveys per monitoring protocol	2020–24	Measure was completed in 2019 and modified in 2020. Effectiveness monitoring was initiated in 2018. Post-construction monitoring was initiated in 2020 and will continue through 2033.
H-30	**Habitat Fund**	PWB will provide money to create a Habitat Fund of $9 million to contribute to large-scale partnership projects and to implement additional projects for adaptive management, if necessary	Determined through measure effectiveness monitoring	2010–59	Ongoing measure. Measure was in full compliance in 2020.

Research

Topic	Research protocol and analysis	Results reporting	Years	Status and report location
Spawning Gravel Placement	Change in gravel from baseline each year, trends over time, using t-tests and linear regression	Include with annual compliance report, Years 2010–2019 and then every fifth year until 2049.	2010–59	Measure was in full compliance in 2020. No data were collected. See previous compliance reports.
Spawning Gravel Scour	Change in bed elevation, depth of scour, percentage of redds with significant scour	Monitoring starts HCP Year 5; reporting in Year 2016	2015–19	Measure was in full compliance in 2020. No data were collected. See previous compliance reports.
Total Dissolved Gas	Exceedence of 110% TDG saturation, rate of TDG dissipation downstream of monitoring. Regression analysis, possibly modeling	Include with annual compliance report	2010–59	Measure was in full compliance in 2020. No data were collected. See previous compliance reports.
BR Adult Chinook Population	Survey, sampling, linear regression	Include with annual compliance report	2010–59	Measure was in full compliance in 2020. See Appendix B.
Sandy River Basin Smolt Monitoring	Mark recapture study, various analyses methods	Include with annual compliance report	2010–59	Measure was in full compliance in 2020. See Appendix C.

Appendix A

Bull Run HCP Effectiveness Monitoring Report

Effectiveness Monitoring for Offsite In-Channel Conservation Measures

July 2021

Burke Strobel
City of Portland Water Bureau

Contents

Tables

Figures

1. Summary

Through 2020, the City of Portland Water Bureau (PWB) implemented seven offsite in-channel conservation measures. Those projects require effectiveness monitoring, which occurs on different schedules for each conservation measure.

PWB was in full compliance with its Habitat Conservation Plan obligations in 2020 with regard to effectiveness monitoring for offsite in-channel conservation measures. Fish habitat surveys were conducted for two offsite measures: H-17 Cedar 2/3 LW Placement and H-27 Zigzag 1A Channel Design.

This appendix summarizes the results of the 2020 surveys. 2020 was the second year of posttreatment monitoring in Cedar Creek and the first year of post-treatment monitoring in the Zigzag River.

2. Introduction

PWB committed through its Bull Run Water Supply Habitat Conservation Plan (HCP; Portland Water Bureau 2008) to implement in-channel fish habitat enhancement measures at offsite locations. Offsite locations are those not in the Bull Run Watershed but located in other Sandy River Basin streams. These include various tributaries in the basin, portions of the main stem of the Sandy River, and the Little Sandy River. In-channel measures are being completed within the normal high-flow channel of a stream. In-channel measures do not include efforts to improve the riparian zone.

One or more measurable habitat objectives are associated with each offsite in-channel measure. The effectiveness of PWB's efforts to improve fish habitat at these offsite locations is being evaluated by measuring the habitat attributes associated with these objectives and determining how closely the habitat attributes approach or surpass the value of the respective objective. A total of seven offsite in-channel measures have been implemented that have associated effectiveness monitoring. These measures, when they were implemented, and when effectiveness monitoring will be completed are summarized in Table 1.

Table 1. HCP offsite instream habitat measures with associated effectiveness monitoring[a]

Measure	Year of construction	Last year of monitoring
H-4 Sandy 2 Engineered Log Jams	2017/18	2031
H-5 Gordon 1A/1B LW Placement	2012	2025
H-6 Trout 1A LW Placement	2012	2025
H-3 Little Sandy 1/2 LW Placement	2014	2027

Table 1. HCP offsite instream habitat measures with associated effectiveness monitoring[a]

Measure	Year of construction	Last year of monitoring
H-17 Cedar 2/3 LW Placement	2016	2029
H-4 Sandy 1/2 Log Jams	2017–18	2031
H-27 Zigzag 1A Channel Design	2019	2032

[a] Some offsite habitat measures (H-7 Trout 2A LW Placement, H-9 Sandy 1 Channel Reconstruction, and H-26 Boulder 0/1 LW Placement) will not be implemented. Other measures will be completed to compensate for the habitat benefits of the original measures. These changes have been authorized by NMFS and are explained in Table 12 of the 2018 Annual Compliance Plan.

The collection of baseline data for offsite in-channel HCP measures was completed in 2019. In 2020, posttreatment data were collected in Cedar Creek and the Zigzag River.

This appendix describes the effectiveness monitoring protocols and results to date for the in-channel measures completed or to be conducted in the Sandy River, Gordon Creek, Trout Creek, and Zigzag River. These measures involve placing large wood and creating log jams to influence stream morphological features such as pools and riffles and to accumulate spawning gravel.

3. Measurable Objectives

Figure 1. PWB and USFS personnel inspect a side channel inlet at Zigzag River, where artificial confinement was removed and large woody debris was placed

The offsite in-channel measures discussed in Chapter 7 of the HCP and their predicted effects on habitat attributes have been evaluated using the Ecosystem Diagnostic and Treatment (EDT) model (City of Portland and Mobrand Biometrics 2004). The anticipated benefits of these measures are summarized by reach and by the predicted net change in the attributes' respective metrics listed in Table 2. The net attribute changes in Table 2 include only those benefits expected to be derived from the proposed in-channel restoration projects. Other measures, such as riparian easements, may occur in and have benefits for the same reaches, but these benefits are expected to occur over timescales that are longer than the timescales for the offsite in-channel measures. The benefits of other measures are not part of the scope of this research.

The net changes predicted in Table 2 represent measurable habitat objectives created for each individual reach. The monitoring objective is to document how effectively the offsite in-channel measures accomplish measurable habitat objectives. PWB's working hypothesis for effectiveness monitoring of these measures is that at least 80 percent of the projected changes in the key habitat attributes (preproject versus postproject conditions) will occur in each affected stream reach.

PWB has committed to a performance level of 80 percent of projected changes (instead of 100 percent) because there will be a high degree of natural variation year to year and site to site. The natural variation will be further compounded by the error associated with measuring habitat variables in the field. Given this high level of variation, it would not be possible statistically to detect a difference between a 100 percent change in a habitat variable and a much smaller change. PWB chose 80 percent as a minimum performance standard. If that level of habitat response is not met, additional actions may be required, and PWB will follow the adaptive management program described in Chapter 9 of the HCP.

Table 2. Attributes and measurable habitat objectives in reaches affected by in-channel measures and surveyed in 2019

	Measurable habitat objective (80% of net change in metric)		
Attribute	**Metric**	**Net change**	**Reach**
Large woody debris	Number of pieces per channel width	326%	Cedar 2
Large woody debris	Number of pieces per channel width	–40%	Cedar 3
Beaver ponds	Percentage of reach (by surface area) that comprises beaver ponds	7%	
Pool habitat	Percentage of reach (by surface area) that comprises pool habitat	13%	
Large woody debris	Number of pieces per channel width	291%	Zigzag 1A
Artificial confinement	% length artificially confined	–38%	
Small-cobble riffle	Percentage of reach (by surface area) that comprises small-cobble riffles	4%	
Pool habitat	Percentage of reach (by surface area) that comprises pool habitat	27%	
Pool tails	Percentage of reach (by surface area) that comprises pool tails	15%	

4. Key Questions and Hypothesis

One key question and its related null hypothesis (H_o) will be answered by the offsite monitoring protocol:

Question: Did the implementation of the restoration projects result in the changes to the monitored habitat attributes that were predicted by the EDT assessment?

> H_o: The difference between the mean of baseline values and the mean of posttreatment values in treatment reaches will not be significantly less than the difference predicted by the EDT assessment.

In order to make this comparison, the baseline values in the EDT model will be updated by collecting at least two years of pretreatment data on all the habitat attributes that are predicted to change significantly (summarized in Table 2). The differences in habitat conditions between the actual pretreatment and posttreatment data will be used to determine whether the projected EDT fish benefits, as expressed in the HCP, are realized.

The comparison of the observed changes in monitored habitat attributes to measurable habitat objectives will be analyzed both numerically and statistically (using a 95 percent level of confidence). The numeric test will simply determine whether the mean of post-treatment values is at least 80 percent of the target values. The measurable habitat objective for each offsite in-channel measure response variable was set at 80 percent of the projected change to account for the fact that each variable is expected to show a large degree of variation. The statistical test will assign a level of confidence to each of the pretreatment to posttreatment comparisons and determine the power of the statistical test to detect significant shortfalls. Having a level of confidence associated with each comparison will be helpful during the adaptive management process should any posttreatment value fall short of the measurable habitat objective.

5. Monitoring Design

5.1 Study Design

PWB uses a Before-After with Control-Impact (BACI) study design to monitor the effects of the HCP offsite in-stream mitigation projects (Roni et al., 2005). Control reaches upstream of the treated reaches will be surveyed in addition to the treated reaches, as indicated in Table 3. Control reaches will be entire upstream reaches delineated for EDT or one mile in length, whichever is less, to minimize survey effort and yet provide a representative length of stream. In cases in which a treated reach is very long (more than five miles), and the treatment is restricted to the lower portion of the reach, the upstream portion of the same reach will serve as a control. This approach is used because the further upstream a control reach is, the less representative it probably is of the habitat in which treatment occurred. PWB will use attribute values for the entire EDT reach (including the control reach segment) as the treatment reach values and just use attribute values from the control reach segment as the respective control reach values.

Table 3. Paired treatment and control reaches in streams surveyed in 2020

Watershed	Treated reaches	Control reaches
Cedar Creek	Cedar 2	Cedar 4
Cedar Creek	Cedar 3	Cedar 4
Zigzag River	Zigzag 1A	Zigzag 1B (lower 1.6 miles)

5.2 Spatial Scale

The measurable habitat objectives (in Table 2) are reach-scale objectives. The survey protocol is to collect data at both the habitat-unit and reach scales, but all the data are used to derive reach-scale assessments of habitat condition. Reaches vary in length, so all attribute values are normalized by either channel length or surface area.

5.3 Replication/Duration

Most habitat attributes are naturally variable from year to year. For example, if wood is added to a reach but high flows do not occur the following winter, there may be no resultant formation of pools. In other years, winter high flows may fill in some pools and create new ones elsewhere. For this reason, before (baseline) and after (posttreatment) data will be replicated over time.

Surveys are conducted in the summer or early fall when flows are low, and the stream channels are most navigable. Two to four pretreatment surveys and five posttreatment surveys are conducted. Pretreatment surveys were conducted annually prior to treatment. Posttreatment surveys are conducted at three-year intervals beginning the year after treatment and continuing for 12 additional years, for a total of five post-treatment surveys.

5.4 Variables

The habitat attributes used by EDT to evaluate restoration alternatives are derived from the data types summarized below. All data types are information collected during stream surveys. However, not all attributes are used to evaluate the effectiveness of the offsite in-channel measures.

- Reach-scale data

- Active channel (bankfull)[1] width (feet)
- Gradient (percent)
- Total surface area of off-channel habitat (estimated visually, in square feet)

- Habitat unit-scale data
  - Habitat type (pool, backwater pool, beaver pond, glide, small-cobble riffle, large-cobble riffle)
  - Average length (feet)
  - Average width (feet)
  - Amount of pool tail-out habitat (data collected in pools only; percentage of total surface area that is at the downstream end of the pool and flowing with velocities comparable to those of neighboring glides and riffles)
  - In-channel wood (number of pieces greater than four inches in diameter and greater than seven feet long in the active channel of the habitat unit)
  - Fine sediment in spawning habitat types (percentage surface area of gravel patches in small-cobble riffles, pool tail-outs, glides)
  - Embeddedness in spawning habitat types (percent of the vertical dimension of surface cobbles and large gravel that is buried in fine sediment in gravel patches in small-cobble riffles, pool tail-outs, glides)

These data enable PWB to evaluate how well it has met most of the measurable habitat objectives summarized in Table 1. The percentage of fine sediment in spawning gravels may show too much in-reach variability to allow the detection of the anticipated change.

5.5 Sampling Scheme

Habitat attributes in both treatment and control reaches are monitored using a modified Hankin and Reeves-type stratified systematic inventory of stream channel characteristics (Hankin and Reeves 1988).

Hankin and Reeves-type protocols involve two main sources of error. PWB adjusts its protocols to reduce these sources of error. The first source of error stems from the strategy of estimating habitat dimensions throughout a reach and then using a subset of measurements to correct the estimates. These corrections are associated with a range of variability, which decreases confidence in the final result. To maximize the statistical power of the monitoring data analysis, given the small sample size of pretreatment data, all habitat unit dimensions are measured. The second source of error is measurement error, which can accumulate over the length of a reach. PWB reduces this form of error by using normalized data (percentages) for habitat quantities and standardized reach

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[1]The active channel, or bankfull channel, is the portion of the channel where flows occur often enough to prevent the establishment of vegetation, generally corresponding to a break in the slope of the bank.

lengths and widths between years for the calculation of pieces of wood per channel width.

6. Analysis

6.1 Data Storage

Monitoring data collected during the HCP are maintained by PWB in Microsoft Excel spreadsheets. Summary data will be added to the Sandy River EDT database. The data will be made available to the National Marine Fisheries Service, US Fish and Wildlife Service, Oregon Department of Fish and Wildlife, and other regulatory agencies ("services") for review at any time and will be extensively discussed during the HCP Year 20 check-in meeting of PWB with the services. Following quality assurance/quality control procedures and review and approval by PWB and the services, the data will be made available to the StreamNet Library (through the Columbia River Inter-Tribal Fish Commission [CRITFC] technical reports), Oregon Department of Fish and Wildlife AIP (http://oregonstate.edu/Dept/ODFW/freshwater/inventory/index.htm), and the US Forest Service Natural Resource Information System (NRIS) Water Module databases. Each of these databases was consulted extensively in the Sandy River Basin EDT analysis. Appropriate treatment and control-reach data that are already in these databases will be used to bolster the sample size of the pretreatment habitat attributes. Preexisting data will not be used if the habitat in the respective streams has since been modified by restoration activities other than the planned HCP offsite in-channel measures.

6.2 Hypothesis Testing

Both the numeric and statistical evaluations of the hypothesis for the monitoring plan key question suggest a fundamental comparison between baseline and posttreatment data on a reach-by-reach, attribute-by-attribute basis. Control reaches will be employed to subtract out variation due to large-scale effects outside of PWB's control. An example of how this will occur is given below (T=treatment reach value, C=control reach value):

$$\left.\begin{matrix} T_{before1}-C_{before1} \\ T_{before2}-C_{before2} \end{matrix}\right\} \textbf{ mean } \text{ vs. } \textbf{ mean } \left\{\begin{matrix} T_{after1}-C_{after1} \\ T_{after2}-C_{after2} \\ T_{after3}-C_{after3} \\ T_{after4}-C_{after4} \\ T_{after5}-C_{after5} \end{matrix}\right.$$

The numeric comparison of the means of pretreatment and posttreatment data will determine whether or not the posttreatment mean is equal to or greater than 80 percent of the measurable habitat objective. For statistical comparisons, t-tests will be performed on the differences between treatment reach and control reach habitat attribute values, with a 95 percent level of confidence.

7. Adaptive Management

If data indicate that the effectiveness monitoring protocol null hypotheses should not be rejected and if the new EDT results indicate that the predicted changes to freshwater productivity are less than originally described for PWB's offsite in-channel conservation measures, PWB will follow the adaptive management process described in Chapter 9 of the HCP.

8. 2020 Results

Tables 4 and 5 summarize the results for offsite in-stream measure effectiveness monitoring surveys conducted in 2020 in Cedar Creek and Zigzag River, respectively. The tables also compare survey results with the values for the current condition of the same habitat attributes in the EDT database. The control reach for Cedar 2 and Cedar 3 is Cedar 4. The control reach for Zigzag 1A is the lower 1.6 miles of the reach immediately upstream.

Table 4. Comparison of values for various habitat attributes[a] in Cedar Creek derived from the EDT database and 2020 survey results

	Treatment reach				Control reach	
	Cedar 2		Cedar 3		Cedar 4	
Attribute[a]	**EDT current**	**2020 survey**	**EDT current**	**2020 survey**	**EDT current**	**2019 survey**
Large wood (pieces/CW)[b,c]	1.5	1.1	1.5	2.8	3.0	1.5
Backwater pools	14.0%	0.0%	7.0%	0.0%	2.0%	0.0%
Beaver ponds	1.0%	0.0%	6.0%	0.0%	0.0%	0.0%
Pools	14.0%	26.4%	21.0%	29.9%	19.0%	24.4%
Pool tails	3.0%	0.2%	4.0%	0.1%	3.0%	0.2%
Small-cobble riffles	25.0%	20.9%	24.0%	5.6%	28.0%	0.0%
Large-cobble riffles	35.0%	52.5%	33.0%	64.4%	50.0%	75.4%
Glides	0.0%	0.0%	6.0%	0.0%	4.0%	0.0%
Off-channel habitat	8.0%	0.0%	15.0%	0.1%	0.0%	0.0%
Percent fines	14.5%	12.8%	8.5%	17.4%	8.5%	23.3%
Embeddedness	0.0%	25.3%	0.0%	33.7%	0.0%	42.9%

[a] The selected attributes are expected to respond to HCP in-stream conservation measures.

[b] Large wood is given as a standardized metric (pieces of wood per average high-flow channel width [CW]).

[c] The Sandy 2 large wood value does not include wood placed by the Metro Regional Government in 2017.

Table 5. Comparison of values for various habitat attributes[a] in the Zigzag River derived from the EDT database and 2020 survey results

	Treatment reach		Control reach	
	Zigzag 1A		Zigzag 1B	
Attribute	**EDT current**	**2020 survey**	**EDT current**	**2020 survey**
Large wood (pieces/CW)[b]	0.7	4.7	0.7	0.7
Backwater pools	0.0%	0.1%	0.0%	0.0%
Beaver ponds	0.0%	1.1%	0.0%	0.0%
Pools	15.0%	19.2%	15.0%	5.0%
Pool tails	3.0%	0.3%	3.0%	0.1%
Small-cobble riffles	57.7%	7.2%	57.7%	0.3%
Large-cobble riffles	20.0%	69.6%	20.0%	94.6%
Glides	7.0%	2.4%	7.0%	0.0%
Off-channel habitat	5.0%	0.0%	5.9%	0.0%
Percent fines	NR[c]	22.3%	NR[c]	15.0%
Embeddedness	14.5%	41.0%	14.5%	33.3%

[a] The selected attributes are expected to respond to HCP in-stream conservation measures.

[b] Large wood is given as a standardized metric (pieces of wood per average high-flow channel width [CW]).

[c] NR = Not rated. The EDT database does not include a Current rating for this attribute.

Table 6 summarizes the averages of baseline values, standard deviations, and posttreatment targets for the habitat attributes that have measurable habitat objectives in each treatment reach. Control reaches are not included because they do not have measurable habitat objectives. The number of baseline survey years that are incorporated into each baseline average and the number of posttreatment survey years incorporated into each posttreatment average are given in respective order in parentheses in the Reach column, separated by a comma.

Table 6. Baseline averages, posttreatment targets, and posttreatment averages for habitat attributes with measurable habitat objectives in streams surveyed in 2020[a,b]

Attribute	Baseline average	Standard deviation	Posttreatment target	Posttreatment average[c]	Reach
Large woody debris (pieces/CW)	2.0	0.3	3.0	1.3	Cedar 2 (n=3, 2)
Large woody debris (pieces/CW)	2.1	0.8	2.5	3.3	Cedar 3 (n=3, 2)
Beaver ponds	0.0%	0.0%	7.9%	0.0%	
Pool habitat	27.1%	2.4%	26.3%	27.2%	

Table 6. Baseline averages, posttreatment targets, and posttreatment averages for habitat attributes with measurable habitat objectives in streams surveyed in 2020[a,b]

Attribute	Baseline average	Standard deviation	Posttreatment target	Posttreatment average[c]	Reach
Large woody debris (pieces/CW)	2.7	0.9%	2.6	4.7	Zigzag 1A (n=2,1)
Artificial confinement	40%	NA	25%	25%	
Small-cobble riffle	3.9%	1.8%	57.0%	7.2%	
Pool habitat	14.4%	0.2%	17.2%	19.2%	
Pool tails	0.4%	0.1%	3.8%	0.3%	

[a] Source: EDT model run (10/20/2005) for current and historical status of attributes and expected values after implementation of individual measures.

[b] Appendix E of the HCP, Offsite Habitat Effects Tables, provides the list of all attributes, habitat objectives, and reaches that may be affected by the HCP measures.

9. Discussion

The results presented in Tables 4, 5, and 6 of this report contribute to the record of posttreatment values for the respective monitored habitat attributes. Measure H-17 (Cedar 2/3 Large Wood Placement) was implemented in 2016 and Measure H-27 Zigzag 1A Channel Design was implemented in 2019, so the habitat attribute data collected in these streams in 2020 were posttreatment data. PWB will collect further posttreatment data in Cedar Creek in 2023, 2026, and 2029.

The schedule for the collection of posttreatment data on Zigzag River has been modified. Additional construction work was completed on Zigzag River in the summer of 2020 to improve the ecological performance of the project. 2020 was the first scheduled year of posttreatment monitoring, but it is possible that modifications to the project in 2020 could affect monitored habitat attributes. Zigzag River will be monitored again in 2021 and then every three years after that—in 2024, 2027, 2030, and 2033.

The comparison of baseline values to the current condition values in the EDT database will help determine whether more restoration is needed than was assumed during the development of the HCP. Comparing the average posttreatment values for habitat attributes to the average baseline values in each treatment reach and with the respective averages in control reaches will determine whether PWB has met its restoration targets in those streams and whether additional efforts are necessary.

10. Works Cited

City of Portland. 2004. Development and Application of the EDT Database and Model for the Sandy River Basin. Prepared with assistance from Mobrand Biometrics, Inc. Portland, Oregon.

Hankin, David G., and Gordon H. Reeves. 1988. Estimating Total Fish Abundance and Total Habitat Area in Small Streams Based on Visual Estimation Methods. *Can. J. Fish. Aquat. Sci.* 45:834-844.

Portland Water Bureau. 2008. Bull Run Water Supply Habitat Conservation Plan for the Issuance of a Permit to Allow Incidental Take of Threatened and Endangered Species. Portland, Oregon.

Roni, Philip, Andrew H. Fayram, and Michael A. Miller. 2006. Monitoring and evaluating instream habitat enhancement. Pages 209–236 in *Monitoring Stream and Watershed Restoration* (P. Roni, ed.). American Fisheries Society. Bethesda, Maryland.

Appendix B

Bull Run HCP Research Report

Lower Bull Run River Adult Chinook Population

July 2021

Burke Strobel

City of Portland Water Bureau

Contents

Tables

Figures

1. Summary

The City of Portland Water Bureau (PWB) was in full compliance with its Bull Run Water Supply Habitat Conservation Plan (HCP; Portland Water Bureau 2008) obligations in 2020 regarding lower Bull Run River adult Chinook Salmon population research. Two snorkel surveys of holding adult Chinook Salmon were conducted during the summer, and weekly walking surveys of spawning and holding Chinook Salmon (spawning surveys) were conducted from late August through early December. The snorkeled portion of the lower Bull Run River included the lower river from its mouth to Larson's Falls (river mile [RM] 3.7). The portion of the river surveyed while walking included the entire lower river from its mouth to the base of the Bull Run diversion dam at Headworks (RM 6.0). In 2020, spawning surveys could not be conducted on four occasions because of wildfire danger and high flows. This year's missed surveys were either early or late in the season, so peak counts, minimum escapement estimates, and cumulative redd counts were probably not affected.

The peak adult counts, minimum escapement[1], and cumulative redd counts for both spring Chinook and fall Chinook in 2020 were the highest recorded since 2007. Approximately 38 percent of adult Chinook observed were hatchery fish. For those adults that were identified as spring Chinook, approximately 54 percent of them were hatchery fish.

The snorkel surveys conducted during the summer followed protocols modified from the survey protocol described in the HCP. These additional surveys were necessary to evaluate efforts by the Oregon Department of Fish and Wildlife (ODFW) to use an adult fish weir and trap near the mouth of the river to prevent adult hatchery Chinook from entering the lower Bull Run River. The modified survey protocols included snorkeling large portions of the river to better count adults holding in deep pools and to attempt to determine whether live fish had clipped or intact adipose fins. A maximum of 31 adult Chinook were observed during snorkel surveys, probably having entered the lower Bull Run River before the ODFW weir was installed in early June. Up to 80.7 percent of those fish were of hatchery origin. The increase in adult counts between snorkel surveys in 2020 is probably a result of adults escaping observation at times in deep pools or among large boulders common in the Bull Run River channel, rather than fish slipping past the weir.

Two prespawning mortalities, both of wild fish, were observed in 2020. One of those fish appeared to be a hooking mortality, with a hook and significant wound in its belly.

[1] Escapement is the number of fish that avoid or escape all harvest and return to spawn in their home streams.

2. Introduction

This section describes the results of surveys of spawning Chinook Salmon adults and redds in the lower Bull Run River. Both spring and fall runs of Chinook Salmon spawn in the lower Bull Run River.

Various agencies have conducted surveys of Chinook adults and redds in the Sandy River Basin since the 1980s. ODFW has conducted surveys of spring Chinook adults and redds in the Sandy River Basin by boat and on foot from 1996 to the present. They have conducted surveys of fall Chinook adults and redds by boat and on foot in index reaches in the lower Sandy River Basin from 1984 to 2013 and following probabilistic sampling protocols from 2012 to the present. These surveys, however, have not included the lower Bull Run River. ODFW conducted weekly surveys of spawning spring and fall Chinook Salmon and redds in the lower Bull Run River (RM 0–RM 5.8) in 1997. PWB continued weekly surveys from RM 1.5 to RM 5.8 in 1998 and 1999. An index reach of the lower Bull Run River (RM 1.5–RM 3.7) was surveyed by PWB in 2005 and 2006. This index reach was expanded to include RM 0–RM 3.7 for surveys conducted from 2007 to 2009 and further expanded to a full census of the lower river, including RM 0–RM 6.0, for all subsequent survey years.

For HCP Years 1–20 (2010–2029), PWB will annually count spawning Chinook Salmon and redds in the lower Bull Run River. The lower Bull Run River Chinook population research is designed to provide biologists with meaningful data within a 20-year time frame to evaluate the long-term trend in adult Chinook abundance for the Bull Run. The Bull Run data could then be used with information gathered by other agencies to determine the status of federally listed Sandy River Chinook populations.

In addition to meeting its HCP obligations, PWB added a new monitoring consideration in 2013, which it retained in 2020. This new consideration assesses the effects of an ODFW program, begun in 2011, to acclimate and release hatchery Chinook smolts in the lower Bull Run River. Adult Chinook belonging to those acclimated cohorts began returning to the Bull Run River in 2013. PWB was concerned that many adult hatchery Chinook might begin returning to the Bull Run River. The percentage of hatchery spring Chinook adults on the spawning grounds in the upper Sandy Basin is considered acceptable if it is below 10 percent (ODFW 2011). A large return of hatchery fish could quickly exceed that threshold in the Bull Run River, undermining PWB's restoration efforts. ODFW began installing a river channel-spanning weir near the mouth of the Bull Run River in 2013 to remove hatchery Chinook adults while allowing wild Chinook adults to enter the river. The weir was also installed in early June 2020. Spawning survey protocols were adjusted in 2020 to evaluate ODFW's efforts to prevent adult hatchery Chinook from entering the Bull Run River.

PWB also assessed prespawning mortality of spring Chinook Salmon in 2020. Hot, dry weather conditions such as those experienced in the Bull Run Watershed in recent years can heat streams. Warm stream temperatures can lead to an increase in mortality among adult salmon before they have had the chance to spawn. PWB wishes to determine whether prespawning mortality in the Bull Run River is related to stream temperatures.

3. Research Objectives

In 2020 and continuing through HCP Year 20, PWB will conduct annual counts of spawning Chinook Salmon and redds in the lower Bull Run River from RM 0–RM 6.0.

The objectives of the lower Bull Run River Chinook population research are to

- document use of the lower Bull Run River by spring and fall Chinook Salmon, and
- contribute to ODFW's annual assessment of spring Chinook in the Sandy River Basin.

4. Key Questions and Hypotheses

The key questions to be answered by the research are the following:

- How many Chinook Salmon adults enter the Bull Run River to spawn each year? This key question does not have an associated null hypothesis (H_o).
- How many Chinook Salmon redds are built in the Bull Run River each year? This key question has been added since PWB's adoption of the HCP and does not have an associated null hypothesis.
- What is the long-term trend (20 years) in spawning Chinook Salmon abundance?

  H_o: The abundance of spawning Chinook Salmon will not change significantly over the long term (20 years, α=0.05, β=0.20).
- What is the timing (range of dates and peak date) of adult Chinook presence and redd creation in the lower Bull Run River? This key question does not have an associated null hypothesis.
- What percentage of the spawning Chinook Salmon are of hatchery origin?[2] This key question does not have an associated null hypothesis.

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[2] The protocols followed by PWB provide the proportion of carcasses found with clipped adipose fins. The proportion of unclipped carcasses that are of hatchery origin were determined in previous years by ODFW analysis of otoliths. Otoliths are tiny bones that form a portion of a fish's inner ear. A fish lays down new bone material on the otolith's edge as it grows, forming bands that record the fish's growth rate over time. ODFW thermally "marked" otoliths in hatchery Chinook by exposing juvenile fish to varying water temperatures. Because fish growth increases in warm water and decreases in cold water, characteristic banding patterns are created, which provide an indication of fish origin (Schroeder et al. 2005). ODFW no longer marks otoliths and otoliths are not collected.

Four additional key questions—to be answered by the lower Bull Run River adult Chinook population research—were pursued in 2020:

- What percentage of spring Chinook Salmon holding in the Bull Run River while the ODFW weir is in operation are of hatchery origin? This key question does not have an associated null hypothesis.
- What percentage of spawning spring Chinook Salmon are of hatchery origin? Spring Chinook represent only a portion of the Chinook adults observed in the lower Bull Run River and are expected to have a different hatchery proportion than the aggregate population of both spring Chinook and fall Chinook. This key question does not have an associated null hypothesis.
- What was the rate of prespawning mortality in 2020 for spring Chinook Salmon, is there a relationship between the yearly maximum seven-day average of daily maximum stream temperature in the Bull Run River and observed prespawning mortality, and what is the relationship of prespawning mortality in the Bull Run River to that in the Sandy River as a whole? This key question does not have an associated null hypothesis.
- Does the number of adipose-clipped spring Chinook in the Bull Run River increase while the ODFW weir is in operation?

PWB also collects tissue and scale samples from adult carcasses found in the lower Bull Run River. PWB sends the samples to ODFW to assist in ODFW's assessment of spring Chinook in the Sandy River Basin. In return, PWB will receive information from ODFW at a future date about the relative number of spring and fall Chinook Salmon in the lower Bull Run River and the proportion of Chinook adults showing aspects of various life history types.[3] The compilation of this information, however, depends on analyses conducted by ODFW and is therefore not reflected in the key questions.

[3] A Chinook Salmon's life history type is defined by when, where, and how it lives over the course of its lifetime. This includes the number of years that it spent in freshwater and in saltwater before returning to freshwater to spawn.

PWB conducts surveys throughout the spawning season for both spring Chinook and fall Chinook, but several of the statistics associated with the key questions and hypotheses apply primarily to spring Chinook. The spring Chinook run in the Bull Run River generally tapers off by the end of October, at about the time the fall Chinook run is beginning. There is undoubtedly overlap between the two runs, although the degree of overlap has not been quantified. ODFW uses October 31 as a cutoff date to distinguish between the two runs in the Bull Run River. The dates for peak counts have consistently occurred before October 31 and, for this reason, have, in the past, reflected the spring Chinook run. Other statistics, such as cumulative redd count and percentage of hatchery fish, have been influenced to varying degrees by the inclusion of fall Chinook. The cutoff date of October 31 was applied in 2020 to estimate peak counts, minimum escapement estimates, and redd counts for both spring Chinook and fall Chinook.

Figure 1. Female spring Chinook over a redd

5. Methods

The study design for the lower Bull Run River Chinook population research uses weekly surveys to count live Chinook adults, Chinook Salmon carcasses, and newly created redds. The surveys are coordinated with operators at the City's Headworks facility and the Eugene Water & Electric Board–operated powerhouses at Bull Run Dam 1 and Dam 2. During surveys, operators maintain flows of 100 cubic feet per second (cfs) or less above the Little Sandy confluence as often as possible. This is the level of flow necessary for safety and for accurate counts. No surveys are conducted if flows of 300 cfs or less cannot be maintained. The HCP allows for departures from minimum flow criteria in the lower Bull Run River (Measures F-1 and F-2) to make Chinook spawning surveys possible.

5.1 Spatial Scale

The lower Bull Run River was divided into the following reaches to provide greater spatial resolution of counts than a simple count of the entire river would provide and to reflect the reaches used in previous surveys for comparison:

Reach 1: The confluence of the Bull Run River with the Sandy River to the upstream end of the large pool adjacent to the former Bull Run PGE Powerhouse (RM 0–RM 1.5)

Reach 2: The upstream end of the large pool adjacent to the former Bull Run PGE Powerhouse to Bowman's Bridge (RM 1.5–RM 2.3)

Reach 3: Bowman's Bridge to the upstream end of the pool at the confluence with the Little Sandy River (RM 2.3–RM 2.8)

Reach 4: The upstream end of the Little Sandy River confluence pool to the upstream end of the pool at Larson's Bridge (RM 2.8–RM 3.7)

Reach 5: The upstream end of the pool at Larson's Bridge to the Road 14 bridge (RM 3.7–RM 4.8)

Reach 6: The Road 14 bridge to the Headworks diversion dam (RM 4.8–RM 6.0)

These reaches correspond to those used for the HCP Chinook spawning gravel research (see past years' Lower Bull Run River Spawning Gravel Research appendices), with the exception that spawning gravel research is not conducted between RM 5.8 and RM 6.0. Reaches 2, 3, and 4 are also the reaches used in previous Chinook spawning surveys conducted by ODFW and PWB. Reach 4 also corresponds to one of ODFW's probabilistic, randomly selected reaches for the Sandy River Basin steelhead and Coho spawning surveys and snorkel surveys. Reaches 5 and 6 were not believed to be used by spawning Chinook Salmon prior to 2011. These reaches were surveyed twice in 2010 to confirm whether they were being used; one spawning Coho Salmon was observed. Based on this result, starting in 2011, Reaches 5 and 6 were surveyed every week after October 1. They were not surveyed earlier in the year because low summer flows make it very unlikely that salmon would be able to pass Larson's Falls at RM 3.7.[4]

Adult and redd abundance and timing information is summarized at the reach scale. The percentage of hatchery fish is summarized at the scale of the entire lower Bull Run River.

[4] Flows generally begin increasing with the autumn rains in October, making it possible, though difficult, for salmon to pass Larson's Falls.

5.2 Replication/Duration

PWB is committed to funding the Chinook population research in the lower Bull Run River for the first 20 years of the HCP. Annual surveys of spawning Chinook Salmon and redds are conducted.

Weekly surveys in 2020 were conducted from mid-September through mid-December. Two weeks were missed because of staffing difficulties and high flows. Three additional snorkel surveys were conducted: one in June, one in July, and one in August. There was no spatial replication because the entire channel was surveyed.

5.3 Parameters

The following information and samples were collected during each survey.

- Live adults
  - Number of adults and number of jacks
  - Species
  - Reach
  - Additional behavioral information (e.g., spawning, defending a redd)
- Carcasses
  - Species
  - Reach
  - Length (both total length from the snout-tip to the fork of the tail and the middle-of-eye-to-posterior-scale [MEPS] length, in centimeters)
  - Sex
    - If a female, whether it died before spawning
  - Presence of adipose fin
    - If no adipose fin, whether it has coded-wire tags (CWT). If CWT were present, researchers collected the snout
    - If an adipose fin was present and the date was October 31 or earlier, researchers collected
      - a tissue sample (for National Marine Fisheries Service distinction of spring from fall Chinook)
      - a scale sample (for ODFW determination of age and life history)
  - Additional information (e.g., whether the individual appeared to be eaten by scavengers or was found in the riparian zone)

- Redds
  - Reach
  - Species (researchers assumed the individual was Chinook unless another species was seen creating or defending it)
  - Size (length x width, in square feet, including excavated pot and gravel mound)
  - Substrate size range (visual estimate of the range from approximately the 10th to the 90th percentile of substrate sizes, in inches, focusing on gravel mound)[5]
  - Channel feature retaining the original gravel patch (e.g., whether the redd is behind a boulder or bedrock, a pool-tail or riffle margin)
  - Evidence of superimposition over a previous redd
- Environmental data
  - Weather (description)
  - Water clarity/visibility
  - Flow (determined from US Geological Survey [USGS] Gage No. 14140000)

5.4 Sampling

Sampling methods have been altered slightly from those proposed in the HCP. PWB intended to conduct spawning surveys by walking the river channel in flows of up to 150 cfs. This was regarded as the maximum flow that would still allow for safe navigation by surveyors on foot wearing waders. Between flows of 150 and 500 cfs, PWB intended to survey while floating the river with kayaks. An initial trial run with kayaks conducted by PWB before 2010 at 400 cfs, however, convinced PWB that this method would not produce reliable data and was not a safe survey approach.

Instead, surveys were conducted by two observers walking downstream on each side of the channel (Figure 2). Between flows of 150 and 400 cfs (which included contributions from the Little Sandy River), surveyors wore dry suits and life vests. This enabled them to swim safely through otherwise impassable areas. If the combined flows of the Bull Run River and Little Sandy River could not be maintained below 400 cfs, surveys were cancelled.

Live adults and jacks were counted, and their locations recorded. Any carcasses that were found with an intact tail were counted. All carcasses that could be retrieved were measured, and their sex was recorded. Females were opened to check for eggs, which would determine whether they died before spawning. All carcasses were checked for the

[5] Substrate sizes are discussed in the HCP, Appendix F. The HCP is available on the Portland Water Bureau website.

presence of an adipose fin. All carcasses with adipose fins found on or before November 1 (corresponding to an approximate date of October 31 used by ODFW to distinguish between live spring and fall Chinook—ODFW has an interest only in samples collected from the earlier, spring-run fish) were sampled for tissue and scales. After November 1, no samples were collected from Chinook carcasses.

ODFW also conducted two independent surveys of adults and carcasses on portions of the lower Bull Run River in September and October of 2020. ODFW carcass counts and carcass data were added to PWB data for the nearest PWB survey date.

Figure 2. A surveyor looks for live adults, carcasses, and redds. In the foreground, a green rock marks a redd that is at least one week old.

Redds were counted and their locations recorded. The approximate surface area of each redd and the size of its substrate were visually estimated. Once these and other data had been collected, each redd was marked with a flag with the date attached to the bank adjacent to the redd. The following week, if there were no signs of adult fish that could still be building the redd, a painted rock comparable in size to those comprising the redd was placed on the redd. The painted rock helped distinguish new redds from old ones. Painted rocks from previous surveys that had been dislodged or buried indicated that further spawning activity had occurred at that location. The flag on the bank aided in confirming the presence of an old redd if the painted rock was missing. If live adults were still observed on or near a redd after two weeks, it was assumed that a new redd was in the process of being built superimposed on the old redd. No rock was placed, but the bank was flagged. If no adults were observed the following week, a rock was placed at that time, and a note of it was made.

Two surveys were conducted in 2020 following an adjusted protocol to provide data to ODFW personnel to evaluate ODFW's efforts to prevent adult hatchery Chinook from entering the lower Bull Run River. The purpose of the additional surveys was to determine whether adult hatchery Chinook had entered the Bull Run River before ODFW installed its weir or despite the weir. Under the modified protocols, as much of the lower Bull Run River as possible (Reaches 1–4) was snorkeled. Snorkelers counted adult Chinook and identified whether each observed fish had a clipped or intact adipose fin or whether the adipose fin status could not be determined. Snorkelers did not look for redds in snorkeled portions of the river. Portions of the river that were too shallow to snorkel effectively were surveyed according to the regular protocols described above. These modified surveys were conducted on July 8 and August 26.

6. Analysis

Data Storage: Monitoring data collected during the HCP Chinook Population Research were entered by PWB in a Microsoft Excel spreadsheet and stored with spreadsheets containing data from previous years' surveys.

Hypothesis Testing: The number and timing of Chinook Salmon in the lower Bull Run in a given year were compared to the number and timing of Chinook Salmon in other years. Individual years were not compared statistically, however, because of the lack of replication.

The trend in peak spawner count (live + dead fish on a given date) and minimum escapement estimate (peak count of live fish on a given date plus cumulative carcass count up to and including that date) were calculated for all surveys to date using linear regression (α=0.05).

The percentage of hatchery fish in the lower Bull Run in a given year was compared to the percentage of hatchery fish in other years. Individual years were not compared statistically, however, because of the lack of replication.

The percentage of hatchery fish in the spring Chinook population, as opposed to the percentage of hatchery fish in the aggregate population of spring and fall Chinook, was estimated by applying a cutoff date of November 1 for distinguishing between carcasses that were considered to be spring Chinook (carcasses of fish that could have spawned on or before October 31) or fall Chinook (carcasses of fish that probably spawned in November or later).

7. Results and Discussion

7.1 Surveys

Fourteen surveys were conducted in 2020 between July 8 and December 9; two followed modified protocols, which included snorkeling, and 12 followed standard protocols

(Figure 3). Surveys were cancelled on September 1, 8, and 15 due to wildfire-related issues and on November 18 due to high flows. Three redds were observed during the last survey, indicating that a small amount of spawning activity at the end of the season may have been missed.

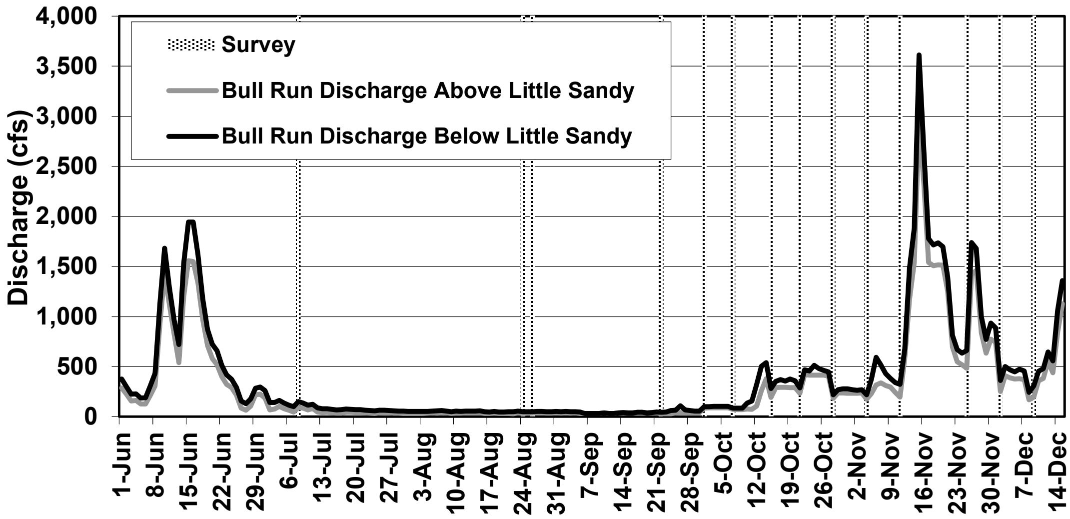

Figure 3. Bull Run River discharge above and below the Little Sandy confluence and dates of Chinook spawning surveys in 2020

7.2 Live Adults

7.2.1 Peak Counts and Minimum Escapement Estimates

The peak count, minimum escapement estimate, and cumulative redd count for Chinook Salmon in the lower Bull Run River in 2020 were the highest ever observed since the removal of Marmot Dam in 2007, as indicated in Table 1.

Table 1. Summary statistics for Chinook spawning runs in the Lower Bull Run River, 2007–2020[a]

Year	Peak count	Minimum escapement	Cumulative redd count	% Hatchery (n)[b]	% Female (n)
2020	93	135	323	37.5% (112)	69.6% (115)
2019	20	32	98	17.4% (23)	75.0% (24)
2018	32	48	133	80.0% (35)	59.5% (37)
2017	24	42	59	78.4% (37)	67.6% (34)
2016[c]	63	63	59	39.1% (23)	64.0% (25)

Table 1. Summary statistics for Chinook spawning runs in the Lower Bull Run River, 2007–2020[a]

Year	Peak count	Minimum escapement	Cumulative redd count	% Hatchery (n)[b]	% Female (n)
2015	37	76	85	27.0% (63)	47.5% (61)
2014	21	37	67	3.7% (27)	37.0% (27)
2013	54	69	124	16.3% (48)	64.6% (47)
2012	30	33	31	60.0% (5)	40.0% (5)
2011	84	99	94	43.1% (72)	54.7% (75)
2010	70	77	43	36.8% (19)	75.0% (16)
2009	61	70	89	11.8% (34)	52.9% (34)
2008	31	38	37	11.5% (26)	73.1% (26)
2007	34	39	62	41.7% (12)	76.9% (13)

[a] Includes peak count, minimum escapement estimate, percent of identifiable carcasses with clipped adipose fins (n=number of carcasses where the state of the adipose fin could be determined), and percent of identifiable carcasses that were female (n=number of carcasses where the sex could be determined).

[b] Fish with clipped adipose fins. A small portion of unclipped fish may also be of hatchery origin. Determined from carcass data only. Up to 81% of adults observed while snorkeling were adipose-clipped. These fish are not included in the % Hatchery estimate because the survey protocols were not comparable to other dates and other years.

[c] Peak count and minimum escapement do not include the results from snorkel surveys. Snorkel surveys follow different protocols that should not be combined with data collected during walking spawning surveys.

Peak adult counts continue to be lower, on average, than they had been prior to the Marmot Dam removal in 2007 ($\text{t-test}_{\text{one-tailed}}$, p=0.005, df=8, assuming unequal variances), but with a large amount of variation, as indicated in Figure 4. The average peak count prior to removal was 129 (±103%–95% confidence interval). In the years after decommissioning, the average has been 47 (±101%–95% confidence interval). There is no trend in the data observed between 2007 and 2020 (p=0.94).

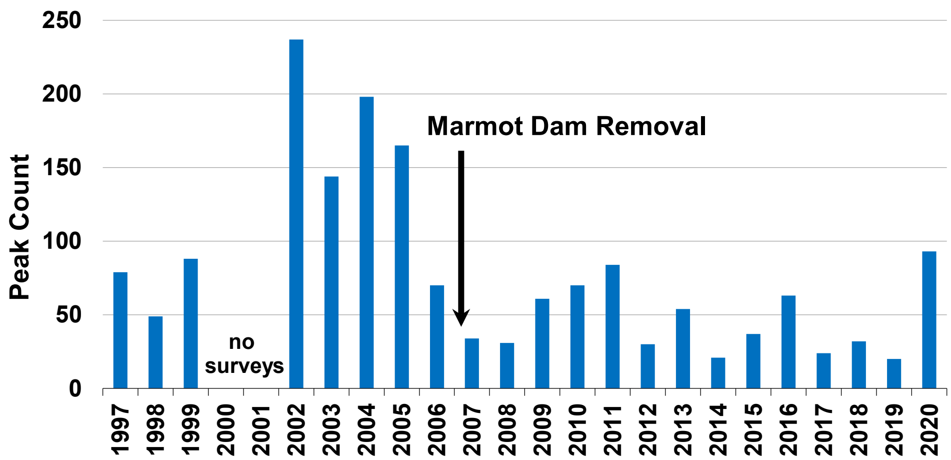

Figure 4. Chinook Salmon peak counts for all years when surveys were conducted

The peak count statistic generally reflects the status of spring Chinook, whereas minimum escapement, cumulative redd count, percent hatchery, and percent female reflect the combined total for spring Chinook and fall Chinook. Dates for peak counts have consistently occurred in October, at the height of spring Chinook spawning activity and before fall Chinook are believed to be present in the river in significant numbers. In 2020, however, the peak count occurred on August 24, when large groups of holding adults were observed during the first walking survey. Large numbers of holding adult spring Chinook have often been present during the summer in recent years, but these have generally been observed while snorkeling and have not been included in the peak adult counts. Snorkel counts involve protocols and probability of detection that are not comparable to walking surveys, so are inappropriate for comparisons across years.

It is difficult to distinguish between spring Chinook and fall Chinook redds and carcasses because of overlap in their run timing at the end of October and early November. ODFW has used November 1 as an approximate date for distinguishing between spring Chinook and fall Chinook. Spawning activity prior to November 1 is assigned to the spring run, and spawning activity observed on or after November 1 is assigned to the fall run. Carcasses recovered on November 1 are assigned to the spring run. Tables 2 and 3 summarize statistics for Chinook assigned to the spring and fall spawning runs, respectively. In the future, genetic analysis may help to distinguish these two runs.

Table 2. Summary statistics for assigned spring Chinook (before November 1) spawning in the Lower Bull Run River, 2007–2020[a]

Year	Peak count	Minimum escapement	Cumulative redd count	% Hatchery (n)[b]	% Female (n)
2020	93	121	232	54.1% (74)	70.1% (77)
2019	11	15	43	22.2% (9)	55.6% (9)

Table 2. Summary statistics for assigned spring Chinook (before November 1) spawning in the Lower Bull Run River, 2007–2020[a]

Year	Peak count	Minimum escapement	Cumulative redd count	% Hatchery (n)[b]	% Female (n)
2018	32	48	70	87.1% (31)	62.5% (32)
2017	24	46	48	80.0% (35)	66.0% (32)
2016	63	63	45	52.9% (17)	64.7% (17)
2015	37	66	55	37.2% (51)	41.5% (41)
2014	21	37	35	5.3% (21)	15.8% (19)
2013	52	62	95	25.0% (33)	61.3% (31)
2012	30	33	28	60.0% (5)	40.0% (5)
2011	84	85	63	50.9% (55)	52.5% (59)
2010	70	77	42	46.7% (15)	75.0% (11)
2009	61	70	61	21.1% (19)	42.1% (19)
2008	31	38	22	18.8% (16)	68.8% (16)
2007	34	39	37	40.0% (10)	70.0% (10)

[a] Includes peak count, minimum escapement estimate, percent of identifiable carcasses with clipped adipose fins (n=number of carcasses where the state of the adipose fin could be determined), and percent of identifiable carcasses that were female (n=number of carcasses where the sex could be determined).

[b] Fish with clipped adipose fins. A small portion of unclipped fish may also be of hatchery origin. Determined from carcass data only. Up to 100% of adults observed while snorkeling were adipose-clipped. These fish are not included in the % Hatchery estimate because the survey protocols were not comparable to other dates and other years.

Table 3. Summary statistics for assigned fall Chinook (November 1 and after) spawning in the Lower Bull Run River, 2007–2020[a]

Year	Peak count	Minimum escapement	Cumulative redd count	% Hatchery (n)[b]	% Female (n)
2020	50	50	91	5.3% (38)	68.4% (38)
2019	20	22	55	14.3% (14)	86.7% (18)
2018	17	17	63	25.0% (4)	40.0% (5)
2017	11	11	11	50.0% (2)	100.0% (2)
2016	8	8	14	0.0% (6)	62.5% (8)
2015	32	32	30	5.0% (20)	60.0% (20)
2014	7	14	32	0.0% (6)	43.8% (16)
2013	35	35	29	0.0% (17)	70.6% (17)
2012[c]	ND	ND	3	ND	ND
2011	23	40	31	17.7% (17)	62.5% (16)

Table 3. Summary statistics for assigned fall Chinook (November 1 and after) spawning in the Lower Bull Run River, 2007–2020[a]

Year	Peak count	Minimum escapement	Cumulative redd count	% Hatchery (n)[b]	% Female (n)
2010	5	6	1	0.0% (4)	80.0% (5)
2009	18	18	28	0.0% (15)	66.7% (15)
2008	8	10	10	0.0% (10)	80.0% (10)
2007	13	15	25	50.0% (2)	100.0% (3)

[a] Includes peak count, minimum escapement estimate, percent of identifiable carcasses with clipped adipose fins (n=number of carcasses where the state of the adipose fin could be determined), and percent of identifiable carcasses that were female (n=number of carcasses where the sex could be determined).

[b] Fish with clipped adipose fins. A small portion of unclipped fish may also be of hatchery origin. Determined from carcass data only.

[c] ND=No data. No fish were observed, but too few surveys were conducted to conclude none were present.

The relative size of the peak count of spring Chinook in the Bull Run River in 2020 does not necessarily reflect the relative size of the spring Chinook escapement to the Sandy River in general. Since the removal of Marmot Dam, there has been no correlation between the Bull Run River peak Chinook counts and the Sandy River Basin spring Chinook escapement estimates for the respective years. Prior to the removal of Marmot Dam, adult Chinook counts in the Bull Run River reflected trends in the greater Sandy River Basin.

Marmot Dam diverted Sandy River water to the adjacent Little Sandy River Basin, where it was further diverted by way of Roslyn Lake to the Bull Run River at RM 1.5. Following chemical cues in the water, a portion of adult Chinook salmon intent on returning to their natal streams in the upper Sandy River Basin apparently strayed into the Bull Run River by mistake. During these years, lower Bull Run adult Chinook peak counts showed a significant positive correlation (R^2=0.72, p=0.008) with the estimated spring Chinook run size upstream of Marmot Dam (Sandy spring Chinook data 2007 and after from ODFW; Kirk Schroeder and Luke Whitman, pers. comm. Data prior to 2007 from PGE. See Figure 5). After Sandy River water was no longer diverted into the Bull Run River, adult Chinook peak counts declined dramatically and showed no significant correlation with Sandy River spring Chinook counts (R^2=0.02, p=0.68 for years 2007–2019; see Figures 3 and 4).

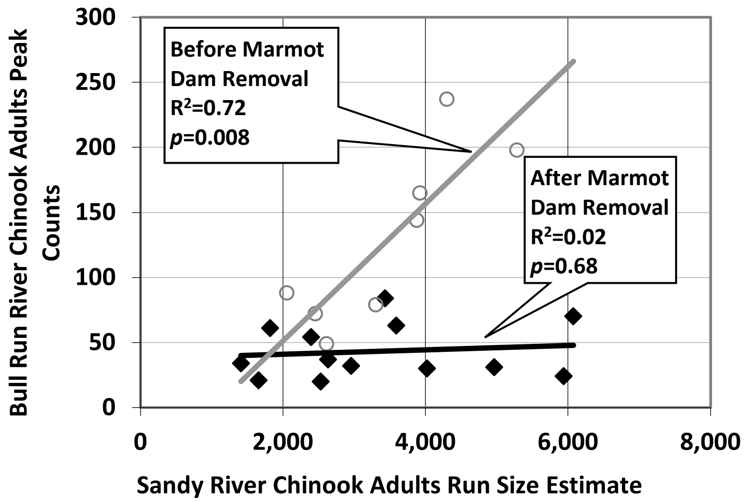

Figure 5. Relationship of peak counts of adult Chinook in the Lower Bull Run River with estimated run size of spring Chinook in the Upper Sandy River Basin before and after the removal of Marmot Dam

7.2.2 Timing

Adult Chinook salmon were observed during walking surveys in the Bull Run River until mid-December, with four adults and one carcass found on December 9. Counts were highest in late August and generally remained high until mid-October, when the number of live adults decreased and the number of carcasses increased (Table 4). The minimum escapement estimate date was in early November. Surveyors found 28 live adults on that date and 107 carcasses up to that date.

Table 4. Timing of adult Chinook peak counts, highest minimum escapement estimate, and peak redd count, 2007–2020. Adult peak count does not include the results of snorkel counts.

Year	Peak count	Minimum escapement	Peak redd count
2020	Aug. 24	Nov. 4	Oct. 21
2019	Nov. 6	Nov. 13	Oct. 30
2018	Sep. 25	Nov. 7	Nov. 7
2017	Oct. 3	Nov. 1	Oct. 3 and 18
2016	Sep. 20	Sep. 20	Oct. 25
2015	Oct. 27	Nov. 12	Nov. 12
2014	Oct. 28	Oct.28	Oct. 28
2013	Oct. 23	Nov. 14	Oct. 16
2012	Oct. 24	Oct. 24	Oct. 24
2011	Oct. 5	Nov. 10	Oct. 5
2010	Oct. 20	Oct. 20	Oct. 20

Table 4. Timing of adult Chinook peak counts, highest minimum escapement estimate, and peak redd count, 2007–2020. Adult peak count does not include the results of snorkel counts.

2009	Oct. 21	Oct. 21	Oct. 21
2008	Oct. 22	Oct. 29	Oct. 15 and 22
2007	Oct. 24	Oct. 24	Oct. 18

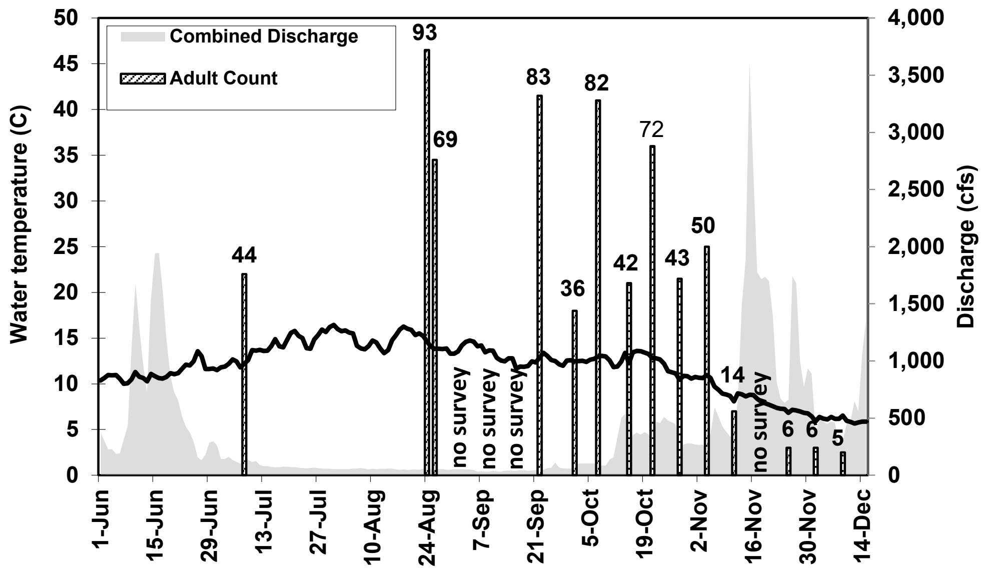

Figure 6. Environmental variables[a] that may be useful in explaining Chinook Salmon run timing in the Lower Bull Run River in 2020. Adult counts include snorkel counts, which were not used in determining the year's peak count.

[a] Includes the estimated mean daily water temperature near the mouth and discharge near the mouth.

7.3 Redds

7.3.1 Cumulative Count

The cumulative Chinook Salmon redd count in the lower Bull Run River was the highest it has been since Marmot Dam was removed in 2007 (Table 1). The cumulative redd count is probably a better measure of spawning activity in the Bull Run River than either peak count or minimum escapement estimate because redds remain visible for weeks after spawning adult Chinook have died and can no longer be observed. Redds that cannot be seen under poor-visibility conditions can also be observed and added to the cumulative total at later dates. The total redd counts attributed to both spring Chinook and fall Chinook were the highest on record (Figure 8). A portion of the redds observed on October 21 and 28 may have actually been fall Chinook redds and a portion of redds observed on November 4 may have been spring Chinook redds.

Figure 7. Redds generally appear as areas of clean gravel with a depression and downstream pile of gravel.

Several redds were also observed that were not attributed to Chinook Salmon. Seven Coho redds were identified during surveys between November 4 and December 9. Nine redds were observed in November and December that could not be confidently assigned to species.

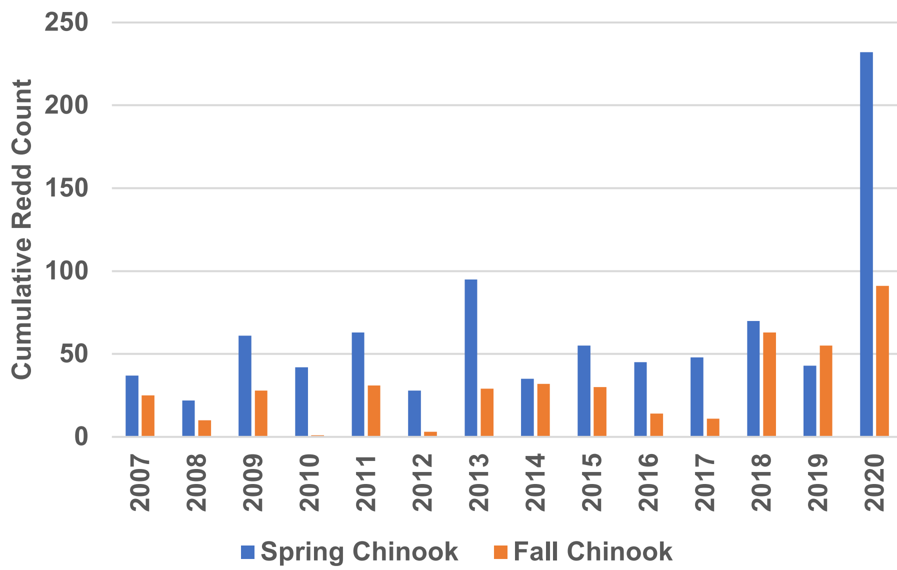

Figure 8. Spring and fall Chinook cumulative redd counts, 2007–2020

7.3.2 Timing

Chinook salmon redds were observed in the Bull Run River between September 22 and December 9. The peak number of new redds (78) was observed on October 21. Figure 9 summarizes the timing of redd construction and compares it to the timing of adults observed in the lower Bull Run River. Figure 9 also includes the cumulative redd count.

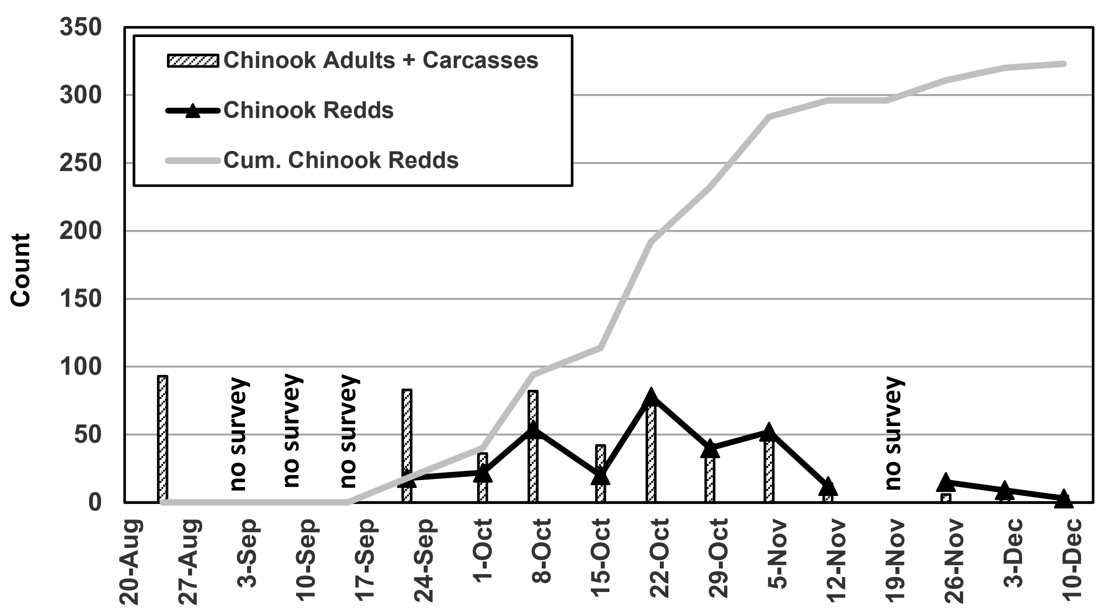

Figure 9. Comparison of the timing of the presence of adult Chinook Salmon and the construction of redds in 2020

7.4 Carcasses

7.4.1 Hatchery Fish

The percentage of Chinook carcasses of both spring and fall runs, combined, in the lower Bull Run River that were of hatchery origin in 2020 (37.5 percent of 112 carcasses) was in the middle of the range of previous years. A large number of hatchery adult fish appeared to enter the Bull Run River prior to installation of the weir in 2020 (at least 31 observed while snorkeling and 42 recovered carcasses), but the unusually large number of unclipped fish reduced the total percentage. The actual proportion of hatchery fish may have been higher than observed. A small proportion of Chinook have inadequately clipped adipose fins, or their fins grow back. For these reasons, ODFW collects otolith samples from spring Chinook Salmon carcasses with adipose fins. The percentage of unclipped fish that are of hatchery origin can be determined from the growth structure of these otoliths. The percentage of unclipped Chinook Salmon carcasses that were of hatchery origin in the Bull Run River was not available at the writing of this report.

In 2020, the percentage of hatchery spring Chinook was in the middle of the range of previous years. The percentage of carcasses considered to be spring Chinook carcasses in 2020 that were of hatchery origin was 54.1 percent, based on a sample size of 74 carcasses. The full Bull Run spawning survey record of percent hatchery fish assigned to the spring Chinook run is summarized in Figure 11.

Figure 10. Male and female Chinook carcasses. To the right is a gaff hook on the end of a walking stick, used to retrieve carcasses.

Most of the hatchery adult Chinook observed during summer snorkel surveys are believed to have passed upstream of the ODFW weir before its installation on June 3, but PWB does not have empirical data to support that assumption.

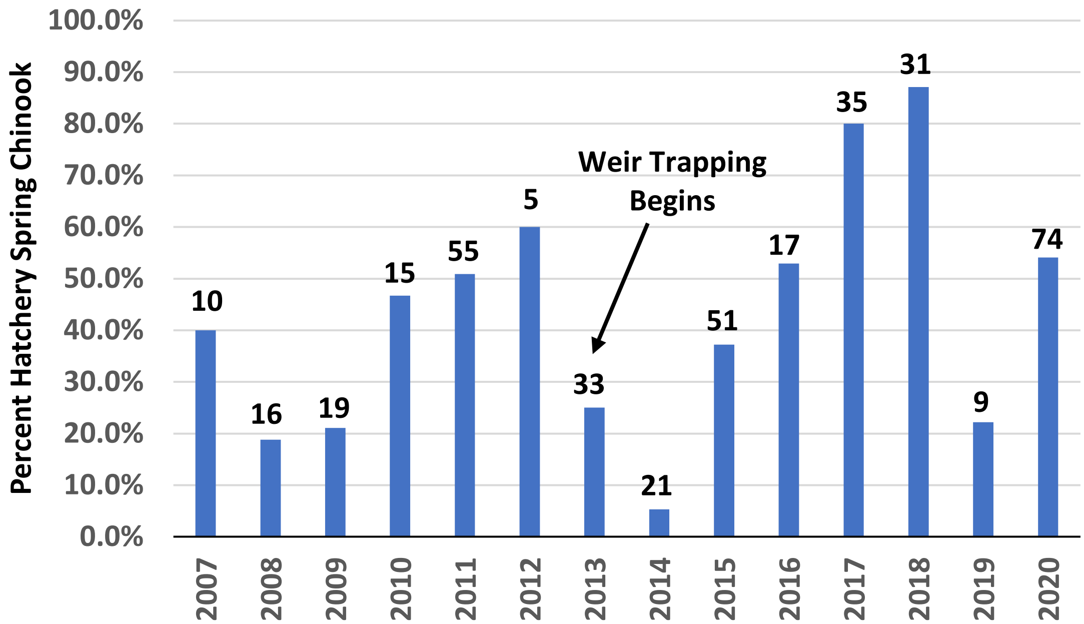

Figure 11. Estimated percent of hatchery spring Chinook adults that spawn in the Bull Run River over time based on carcass recoveries. The number of carcasses incorporated into each estimate is given above the respective column.

7.4.2 Sex Ratio

Seventy percent of the Chinook carcasses recovered in 2020 were female. Of the 125 Chinook carcasses observed in the Bull Run River in 2020, 115 were intact enough to determine sex. Of these, 80 (69.6 percent) were female.

Females have tended to make up a larger percentage of carcasses recovered in the lower Bull Run River in the past. Their percentage has ranged between 52.9 percent and 76.9 percent in ten out of fourteen survey years. The only years when males made up a larger percentage of recovered carcasses were 2015, 2014, and 2012. The reason for the asymmetries observed in the past is unknown. The asymmetries may reflect actual difference between the sexes or differences in the detectability of their carcasses. Females, for instance, appear to remain near their redds for longer periods of time than males and may die, on average, in shallower water where they are more readily found by surveyors. Actual differences in sex ratio can arise through differences between the sexes in marine survival, life history differences, or other factors such as gender reversal.

Significant differences in size, which can influence marine survival, were not observed between sexes in the Bull Run watershed in 2020 as they have been in previous years. Female and male Chinook carcasses had an average middle-of-eye-to-posterior-scale (MEPS) length of 64.0 cm.

Life history differences can, in theory, lead to differences in sex ratio if, for example, a significant number of one gender return at a different age than the other. A portion of male Chinook Salmon return to spawn after only one year in the ocean. These are called jacks. If a large number of males in a given cohort of Chinook return as jacks, returning adults the following year may show a reduced percentage of males. Large numbers of mini-jacks were observed in the Bull Run River in 2015 and 2016, but not in 2018 (the year when returning mini-jacks would have contributed to a smaller adult return in 2020).

Gender reversal, generally male to female, can occur when developing embryos are exposed to high water temperatures or estrogen-imitating chemicals in the environment (Olsen et al. 2006). The possible role of either of these factors in influencing the Chinook Salmon sex ratio in the Bull Run River cannot be evaluated with current data.

Given the small number of carcasses typically recovered in the Bull Run River, it is also possible that the biased sex ratios observed in the past few years in the Bull Run River are entirely due to chance.

7.4.3 Prespawning Mortality

Two Chinook Salmon carcasses were recovered in the Bull Run River in 2020 that had died before spawning. One of the fish appeared to be a hooking mortality, with a fishing hook causing a significant injury in its belly.

This year appears to have been an exception to the previously observed relationship between water temperature and prespawning mortality of spring Chinook Salmon in the Bull Run River, whereby prespawning mortality increases when the annual maximum seven-day average of daily maximum stream temperature is above 19.5°C (Figure 12, Table 5).

There is a growing body of research indicating that high water temperatures, often expressed as the annual peak seven-day average of daily maximum temperatures (7DADM), contribute to mortality of adult salmon on spawning grounds (Bowerman et. al. 2017). The maximum 7DADM in the lower Bull Run River in 2020 between June 1 and October 31 was 17.7°C.

PWB compared prespawning mortality from the lower Bull Run River to values obtained from the entire Sandy River Basin (including the Bull Run River). Sandy River Basin data were provided by ODFW (Luke Whitman, personal communication). The percentage of prespawning mortality in both the Bull Run River and the greater Sandy River basin was low in 2020. The mean value for the Bull Run, from 2010–2020, has not been significantly different from the mean value for the Sandy River basin (paired t-test$_{\text{two-tailed}}$ p=0.31). Prespawning mortality in the Bull Run ranged from 0 percent to 11 percent, while it ranged from 1 percent to 6 percent in the greater Sandy River basin, for that time period. The percentage of prespawning mortality in the Bull Run River has not been significantly correlated with percentage of prespawning mortality throughout the

Sandy River (including the Bull Run) since 2010 (Table 5, p=0.81). Data have been insufficient outside the Bull Run River to attempt to correlate Sandy River–scale prespawning mortality data with water temperature.

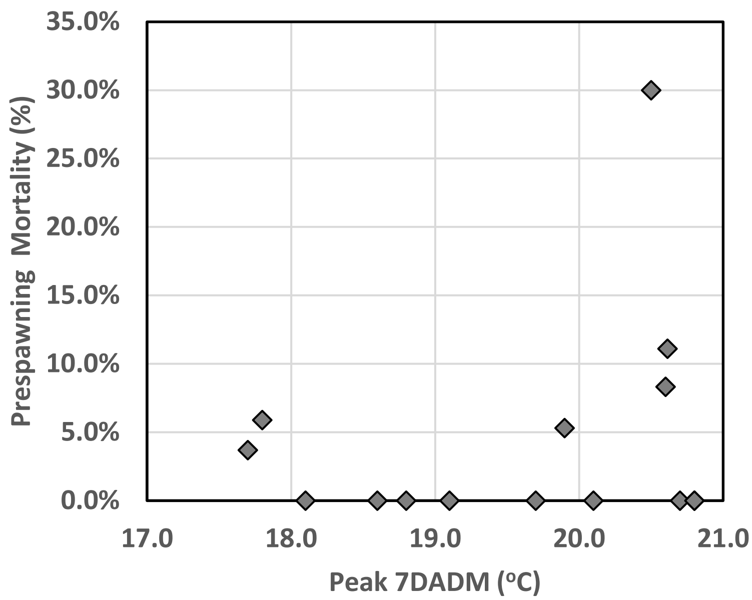

Figure 12. Relationship between peak seven-day average daily maximum stream temperature (7DADM) and prespawning mortality in the Lower Bull Run River, 2006–2020

Table 5. Peak 7DADM and corresponding observed prespawning mortality, 2006–2020

Year	Peak 7DADM (June 1–Oct 31; °C)	Prespawning mortality (Bull Run R.)	Prespawning mortality (Sandy R.)	Spring Chinook minimum escapement estimate
2006	20.6	8.3%		82
2007	20.5	30.0%		39
2008	18.6	0.0%		38
2009	20.8	0.0%		70
2010	19.7	0.0%	4.6%	77
2011	20.1	0.0%	5.1%	85
2012	20.6	11.1%	5.6%	33
2013	20.7	0.0%	4.7%	64
2014	18.8	0.0%	5.7%	37
2015	20.8	0.0%	5.7%	66
2016	18.1	0.0%	1.2%	63

2017	19.1	0.0%	3.0%	42
2018	19.9	5.3%	1.0%	48
2019	17.8	5.9%	3.1%	15
2020	17.7	3.7%	1.5%	121

7.5 ODFW Weir and Holding Adult Chinook

The ODFW weir located at Dodge Park appeared to be effective at capturing adult fish while it was in operation. However, hatchery spring Chinook entered the lower Bull Run River before the weir was installed. The weir was installed on June 3. Two snorkel surveys were conducted in the lower Bull Run River during the summer after installation of the weir. Their results are summarized in Table 6. Between the first and second snorkel survey, the count of adult Chinook holding in the lower Bull Run River increased from 44 to 69. A total of 23 wild Chinook was passed upstream between the two surveys, which accounts for most of the observed difference. The count of hatchery fish increased from 25 to 31, the difference probably coming out of the pool of fish for which adipose-clip status could not be determined ("unknown"). The snorkelers also felt that it was very possible that many fish could have been missed during surveys despite excellent visibility, due to the depth of many of the pools and the amount of large substrate cover in the lower river. The weir was inspected daily by ODFW personnel, showed no apparent gaps, and continued to catch adult fish throughout the summer (Table 7).

Table 6. Chinook adult counts from summer snorkel surveys conducted in the Lower Bull Run River in 2020

Date	# Hatchery adults	# Wild adults	# Unknown adults
July 18	25	6	13
August 21	31	9	29

Table 7. Weekly captures at ODFW weir at Dodge Park in 2020

Week	Chinook (wild)	Chinook (hatchery)	Coho (wild)	Coho (hatchery)	Steelhead (wild)	Steelhead (hatchery)
6/7/2020	0	6	0	0	0	0
6/14/2020	Weir not in operation					
6/21/2020	0	3	0	0	0	0
6/28/2020	2	32	0	0	1	0
7/5/2020	3	68	0	0	2	0
7/12/2020	1	101	0	0	5	0
7/19/2020	2	174	0	0	4	0
7/26/2020	7	128	0	0	1	0
8/2/2020	4	93	0	0	5	1
8/9/2020	5	38	0	0	0	0
8/16/2020	2	30	0	0	1	0
8/23/2020	2	25	0	0	1	0
8/30/2020	1	9	0	0	0	0
9/6/2020	7	28	0	0	0	0
9/13/2020	4	36	0	0	0	0
9/20/2020	4	17	1	0	0	0
9/27/2020	7	11	1	0	0	0
Total	51	799	2	0	20	1

8. Findings and Conclusions

The findings and conclusions directly address the key questions posed in Section 4.0:

- **How many Chinook Salmon adults enter the Bull Run River to spawn each year?**

  At least 136 adult Chinook salmon entered the Bull Run River upstream of the ODFW weir to spawn in 2020. The peak daily count of live adults plus carcasses during walking surveys was 93. These were the highest values for the two statistics observed in the lower Bull Run River since Marmot Dam was removed in 2007.

- **How many Chinook Salmon redds are built in the Bull Run River each year?**

  A total of 323 Chinook redds were identified in the Bull Run River in 2020.

- **What is the long-term trend (20 years) in spawning Chinook Salmon abundance?**

  The long-term (20-year) trend in spawning Chinook Salmon abundance will be calculated in 2028. The number of spawning Chinook Salmon in the lower Bull Run River shows no significant trend since the Marmot Dam removal in 2007.

- **What is the timing (range of dates and peak date) of adult Chinook presence and redd creation in the lower Bull Run River?**

  Live adult Chinook Salmon were observed in the Bull Run River between July 8 and December 9, 2020. The peak date was August 24, 2020. Chinook redds were observed between September 22 and December 9, 2020. The peak date for redd observation was October 21.

- **What percentage of the spawning Chinook Salmon are of hatchery origin (clipped adipose fin) and what percentage are female?**

  In 2020, the percentage of hatchery (clipped adipose fin) fish among the observed Chinook Salmon carcasses in which the condition of the adipose fin could be determined was 37.5 percent. The percentage of females among the observed Chinook Salmon carcasses in which sex could be determined was 69.6 percent.

- **What percentage of spring Chinook Salmon holding in the Bull Run River while the ODFW weir is in operation are of hatchery origin?**

  The largest percentage of hatchery fish observed among adult spring Chinook holding in Bull Run River during snorkel surveys was 80.7 percent of 44 fish, observed on July 8.

- **Is the ODFW weir effective at excluding hatchery spring Chinook from the Bull Run River?**

  In 2020, up to 31 hatchery spring Chinook were observed holding the Bull Run River during the summer, presumably having entered the river before the ODFW weir was installed. The number of spring Chinook (hatchery, wild, and unknown) observed during snorkel surveys did not appear to increase between snorkel surveys more than could be accounted for. This suggests that many fish were able to enter the river before the weir was installed, but the weir was effective at excluding them while in operation.

- **What percentage of the spawning spring Chinook Salmon are of hatchery origin (clipped adipose fin)?**

  In 2020, the percent of hatchery (clipped adipose fin) fish among the observed Chinook Salmon carcasses—for which the condition of the adipose fin could be determined and assuming that only carcasses observed on or before November 1 were spring Chinook—was 54.1 percent (of 74 carcasses). This was in the middle of the range of past years' percentages observed in the lower Bull Run River.

- **Was prespawning mortality of spring Chinook Salmon observed in 2020? What is the relationship between stream temperature and observed prespawning mortality in the lower Bull Run River? Is prespawning mortality in the lower Bull Run River different from what has been observed in the greater Sandy River Basin?**

Of the 54 recovered female spring Chinook carcasses recovered in 2020 for which spawning status could be determined, two were prespawning mortalities (3.7 percent). This was the second year when prespawning mortality among female Chinook salmon was observed when the seven-day average of daily maximum stream temperature was below 19.5°C. The highest seven-day average observed in the Bull Run in 2020 was 17.3°C between August 15 and October 31. The female Chinook that died before having the opportunity to spawn were wild. One appeared to be a hooking mortality. Between 2010 and 2020, the incidence of prespawning mortality in the Bull Run River has not been statistically different from or correlated with prespawning mortality in the greater Sandy River basin.

9. Works Cited

Bowerman, Tracy, Adrienne Roumasset, Matthew L. Keefer, Cameron S. Sharpe & Christopher C. Caudill (2017): Prespawn Mortality of Female Chinook Salmon Increases with Water Temperature and Percent Hatchery Origin, Transactions of the American Fisheries Society, DOI: 10.1080/00028487.2017.1377110

Olsen, Jeffrey B., Steve J. Miller, Ken Harper, Kevin Van Hatten, Kellie Whitton, James J. Nagler, and John K. Wenburg. "Sex Ratios of Juvenile and Adult Chinook Salmon in the Kuskokwim and Yukon Rivers." *US Fish and Wildlife Service*, 2006.

Oregon Department of Fish and Wildlife. "Final Hatchery and Genetic Management Plan: Spring Chinook." 2011.

Portland Water Bureau. "Bull Run Water Supply Habitat Conservation Plan for the Issuance of a Permit to Allow Incidental Take of Threatened and Endangered Species." 2008.

Schroeder, R. Kirk, Ken R. Kenaston, and Lisa K. Krentz. "Spring Chinook Salmon in the Willamette and Sandy Rivers." Oregon Department of Fish and Wildlife *Fish Research Report* F-163-R-10 (2005).

Appendix C

Bull Run HCP Monitoring Report

Sandy River Basin Smolt Monitoring

July 2021

Burke Strobel
City of Portland Water Bureau

Photo (left) of Mount Hood and Sandy River provided by Josh Kling/Western Rivers Conservancy

Photo (right) of the Gordon Creek smolt trap provided by the Portland Water Bureau

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1. Summary

The Portland Water Bureau (PWB), the US Forest Service (USFS), and the Oregon Department of Fish and Wildlife (ODFW) collaborated in 2020 to continue a long-term study monitoring steelhead and Coho smolt production for the Sandy River Basin in Oregon. The study, initiated in 2009, is intended to detect declines or increases in abundance and productivity of smolts at the basin scale and to provide useful data at the tributary scale to guide restoration efforts. The sampling design involves monitoring different sets of tributaries every year. Some tributaries are monitored every year; others are monitored on an irregularly rotating basis. The study is intended to provide basin-scale trends after 20 years.

Smolt numbers, fork length, condition factors, and emigration timing were monitored using rotary smolt traps in five streams: Cedar Creek, Little Sandy River, Bull Run River, Gordon Creek, and Beaver Creek. Safety issues associated with the 2020 COVID-19 pandemic precluded scheduled monitoring on Clear Fork Sandy, Lost Creek, and Clear Creek. Clear Creek was operated for eight days before restrictions ended monitoring. Population estimates, fork length distributions, and emigration statistics were calculated for steelhead and Coho smolts in all five streams. The average age of smolts was calculated by aging fish using fish scale samples collected between 2009 and 2019.

Trapping efforts were hampered in 2020 by safety and logistics issues arising from the COVID-19 pandemic and high-flow and low-flow periods in all streams.

Preliminary Sandy River Basin–level population estimates were calculated for each year from 2009 to 2020. Freshwater productivity (smolts per adult) was also estimated, with the help of age data, for steelhead adult year classes 2010 to 2018 and for Coho adult year classes 2007 to 2018.

Steelhead and Coho smolts from different streams in the Sandy River Basin showed significant differences in weighted mean fork length of smolts. Neither species showed a correlation between stream elevation and weighted average fork length in 2020, but the spread in stream elevations without data from upper basin streams was much less than usual.

Steelhead and Coho smolts from different streams in the Sandy River Basin also showed significant differences in mean condition factors. Condition factors were not significantly correlated with fork length for either species, unlike in previous years when a negative correlation has been observed.

Steelhead smolts emigrated earlier than Coho smolts, on average, in all streams but the Little Sandy. Neither Coho nor steelhead smolts showed a clear tendency to emigrate from lower-elevation streams earlier than from higher-elevation streams, as has been observed in the past. No data were collected, however, from the highest elevation streams in the upper basin in 2020.

High-elevation streams have a larger proportion of older age steelhead and Coho smolts than low-elevation streams. Length-at-age calculations have revealed that steelhead smolt fork lengths tend to be shorter on average for a given age in higher-elevation streams than in lower elevation streams, but this fact is masked by their older average age.

2. Introduction

2.1 Background

In 2019, the Portland Water Bureau, the Mount Hood National Forest, and the Oregon Department of Fish and Wildlife continued collaboration on a long-term study, monitoring steelhead and Coho smolt production throughout the Sandy River Basin in Oregon. The Sandy River enters the lower Columbia River just east of Portland, Oregon, and includes several large tributaries—the Bull Run, Salmon, and Zigzag rivers—as well as many smaller tributaries such as Beaver, Cedar, Clear, Gordon, and Lost creeks, and the Clear Fork Sandy River.

Smolt monitoring has been conducted in various Sandy River tributaries in the past. The USFS has monitored smolt production continuously in Still Creek, a tributary of the Zigzag River, since 1989 and sporadically in the Clear Fork Sandy River, Lost Creek, and the Salmon River. The purpose of these efforts originally included monitoring the benefits of stream restoration projects and, more recently, supporting efforts to evaluate the effects of the removal of Marmot Dam in 2007. The USFS also operated a smolt trap on the Little Sandy River in 2007 and 2008, upstream of a diversion dam operated as part of Portland General Electric's Bull Run Hydroelectric Project. The Portland Water Bureau has operated a smolt trap in the Bull Run River near its mouth since 2008 and assumed the management of the Little Sandy River trap in 2009. Two related factors led to an expansion of salmonid smolt monitoring in the Sandy River Basin, beginning in 2009. The first was the formation of the Sandy River Basin Partners in 1999—a group intended to coordinate the fish and fish habitat management efforts of various agencies and groups. This coordination led to a broadening of the monitoring focus to better correspond with an emerging holistic approach to watershed restoration and to mesh with other programs that collect biological information at a basin scale. The second factor was that PWB created the Bull Run Water Supply Habitat Conservation Plan (HCP; Portland Water Bureau 2008) in 2008 to bring its municipal water supply operations in the Bull Run River into compliance with the Endangered Species Act and the Clean Water Act.[1] Among the many measures detailed in the HCP is a commitment to contribute resources toward smolt monitoring in the Sandy River Basin.

[1] You can read more about the HCP on our website.

Monitoring smolt production can benefit a number of management efforts on many spatial scales, including viability analyses and adaptive restoration. Given limited resources, however, managers face potential trade-offs between collecting smolt information that is meaningful at the population scale (that is, enumerating smolts at the mouths of large rivers) and collecting smolt information at a scale that is most meaningful to individual restoration efforts (that is, enumerating smolts in tributaries). The sampling plan adopted by the monitoring subgroup of the Sandy River Basin Partners is intended to provide information at both scales in order to maximize the usefulness of the data-collection effort. The sampling plan is summarized in the HCP Appendix F (Portland Water Bureau 2008).

2.2 Goal and Objectives

The goal of the Sandy River smolt monitoring project is to contribute to the viability assessment of salmonid stocks in the Sandy River Basin and support their adaptive management. The objectives of the Sandy River Smolt Monitoring project are to

- collect information to assess the long-term (20-year) trend in steelhead and Coho smolt populations for as much of the Sandy River Basin as possible (population scale),
- collect information to assess the long-term (20-year) trend in steelhead and Coho smolt populations at the scale of individual tributaries (tributary scale),
- evaluate steelhead and Coho smolt production of individual tributaries relative to one another (tributary scale),
- evaluate steelhead and Coho smolt physical quality from individual tributaries relative to one another (tributary scale), and
- determine the values of various life-history characteristics at the scale of individual tributaries in the Sandy River Basin (tributary scale).

The proximate objectives each year will be to determine the values for the following variables for each stream that is trapped:

- Smolt population (for every salmonid species possible)
- Mean fork length (by species)
- Mean condition factor ($[\text{weight}/(\text{fork length}^3)] \times 100{,}000$)
- Mean date of emigration (by species)

Beginning in 2014, a collaboration between PWB and ODFW provided age information from scale samples collected by PWB, USFS, and ODFW between 2009 and 2018. This information allowed the pursuit of an additional life-history objective:

- Determine the mean age at emigration for steelhead and Coho smolts

2.3 Sample Area and Scope

2.3.1 Study Area

The portions of the Sandy River Basin that are accessible to anadromous fish include approximately 190 miles of streams and rivers spanning a wide range of environments from cold, high-elevation, high-gradient streams in wilderness areas to warm, low-gradient, and tidally influenced streams within the Portland urban growth boundary, as indicated in Figure 2. About 30 percent of these stream miles are influenced by glacial runoff, often with high turbidity (Portland Water Bureau 2008).

2.3.2 Sample Area

Not all of the Sandy River Basin that is accessible to anadromous fish is included in the sample area. Streams selected for smolt sampling total 106 miles, or 56 percent of the total habitat in the Sandy River accessible to anadromous fish. Over 80 percent of the clear water stream miles are included. Clear water streams are streams not influenced by glacial runoff. These are the streams expected to contribute most to total smolt production due to the suitability of spawning habitat (Suring et al. 2006) and relatively greater primary productivity and ease of locating prey. The remaining clear water streams are generally small, have relatively high gradients, and are not expected to produce a large number of salmon or steelhead smolts. This sample area covers nearly the full range of environmental conditions that salmon and steelhead encounter in the Sandy River Basin and is considered by the Sandy River Basin Partners monitoring group to constitute a representative index for the entire basin for steelhead and Coho. It also closely corresponds with the area for which steelhead and Coho spawner counts are developed annually by ODFW (Suring et al. 2006, Hutchinson et al. 2007). The sample area covered by the Sandy River Basin Smolt Monitoring effort is henceforth referred to as the Sandy River Basin Index Area. The products of this effort eventually will be applicable to the entire index area. Information that is collected will be immediately applicable at the scale of individual tributaries.

Figure 1. The Little Sandy trap operating approximately 500 feet upstream of the site of the old diversion dam.

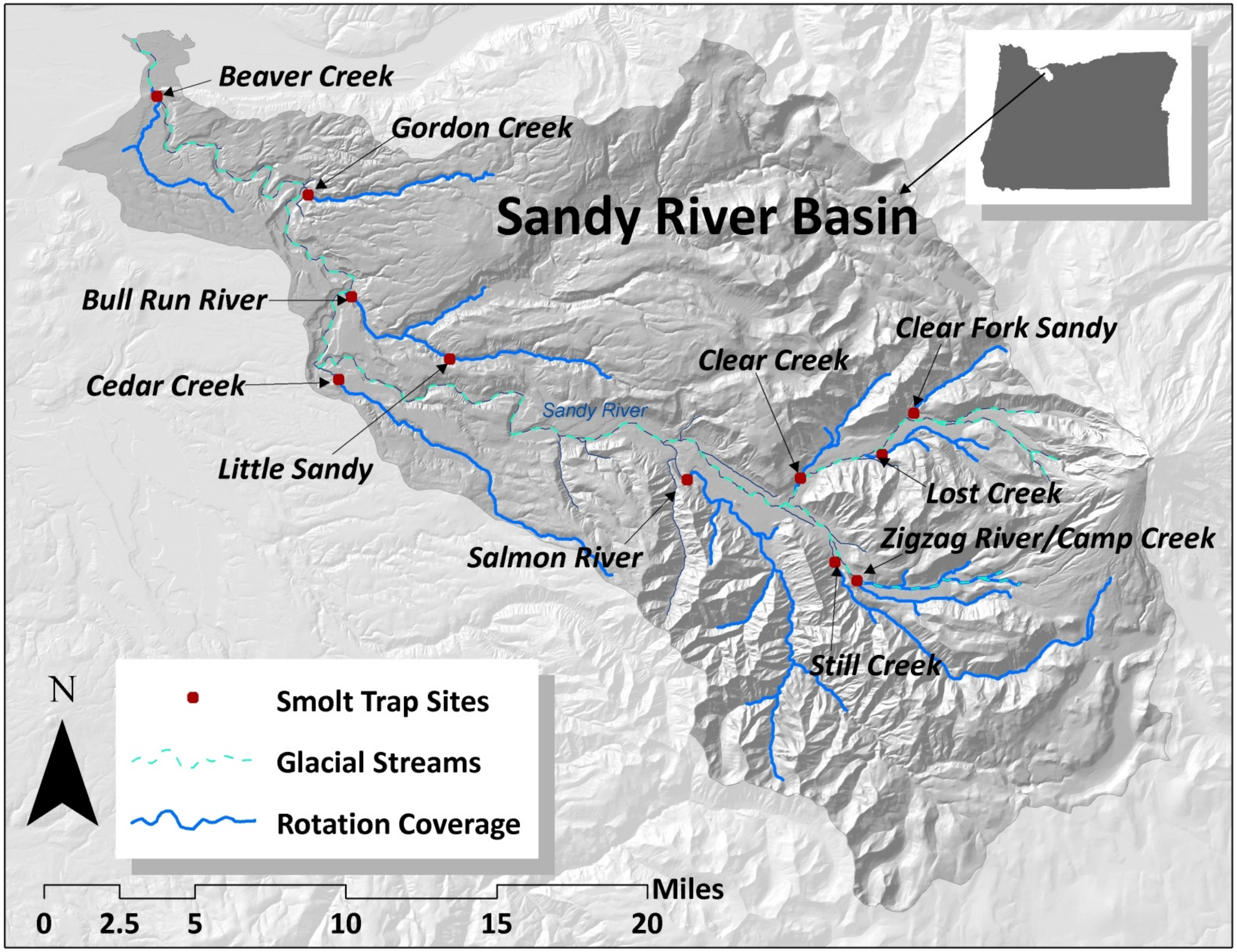


Figure 2. Sandy River Basin—smolt trap sites, streams covered by rotating smolt trap study, and streams receiving glacial runoff

3. Methods

3.1 Sampling

Juvenile outmigrant (JOM) sampling in the Sandy River Basin is implemented following a carefully coordinated, long-term sampling schedule, using methods that are consistent across geography and time. Sampling protocols follow existing guidelines and precedents (e.g., Thedinga et al. 1994 and Volkhardt et al. 2007). The sampling schedule was reviewed and improved through the ODFW Research Laboratory, Corvallis, Oregon.

3.1.1 Sampling Schedule

Eleven streams were identified by the monitoring subgroup as being feasible and appropriate for operating a smolt trap. These streams are summarized in Table 1.

Table 1. Streams sampled for salmon and steelhead smolts, with miles of anadromy upstream of each trap site, sampling category, range of elevations of anadromous reaches, and average gradient

Stream	Upstream miles used by anadromous fish	Sampling category[a]	Anadromous elevation range (feet above mean sea level)	Average gradient
Bull Run River (without the Little Sandy River)	7.5	Fixed	240–700	1.3%
Little Sandy River	5.9	Fixed	430–1,600	2.9%
Cedar Creek	13.2	Fixed	360–3,240	4.1%
Clear Fork Sandy River	4.3	Rotation	2,130–3,390	5.4%
Lost Creek	4.9	Rotation	1,770–2,660	3.7%
Clear Creek	5.5	Rotation	1,440–2,780	4.6%
Still Creek	8.7	Rotation	1,580–3,120	3.1%
Zigzag River/Camp Creek	16.4	Rotation	1,840–3,360	4.1%
Salmon River	24.0	Rotation	1,010–1,850	1.2%
Gordon Creek	7.4	Rotation	100–1,630	4.0%
Beaver Creek	7.7	Rotation	20–550	1.3%

[a] Sampling category: Fixed=sampled annually, rotation=sampled according to rotating schedule

It is anticipated that at least seven smolt traps will be operated each year. The provisional sampling schedule is summarized in Table 2. Three trap locations are fixed and operated every year because of additional monitoring needs. The Bull Run River and Little Sandy River are monitored annually to meet specific commitments in the HCP. Cedar Creek has been monitored annually as a part of the Sandy River Hatchery Genetic Management Plan and to document recolonization by salmon and steelhead since 2010 when adult salmon and steelhead were again allowed access to historical habitat blocked by the ODFW hatchery at river mile 1.5.

Table 2. Provisional schedule for sampling major tributaries in the Sandy River Basin[a]

Year	Cedar Creek	Little Sandy River	Bull Run River	Clear Fork Sandy River	Lost Creek	Clear Creek	Still Creek	Zigzag River/ Camp Creek	Salmon River	Gordon Creek	Beaver Creek
2009		x	x		x	x	x			x	
2010		x	x	x				x	x		x
2011		x	x		x		x	x		x	
2012		x	x				x	x	x		x
2013	x	x	x	x	x				x	x	
2014	x	x	x			x	x	x			x
2015	x	x	x	x	x		x				x
2016	x	x	x			x			x	x	x
2017	x	x	x		x	x			x		
2018	x	x	x		x	x			x		x
2019	x	x	x	x			x	x		x	
2020	x	x	x	x	x	x					x
2021	x	x	x	x		x		x		x	
2022	x	x	x	x			x		x	x	
2023	x	x	x				x		x	x	x
2024	x	x	x	x		x	x		x		
2025	x	x	x		x	x		x		x	
2026	x	x	x	x	x			x			x
2027	x	x	x		x			x		x	x
2028	x	x	x	x		x	x		x		

[a] Schedules for years 2009, 2010, 2018, 2019, 2027, and 2028 (shaded gray) are fixed, but the remaining years may be changed to accommodate other monitoring needs as long as all sites scheduled for a given year remain grouped together as a unit.

This smolt monitoring plan extends the reference area of the remaining four traps by rotating them among eight streams according to the following constraints (assuming that Camp Creek and the Zigzag River are combined):

- Each site will be trapped, on average, every other year.
- All sites will be trapped once in the first two years, once in the middle two years, and once in the last two years of a 20-year period.

Rotated sites will be trapped according to a schedule that maximizes the pair-wise comparisons between them.

The original provisional smolt trap rotation schedule established in 2009 was adjusted in 2011 to accommodate logistical needs. The group of traps scheduled for 2011 was traded with that scheduled for 2021. Table 2 reflects the new schedule. Additional sites may also be trapped if resources allow. For instance, Still Creek had been trapped every year until 2020 because of the particular value of the resulting data. Since 2016, both Beaver Creek and Gordon Creek also have been trapped every year.

3.1.2 Sampling in 2020

Smolt production was monitored in Cedar Creek, the Little Sandy River, the Bull Run River, Gordon Creek, and Beaver Creek in 2020. Monitoring had been scheduled on Clear Fork Sandy, Lost Creek, and Clear Creek but did not occur because of safety considerations associated with the 2020 COVID-19 pandemic. The trap on Clear Creek was operated for a total of eight days before being pulled. An eight-foot-diameter rotary trap was used on the Bull Run River. Five-foot-diameter rotary screw traps were used on all other streams. Screw traps modified with wooden pontoons and other trap parts were used on Gordon Creek and Beaver Creek to discourage metal theft. A motor was added to the Beaver Creek trap in 2015 to continue trapping despite low stream flows. The Cedar Creek trap was checked and maintained by ODFW staff. PWB staff checked and maintained the Little Sandy River, Bull Run River, Gordon Creek, and Beaver Creek traps. All traps were operated seven days per week throughout the season to the maximum extent possible. The periods of operation for each site are summarized in Table 3, together with the number of days that each trap was not in operation due to scheduling, high or low flows, or other considerations.

Figure 3. PWB personnel clean the Beaver Creek trap during high flows

A variety of factors contributed to time periods when traps were not in operation in 2020. COVID-19-related safety concerns and logistical difficulties led to a nearly two-week pause in the operation of PWB traps and the cancellation of monitoring efforts at USFS traps. Clear Creek was monitored for eight days in March before safety restrictions were implemented. High flows and windstorms led to traps being pulled for several days on all monitored streams.

The trapping season ended early in Little Sandy, Bull Run, Gordon Creek, and Beaver Creek because of low water and a lack of smolts.

Table 3. Dates of operation and the number of days traps did not operate in the Sandy River Basin in 2020

Stream[a]	Trap In	Trap Out	Down Time (Days)
Clear Creek	March 18	March 27	2
Cedar Creek	April 1	June 11	6
Little Sandy River	March 8	June 4	22
Bull Run River (without the Little Sandy River)	March 8	June 3	24
Gordon Creek	March 8	June 4	18
Beaver Creek	March 8	May 29	21

[a] Streams are presented in order from highest-elevation Clear Creek to lowest elevation Beaver Creek.

3.1.3 Data Collection

Traps were checked daily, and all fish were removed from the trap's live well. Fish were anesthetized using Alka-Seltzer Gold (buffered sodium bicarbonate). The following data were collected for most fish:

- Species
- Life stage (smolt, juvenile, fry, or adults)
- Fork length (mm)
- Weight (g)
- Fin marks given or observed (see Mark-Recapture Study section below)
- Comments (e.g., injuries, pathogens, etc.)

Life stage was determined using external characteristics. Smolts show a general silvering, fading of parr marks, and a darkening of the posterior edge of the caudal fin. Juveniles are small fish, but they are larger than 50 millimeters (mm) and show none of the above smolt characteristics. Fry are 50 mm or less. At times, and especially early in the season, steelhead smolts were just beginning to develop their characteristics and could be difficult to distinguish from juveniles. In these borderline cases, the following rule set was applied:

> If a steelhead has a fork length longer than 130-mm consider it a smolt unless there are absolutely no signs that smoltification may have begun, in which case consider it a juvenile. If a steelhead is 130 mm or less, consider it a juvenile, unless there are clearly signs of it being a smolt.

Tissue and scale samples were collected from steelhead and Coho smolts at all sites. Scale samples were collected from 10 individual fish in each 10-millimeter fork-length increment throughout the fork length range of both steelhead and Coho smolts at each trap site. Approximately 50 steelhead and 50 Coho tissue samples are collected each year from each monitored trap site.

The ages of sampled fish are determined from scale samples by the ODFW Fish Life History Analysis Project laboratory in Corvallis, Oregon. The ages of smolts sampled between 2009 and 2019 were determined and are incorporated into this report.

3.1.4 Mark–Recapture Study

An ongoing trap efficiency study was conducted throughout the trapping season to determine the proportion of the outmigration that was being captured in the traps. Following a modified mark–recapture protocol, up to 25 smolts of each species at each site each day were given a fin mark specific to the day of the week. An alternative marking schedule was piloted at Cedar Creek, where two fin clip locations were alternated at two-week intervals. Marked fish were subsequently released from approximately 0.1 to 1.5 miles upstream of the trap, depending on access to appropriate release sites. Fins were marked either with small clips or injected dye. Captured fish were sorted each day to look for fin marks from previous days' releases.

In deciding to mark fish for the trap efficiency study with only seven specific fin-clip markings—one for each weekday—researchers assumed that all marked fish would travel from the release point to the trap within seven days. An analysis of the recapture data appears to bear this assumption out. Most fish appeared to be recaptured after one to three days, with very few indicating a travel time of four or more days. The consequences of some fish taking more than seven days to travel from the release point to the trap are reduced by pooling adjacent weeks together into two-week mark–recapture periods. The alternative marking schedule involving two fin clips is simpler to implement and avoids some of the risk of assigning recaptures to the wrong marking stratum while losing some information on transit time.

Figure 4. PWB personnel process fish at the Bull Run River trap

3.2 Assumptions

The mark–recapture procedures are subject to the same limitations inherent to all similar studies. The model assumes the following:

- The target species and life stages are actively moving downstream (equivalent to the "closed population" requirement of the Peterson estimator, discussed in Volkhardt et al. 2007).
- All fish in a capture period (stratum) of a given species and life stage have equal probability of first-time capture.
- Marking fish does not affect their catchability (that is, they do not suffer mortality between marking and potential recapture).
- Marked and unmarked fish traveling together have an equal probability of recapture (that is, fish do not become "trap-shy" or "trap-happy," leading to overestimated or underestimated populations, respectively).
- Fish do not lose their marks.
- All recaptured marked fish are recognized.

3.3 Data Analysis

3.3.1 Smolt Population Estimation

Smolt population sizes for individual streams are estimated using Darroch Analysis with Rank Reduction for R (DARR 2.0.2, Bjorkstedt 2010), a program provided by the National Marine Fisheries Service. DARR 2.0.2 relies on a stratified Peterson estimator for mark–recapture data. Prior to calculation of the estimate, however, time periods are aggregated following rules designed to avoid the pitfalls associated with small populations and low recapture rates.

In the Sandy River Basin, fish total captures (C) and marks (M) are stratified by two-week time periods to reduce variation associated with flows, water temperature, and changing fish behavior. The associated recaptures (R) are identified by both the time period in which they originated and the time period in which they are recaptured, resulting in a recapture matrix. The Darroch estimator uses the recapture matrix to estimate the number of marked fish passing the trap during a given time period. The total estimate is the sum of the individual time period estimates. Details of the calculation of the total estimate and its variance are fully described in Bjorkstedt (2005).

For the special cases in which all recaptures occur in the same stratum from which they originated (all nonzero values occur along the middle diagonal of the recapture matrix), the Darroch estimator reduces to a simple Peterson estimator (Equation 1: where N refers to population estimate, and the subscript s refers to the stratum):

$$\text{Stratum estimate } (N_s) = C_s\,(M_s / R_s) \qquad \text{(Equation 1)}$$

In the special case where pooling of strata leads to only one stratum, DARR 2.0.2 essentially uses the Chapman estimator (Equation 2), which avoids some of the biases of the simple Peterson estimator. This was the case with the steelhead smolt estimate at Beaver Creek and Cedar Creek in 2020.

$$\text{Stratum estimate } (N) = (C+1)[(M+1)/(R+1)] - 1 \qquad \text{(Equation 2)}$$

There were several days at each site when certain smolt traps were not in operation because of damage, potential damage, or scheduling issues (see Table 3). For these days, the daily smolt output was estimated using a two-week running average of daily population estimates (daily total capture without recaptures ÷ trap $\text{efficiency}_{\text{stratum}}$; with trap efficiency provided by DARR 2.0.2). Only days with actual captures within seven days before and after a particular date were included in the running average of daily population estimates and the average had to include at least two days. The variance of downtime estimates was calculated by adding the variances of each daily estimate, which, in turn, was added to the variance provided by DARR to produce 95 percent confidence intervals for each smolt population estimate.

The Sandy River Basin Smolt Monitoring Plan is designed to produce Sandy River Basin–level (index area) smolt populations estimates, population trend estimates, and freshwater productivity estimates (smolts per adult) after 20 years of annual smolt monitoring. Preliminary calculations, however, can be made now. The preliminary calculations illustrate the process of filling gaps in each time series of subbasin estimates and the process of adding individual subbasin population estimates in a given year together to produce a Sandy River Basin–level estimate.

The Sandy River Basin Smolt Monitoring Plan sampling schedule (Table 2) results in gaps that must be filled in each subbasin's time series of population estimates. These gaps were filled in 2020 by using the average and the associated variance of all past population estimates for each respective subbasin. The number used to fill gaps in a given trap's time series of population estimates is henceforth referred to as a "gap estimate." For each year between 2009 and 2020, all subbasin smolt trap estimates and gap estimates were summed by species to calculate Sandy River Basin–level population estimates for steelhead and Coho smolts. The variances associated with each smolt trap estimate and each gap estimate were similarly summed by species to calculate a variance for each Sandy River Basin–level population estimate. Gap estimates will be recalculated in the future, once more subbasin estimates are available, to retroactively produce refined Sandy River Basin–level smolt population estimates.

Estimates of the number of adult steelhead and Coho spawners in the Sandy River Basin for each parent generation that produced the steelhead and Coho smolts monitored in 2009 through 2018 were used to tentatively calculate freshwater productivity (smolts per adult) for as many adult spawner years as possible. Adult steelhead and Coho spawner estimates were obtained from the ODFW Oregon Adult Salmonid Inventory & Sampling (OASIS) Program. The adult steelhead and Coho spawner estimates correspond to approximately the same geographic reference frame (index area) as the Sandy River Basin Smolt Monitoring Plan.

3.3.2 Smolt Fork Lengths

Weighted average fork lengths for all smolt populations were calculated. Smolt fork lengths for each site were compiled and then weighted by capture stratum using trap efficiency (provided by DARR 2.0.2). If trap efficiency for a given stratum was low, the weights for fish captured in that stratum were weighted more heavily. This prevented strata with few fish but high trap efficiencies, for example, from influencing the average more than strata with many fish but low trap efficiencies. Fork lengths of actual captures were compared among streams using analysis of variance (ANOVA). If the resulting F statistic was found to be significant at an α level of 0.05, a Tukey test was applied to all combinations of pairs of streams to determine how average fork lengths of captured fish differed from one another.

3.3.3 Smolt Condition Factors

Condition factors (K) were determined for all steelhead and Coho smolts by basin using weights (W) and fork lengths (L) according to the following formula:

$$K=(W/L^3) * 100{,}000 \qquad \text{(Equation 3)}$$

Condition factors give an indication of how thin or fat a fish is. Condition factors were compared among basins by statistically testing for differences using ANOVA. If the resulting F statistic was found to be significant at an α level of 0.05, a Tukey test was applied to determine how mean condition factors differed from each other. Condition factors were not weighted by capture stratum using trap efficiency because of the analytical complexities involved.

3.3.4 Emigration Dates

Steelhead and Coho smolt mean and peak emigration dates were calculated for each site. The mean emigration date was defined as the sum of the product of daily captures corrected for stratum efficiency (C) and the date of capture (D) on any given day (i for days 1–k), divided by the sum of corrected captures using the following formula:

$$\sum_{i=1}^{k}(CD)_i \Big/ \sum_{i=1}^{k} C_i \qquad \text{(Equation 4)}$$

The peak emigration date was defined as the day when most fish of a species and condition were estimated to have passed the trap site (daily captures corrected for stratum trap efficiency).

4. Results

4.1 Smolt Population Estimation

4.1.1 Trap Efficiencies

The efficiencies of traps varied across sites and time. Trap efficiencies are summarized in Table 4 for each site and two-week trapping period. Period 1 for each site started the Sunday of the week that trapping began for the respective site (see Table 3 for start dates). Given a certain number of marked fish, the higher the trap efficiency, the more precise the population estimate. A trap efficiency of at least 0.1 and preferably closer to 0.25 is desirable. The precision of estimates from traps with lower efficiencies can be greatly improved by marking a large number of individuals, such as in the Bull Run River.

Table 4. Trap efficiencies for each site, species, and two-week trap period in 2020

		Period						
Site[a]	Species	1	2	3	4	5	6	7[b]
Cedar Creek	Steelhead	0.053	0.053	0.053	0.053	0.053	0.053	—
	Coho	0.258	0.172	0.198	0.182	0.400	0.400	—
Little Sandy River	Steelhead	0.073	0.073	0.073	0.073	0.101	0.101	—
	Coho	0.079	0.079	0.079	0.079	0.158	0.158	—
Bull Run (without Little Sandy River)	Steelhead	0.027	0.027	0.027	0.027	0.220	0.036	—
	Coho	0.081	0.081	0.081	0.081	0.081	0.121	—
Gordon Creek	Steelhead	0.217	0.217	0.250	0.167	0.115	0.115	—
	Coho	0.346	0.346	0.346	0.379	0.357	0.305	—
Beaver Creek	Steelhead	0.048	0.048	0.048	0.048	0.048	0.048	—
	Coho	0.200	0.200	0.200	0.271	0.194	0.194	—

[a] Streams are presented in order from highest-elevation Cedar Creek to lowest-elevation Beaver Creek.

[b] There was no seventh two-week trapping period in any stream because traps were not operated long enough due to low flows, lack of fish, or other factors.

4.1.2 Subbasin Population Estimates

Monitored smolt production was moderate to relatively high for steelhead and Coho in 2020. The Bull Run River had the highest number of steelhead smolts and Cedar Creek had the highest number of Coho smolts of any streams monitored in 2020 (Table 5). Little Sandy produced more steelhead smolts than in any previous monitored year (Table 9). Cedar Creek, Little Sandy, and the Bull Run River all produced more Coho smolts than in any previous monitored year. Beaver Creek had a relatively low Coho smolt estimate in

2020. All other streams produced moderate numbers of steelhead and Coho smolts. Exhibit A summarizes the total captures at all trap sites.

A portion of the emigration of smolts from several streams may have been missed. A small number of steelhead smolts were caught on the first day of trapping in the Little Sandy and Gordon Creek. Coho smolts were caught on the first day of trapping in Cedar Creek, Gordon Creek, and Beaver Creek. Steelhead and Coho smolts were captured on the last day of trapping in the Bull Run River. Trapping in each of these streams in 2020 coincided with the period of spring smolt emigration observed in the past, so it is likely that the proportion of the population that was missed was small. No downtime estimate could be calculated for one day of downtime on the Bull Run River and two days of downtime on Beaver Creek because there were not at least two days to include in the average.

The variances associated with estimates in several streams were large relative to the estimates themselves in 2020. Steelhead estimates tended to be less precise than Coho estimates, given similar population sizes, because of lower trap efficiencies for steelhead than for Coho (see Table 4). The Beaver Creek estimate was the least precise for steelhead, and the Little Sandy was least precise for Coho. Lack of precision was generally due to a combination of low marking rates due to small population sizes and low trap efficiencies.

Table 5. Steelhead and Coho smolt population estimates and 95% confidence intervals for 2020

	Steelhead		Coho	
Stream[a,b]	**Estimate**	**95% CI**	**Estimate**	**95% CI**
Cedar Creek	281	87%	4,189	18%
Little Sandy River	2,668	44%	1,352	70%
Bull Run River (without Little Sandy)	21,783	49%	4,058	52%
Gordon Creek	1,139	35%	1,362	13%
Beaver Creek	960	97%	454	36%

[a] Confidence intervals are expressed as percentages of the associated estimates.

[b] Streams are presented in order from highest-elevation Cedar Creek to lowest-elevation Beaver Creek.

Of all streams monitored in 2020, steelhead smolt production per unit of stream length and per unit of surface area was highest in the Bull Run River, as summarized in Table 6. Little Sandy had the second highest estimates for both per unit length and area production, but estimates were an order of magnitude lower than the Bull Run's. Cedar Creek had the lowest steelhead smolt production per unit of length and surface area.

Table 6. Steelhead and Coho smolts per mile and smolts per 1,000 ft^2 for 2020

	Steelhead		Coho	
Streams[a]	**Smolts/mile**	**Smolts/1,000 ft^2**	**Smolts/mile**	**Smolts/1,000 ft^2**
Cedar Creek	19.12	0.10	284.97	1.47
Little Sandy River	452.20	1.36	229.15	0.69
Bull Run River	2624.46	5.63	488.92	1.05

Table 6. Steelhead and Coho smolts per mile and smolts per 1,000 ft² for 2020

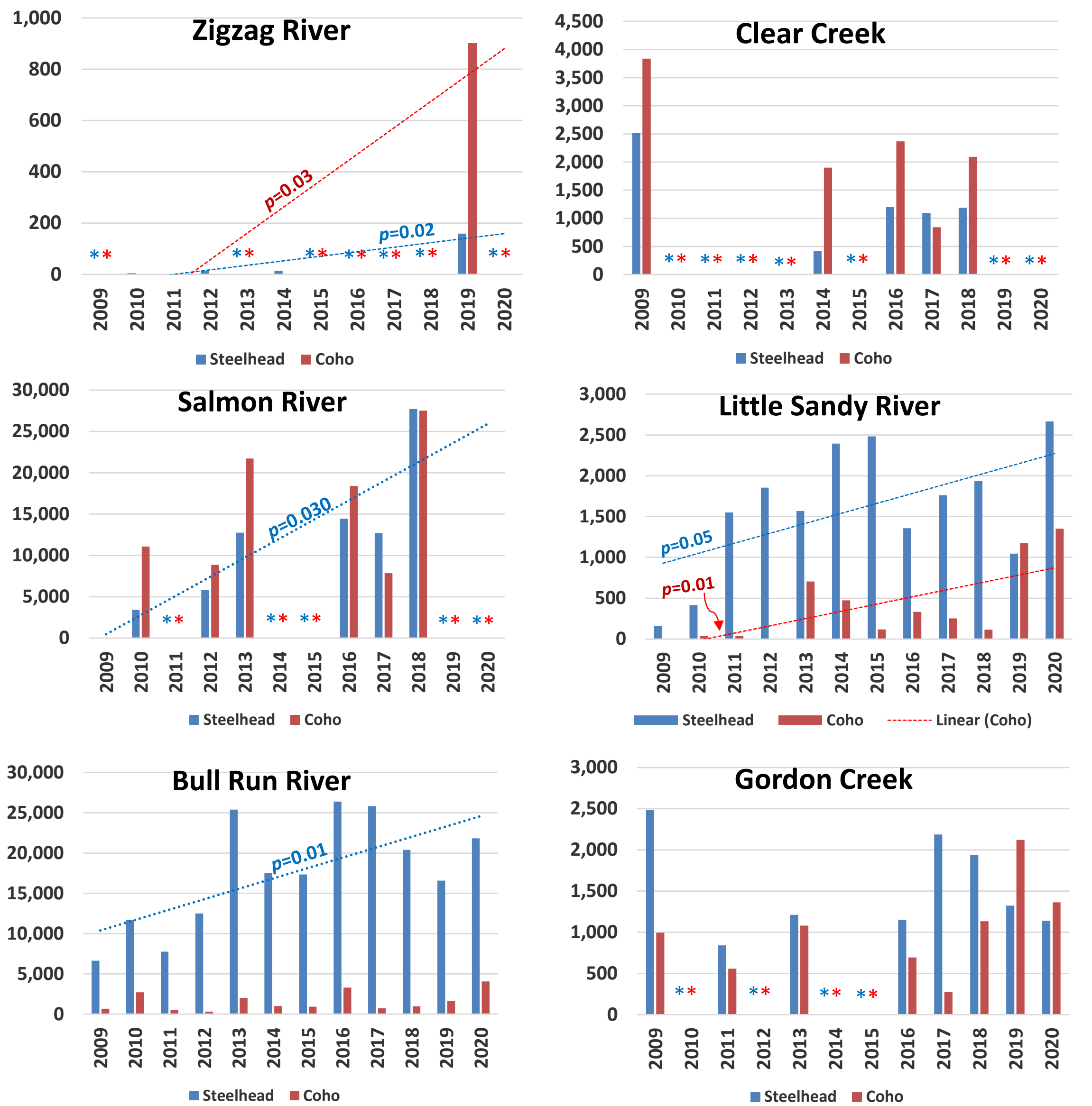
	Steelhead		Coho	
Streams[a]	**Smolts/mile**	**Smolts/1,000 ft²**	**Smolts/mile**	**Smolts/1,000 ft²**
Gordon Creek	153.92	0.73	189.17	0.90
Beaver Creek	124.68	1.09	58.96	0.51

[a] Streams are presented in order from highest-elevation Cedar Creek to lowest-elevation Beaver Creek.

Of the streams monitored in 2020, Coho smolt production was highest per unit of stream length in the Bull Run River and highest per unit of surface area in Cedar Creek. Cedar Creek had the second-highest production per unit length and the Bull Run River had the second highest per unit surface area. Beaver Creek had the lowest Coho smolt production per unit stream length, and per unit surface area.

An estimated 25 steelhead smolts and 18 Coho smolts had emigrated from Clear Creek during the eight days of monitoring before the trap was pulled for the season on March 27.

Some streams have shown significant changes in smolt production over their monitoring record (Figures 5 and 6). Steelhead have increased significantly in the Salmon River, Little Sandy River, and the Bull Run River. Coho have increased significantly in Still Creek. Coho have decreased significantly in Beaver Creek. A trend in numbers with a *p*-value of 0.1 or less was considered significant because of the high amount of variability seen in population estimates across years.



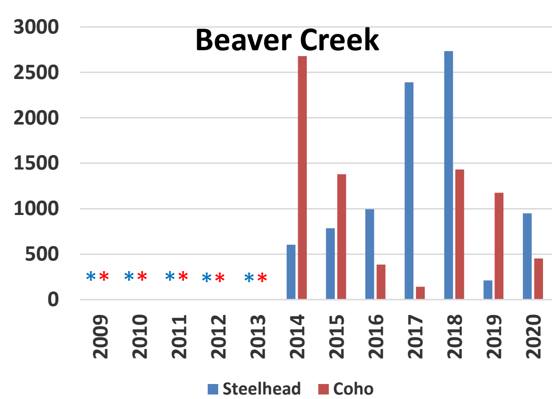


Figure 5. Steelhead and Coho smolt population estimates over time for individual subbasins Statistically significant changes over time are indicated with a trendline and associated *p*-value. Red lines indicate Coho trends; blue lines indicate steelhead trends. Years with no population estimate are indicated with an asterisk to distinguish them from years with an estimate of zero.

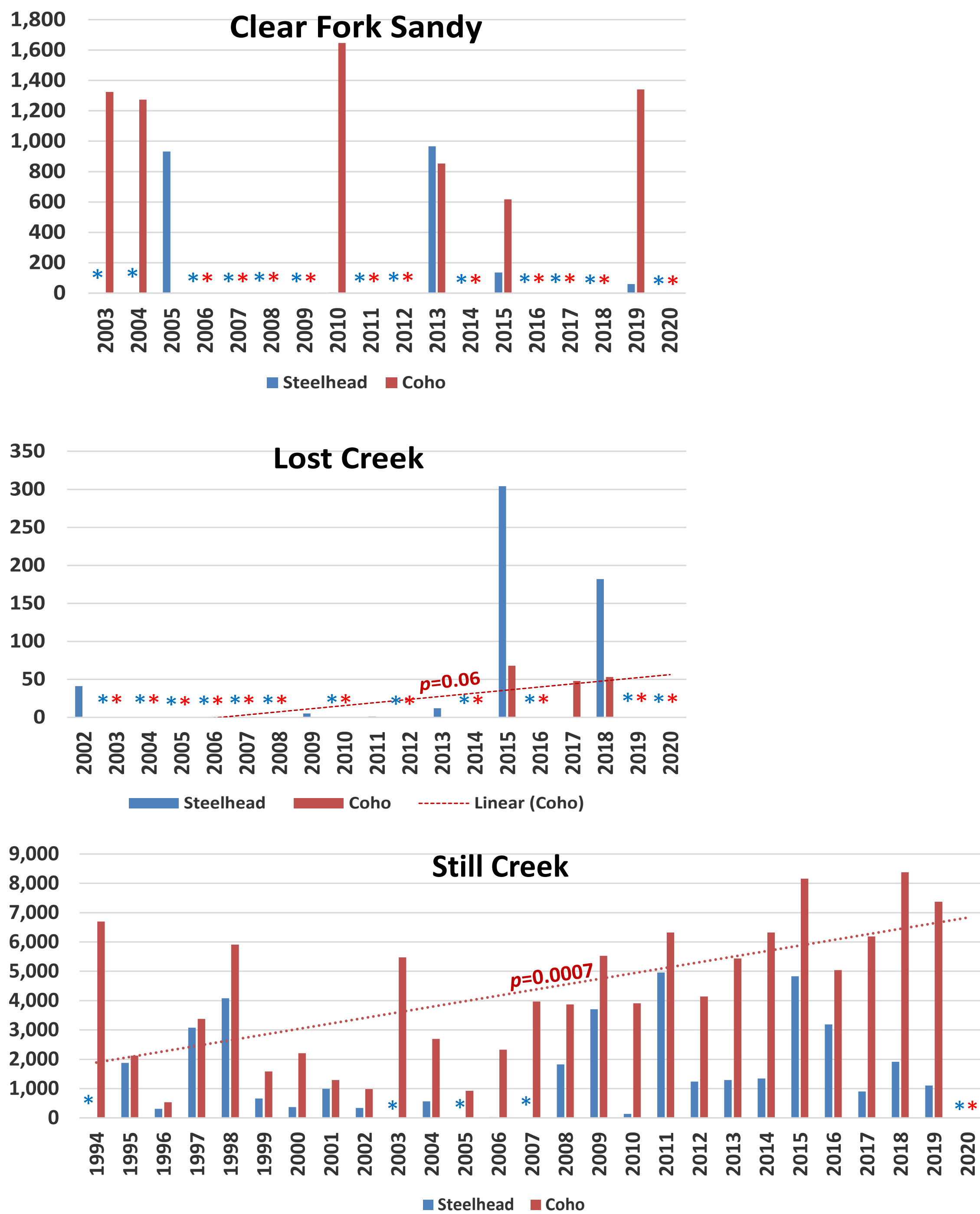


Figure 6. Steelhead and Coho smolt population estimates over time for individual subbasins with extended records

Figures are right margin-justified to align trapping years. Statistically significant changes over time are indicated with a trendline and associated *p*-value. Red lines indicate Coho trends; blue lines indicate steelhead trends. Years with no population estimate are indicated with an asterisk to distinguish them from years with an estimate of zero.

4.1.3 Sandy River Basin Index Area Population Estimates

At least four smolt population estimates were compiled from past trapping efforts in each subbasin. The smolt population estimates were used to create gap estimates. The subbasin smolt population estimate statistics are summarized in Table 7 for steelhead and Table 8 for Coho. The average relative contributions of each of the streams monitored in the Sandy River Basin Index Area are illustrated for steelhead and Coho in Figures 7 and 8, respectively. For streams in Tables 7 through 10 with continuous records, the average is calculated using the most recent eight years for steelhead and the most recent six years for Coho, or two full life cycles to account for potential trends.

Table 7. Statistics for steelhead subbasin smolt trap population estimates compiled from the Sandy River Basin Index Area, 2009–2020

	Clear Fork Sandy	Lost Creek	Clear Creek	Zigzag River	Still Creek	Salmon River	Cedar Creek	Little Sandy	Bull Run	Gordon Creek	Beaver Creek
n	5	7	5	5	23	6	4	9	11	7	6
Average	420	78	1,283	38	1,977	12,805	383	1,902	21,401	1,533	1,240
St. dev.[a]	486	119	761	68	1,616	8,505	246	577	4,083	589	946

[a] Standard deviation (St. dev.) describes the spread of individual subbasin estimates around their average.

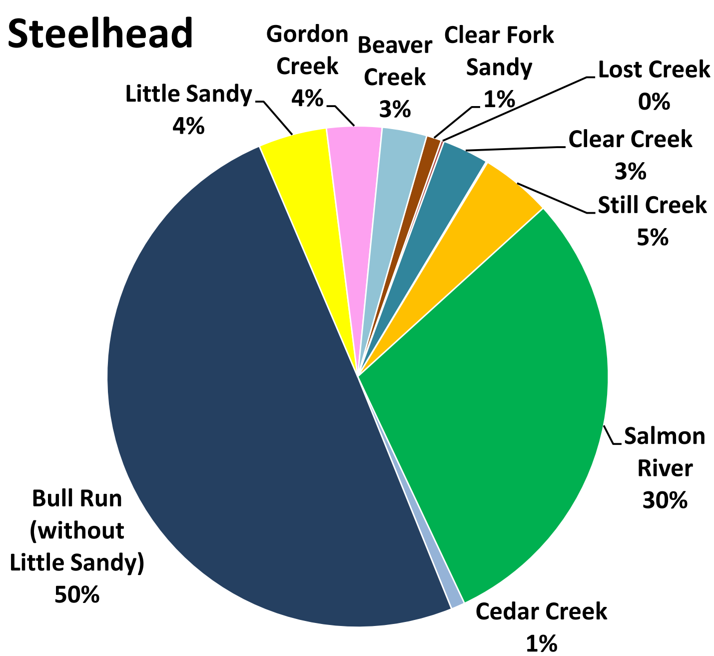


Figure 7. Average relative contributions of monitored streams to steelhead smolt production in the Sandy River Basin Index Area, 2009–2020

Table 8. Statistics for Coho subbasin smolt trap population estimates compiled from the Sandy River Basin Index Area, 2009–2020

	Clear Fork Sandy	Lost Creek	Clear Creek	Zigzag River	Still Creek	Salmon River	Cedar Creek	Little Sandy	Bull Run	Gordon Creek	Beaver Creek
n	6	7	5	4	25	6	4	10	10	6	5
Average	1,009	24	2,208	180	6,912	15,902	2,176	557	1,936	1,027	828
St. dev.[a]	591	31	1,079	0	1,287	7,911	781	399	1,401	591	566

[a] Standard Deviation (St. Dev.) describes the spread of individual subbasin estimates around their average.

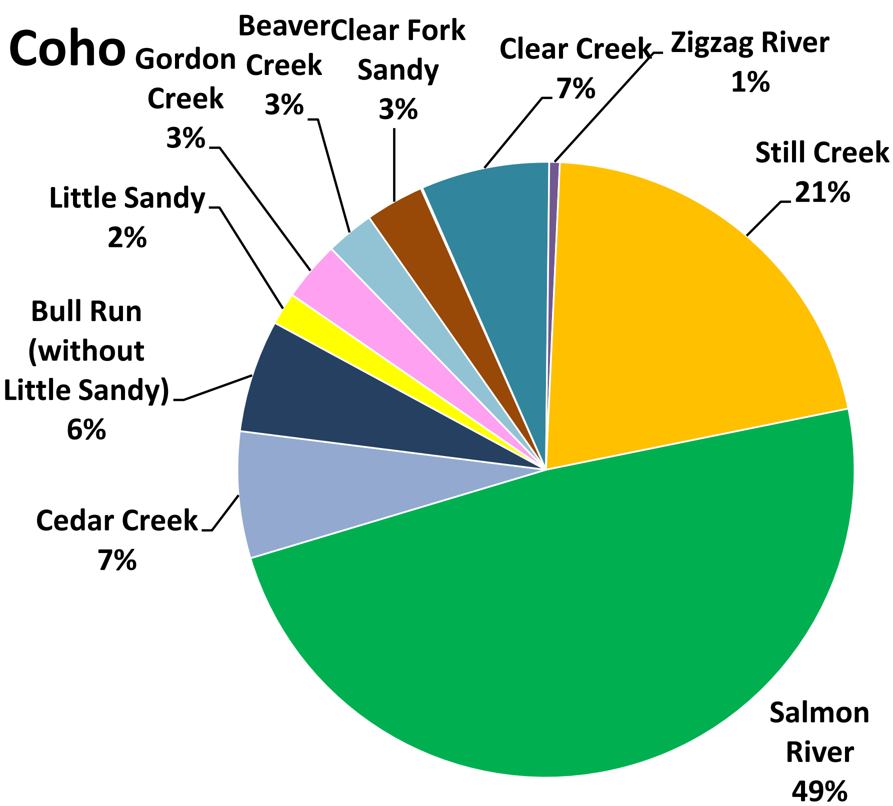


Figure 8. Average relative contributions of monitored streams to Coho smolt production in the Sandy River Basin Index Area, 2009–2020

The subbasin steelhead and Coho smolt population estimates and demonstrative gap estimates, as well as their 95 percent confidence intervals, are summarized in Tables 9 and 10, respectively, for the 12 years of the Sandy River Basin Smolt Monitoring Plan period (2009–2020). Expanded estimates were used for the 2011 subbasin population estimates and for Still Creek and the Salmon River in 2012, when trapping started late enough in the season to miss a significant portion of the smolt emigration. Averages of existing subbasin smolt population estimates (from Tables 7 and 8) were used as the gap estimates for this exercise.

Table 9. Subbasin steelhead smolt population estimates and gap estimates since the inception of the Sandy River Basin Smolt Monitoring Plan[a]

	Clear Fork Sandy	Lost Creek	Clear Creek	Zigzag River	Still Creek	Salmon River	Cedar Creek	Little Sandy	Bull Run	Gordon Creek	Beaver Creek
2009	420	5	2,514	38	3,709	12,805		160	6,637	2,483	1,287
	227%	n/a	83%	n/a	87%	130%		153%	96%	97%	25%
2010	4	78	1,283	5	138	3,419		416	11,701	1,590	1,287
	n/a	300%	116%	n/a	102%	77%		56%	149%	75%	25%
2011	420	1	1,283	1	4,958	12,805		1,552	7,750	839	1,287
	227%	n/a	116%	n/a	15%	130%		51%	33%	63%	25%
2012	420	78	1,283	13	1,236	5,819		1,856	12,495	1,590	1,287
	227%	300%	116%	n/a	39%	20%		67%	59%	75%	25%
2013	967	12	1,283	38	1,293	12,755	169	1,569	25,399	1,210	1,287
	51%	55%	116%	n/a	38%	47%	56%	40%	36%	122%	25%
2014	420	78	418	14	1,341	12,805	791	2,395	17,490	1,590	603
	227%	300%	38%	n/a	42%	130%	68%	39%	43%	75%	53%
2015	136	304	1,283	38	4,834	12,805	409	2,483	17,341	1,590	785
	73%	63%	116%	345%	38%	130%	133%	36%	24%	75%	34%
2016	420	78	1,201	38	3,192	14,443	426	1,357	26,392	1,150	994
	227%	300%	8%	345%	7%	48%	72%	62%	31%	39%	86%
2017	420	0	1,094	38	905	12,689	248	1,762	25,825	2,185	2,391
	227%	0%	33%	345%	19%	27%	58%	35%	60%	74%	55%
2018	420	182	1,189	38	1,914	27,707	409	1,936	20,402	1,939	2,735
	227%	65%	27%	345%	18%	42%	133%	39%	37%	93%	43%
2019	60	78	1,283	159	1,101	12,805	409	1,046	16,576	1,322	211
	23%	300%	116%	37%	23%	130%	0%	125%	55%	77%	37%
2020	420	78	1,283	38	1,977	12,805	281	2,668	21,783	1,139	960
	227%	300%	116%	345%	160%	130%	87%	44%	49%	35%	97%

[a] Shaded cells indicate gap estimates using the best information available.

Table 10. Subbasin Coho smolt population estimates and gap estimates since the inception of the Sandy River Basin Smolt Monitoring Plan[a]

	Clear Fork Sandy	Lost Creek	Clear Creek	Zigzag River	Still Creek	Salmon River	Cedar Creek	Little Sandy	Bull Run	Gordon Creek	Beaver Creek
2009	1,009	0	3,838	180	5,528	15,902		0	661	994	1,199
	115%	0%	24%	0%	21%	98%		0%	109%	41%	92%
2010	1,646	24	2,208	0	3,911	11,077		37	2,708	979	1,199
	51%	249%	96%	0%	12%	53%		50%	68%	118%	92%
2011	1,009	0	2,208	0	6,325	15,902		39	483	557	1,199
	115%	0%	96%	0%	9%	98%		166%	61%	70%	92%
2012	1,009	24	2,208	0	4,144	8,838		0	314	979	1,199
	115%	249%	96%	0%	28%	14%		0%	141%	118%	92%
2013	853	0	2,208	180	5,435	21,721	2,589	706	2,010	1,080	1,199
	29%	0%	96%	0%	12%	18%	44%	35%	57%	50%	92%
2014	1,009	24	1,902	0	6,322	15,902	1,208	473	1,009	979	2,680
	115%	0%	20%	0%	8%	98%	14%	85%	200%	118%	41%
2015	618	68	2,208	180	8,159	15,902	1,673	116	937	979	1,380
	59%	111%	96%	0%	8%	98%	91%	103%	58%	118%	14%
2016	1,009	24	2,366	180	5,043	18,399	2,028	332	3,289	694	385
	115%	249%	37%	0%	27%	13%	20%	32%	48%	35%	57%
2017	1,009	48	841	180	6,191	7,859	868	253	733	272	141
	115%	101%	15%	0%	10%	9%	58%	52%	99%	63%	74%
2018	1,009	53	2,091	180	8,380	27,518	1,673	114	966	1,132	1,433
	115%	59%	16%	0%	9%	17%	91%	57%	69%	68%	17%
2019	1,341	24	2,208	901	7,375	15,902	1,673	1,177	1,633	2,121	1,175
	9%	249%	96%	19%	8%	98%	91%	90%	78%	17%	17%
2020	1,009	24	2,208	180	6,912	15,902	4,189	1,352	4,058	1,362	454
	115%	249%	96%	0%	37%	98%	18%	70%	52%	13%	36%

[a] Shaded cells indicate gap estimates using the best information available.

Preliminary steelhead and Coho smolt population estimates for the entire combined index area of the Sandy River Basin are summarized in Table 11 and Figure 9 with their associated 95 percent confidence intervals. Population trends are illustrated in Figure 10. Steelhead have shown a significant increasing trend since 2009 at a 95% level of confidence. Coho have also shown an increasing trend, but only at a 90% level of confidence.

Table 11. Sandy River Basin Index Area steelhead and coho smolt population estimates and 95% confidence intervals[a]

	Steelhead		Coho	
Year	**Estimate**	**95% CI**	**Estimate**	**95% CI**
2009	30,058	61.4%	29,311	53.5%
2010	19,920	89.1%	23,788	28.4%
2011	30,896	55.0%	27,721	56.8%
2012	26,076	30.4%	18,714	18.1%
2013	45,982	24.2%	37,981	13.0%
2014	37,945	48.5%	31,507	50.1%
2015	42,008	41.5%	32,220	49.0%
2016	49,691	21.8%	33,749	10.4%
2017	47,557	33.6%	18,395	9.6%
2018	58,871	23.8%	44,549	11.5%
2019	35,050	54.5%	35,530	44.5%
2020	43,433	46.4%	37,649	42.7%

[a] Confidence intervals are expressed as percentages of the associated estimates.

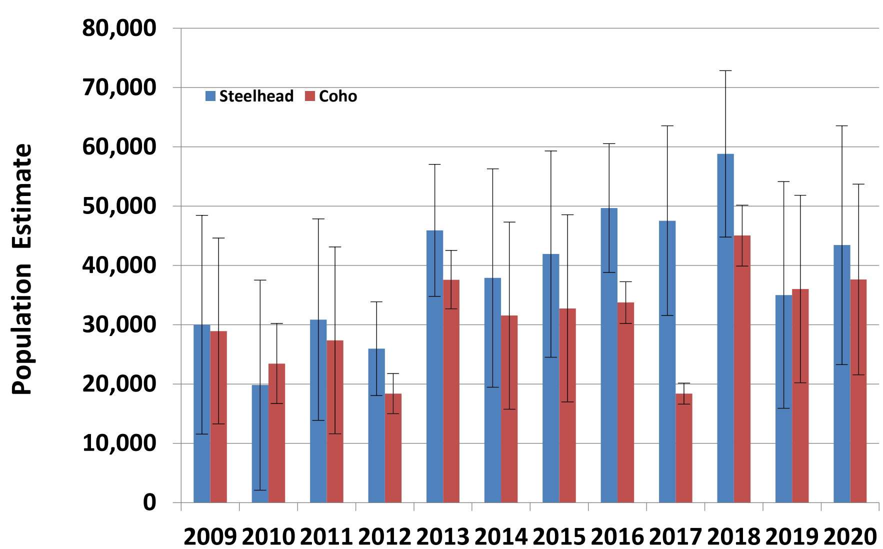


Figure 9. Sandy River Basin Index Area steelhead and Coho smolt population estimates and 95% confidence intervals

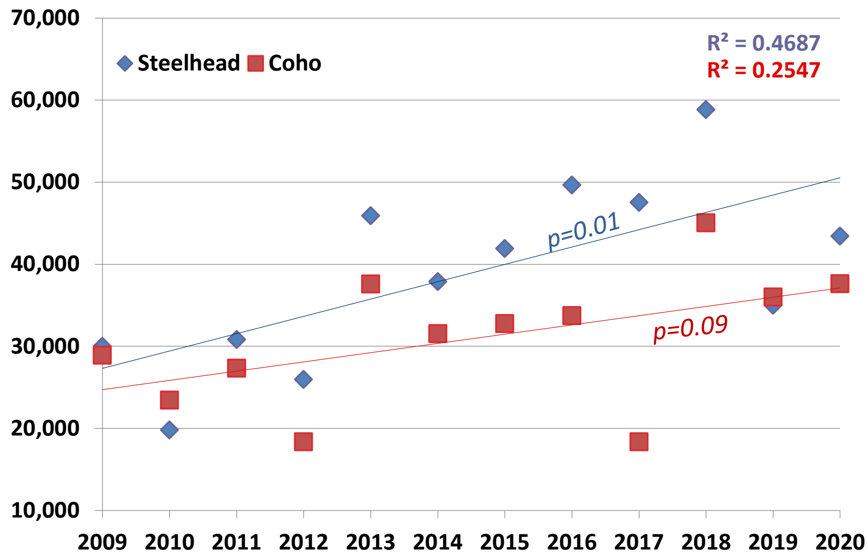


Figure 10. Sandy River Basin Index Area steelhead and Coho smolt population estimates and linear trends

Estimates of freshwater productivity (smolts per adult) for steelhead are presented in Table 12. Estimates of freshwater productivity (smolts per adult) for Coho are presented in Table 13. The number of steelhead and Coho smolts are plotted against the number of steelhead and Coho spawners in the parent generation in Figures 10 and 11, respectively. Also plotted in Figures 11 and 12 are spawner/recruit curves fitted to the Sandy River Basin steelhead and Coho data using the Beverton–Holt model. A spawner/recruit curve describes how the number of recruits (offspring) produced per spawner (parent) changes depending on the number of spawners there are, according to a given model. The Beverton–Holt model used in this analysis assumes that the number of recruits is dependent on the density of spawners. The Beverton–Holt equation follows:

$$R = \frac{\propto S}{(1+{}^{S}/_{K})} \qquad \text{(Equation 5)}$$

where R is the number of recruits (smolts), S is the number of spawners, α is a parameter related to the productivity (recruits per spawner) of the population at its maximum (low numbers of spawners), and α and K together describe the maximum production (total number of possible recruits). As the number of spawners becomes very large, the number of recruits (smolts) begins to level off near α/K. Two Beverton–Holt spawner/recruit curves were fitted to steelhead data, one including all years of steelhead spawner data since 2010 and the other excluding spawner data from 2011 and 2012. Visibility was unusually poor throughout the steelhead spawning survey season those years, and the resulting steelhead numbers are suspected of being underestimates (Eric Brown, ODFW, pers. comm., 2013).

The number of smolts resulting from each parental generation for each species was determined by using age distribution information derived from the reading of scale samples (see Methods) and smolt fork length distribution data from each smolt trap year. Steelhead and Coho smolts from a particular parental year class emigrated at age 1, age 2, and age 3[2] in proportions that varied by stream.

Table 12. Estimates of freshwater productivity for steelhead in the Sandy River Basin Index Area, 2010–2018

Steelhead spawners		Steelhead smolts		Freshwater productivity
Year	**Estimate**	**Year**	**Estimate**	**Smolts per adult**
2010	2,100	2011–13	28,297	13
2011	527	2012–14	41,510	79
2012	391	2013–15	29,947	77
2013	3,767	2014–16	34,530	9
2014	3,344	2015–17	46,550	14
2015	5,189	2016–18	46,533	9
2016	5,831	2017–19	63,678	11
2017	2,127	2018-20	36,405	17
2018	6,539	2019-21	41,449	7

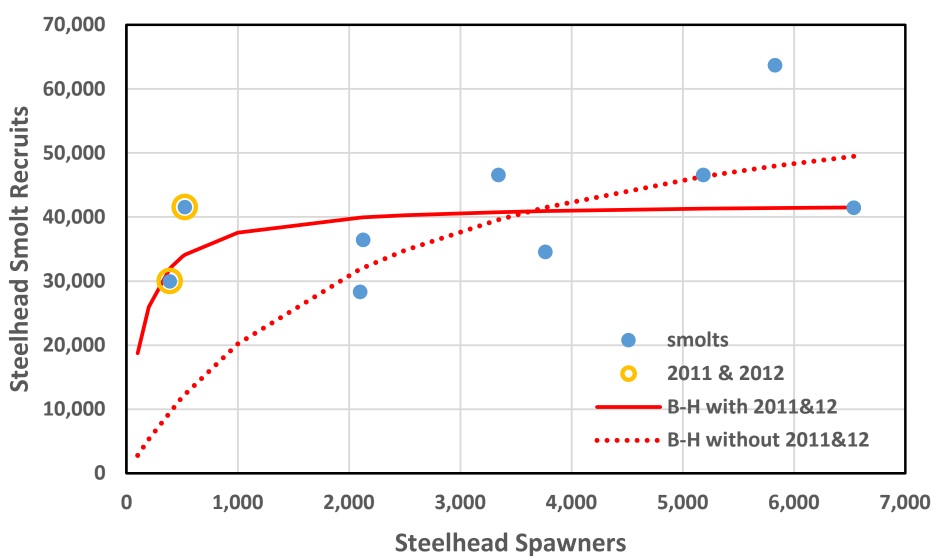


Figure 11. Steelhead spawners compared to resulting steelhead smolts in the Sandy River Basin Index Area, spawner years 2007–2018

[2]According to the aging convention for steelhead, an age 1 smolt is the offspring of adults that spawned the previous spring, approximately 12 months before. For Coho, an age 1 smolt is the offspring of adults that spawned the previous fall, approximately five to six months before (ODFW 2014).

Table 13. Estimates of freshwater productivity for Coho salmon in the Sandy River Basin Index Area, 2010–2018

Coho spawners		Coho smolts		Freshwater productivity
Year	Estimate	Year	Estimate	Smolts per adult
2007	753	2009–10	27,818	37
2008	1,277	2010–11	25,001	20
2009	1,667	2011–12	27,166	16
2010	795	2012–13	20,023	25
2011	3,619	2013–14	36,948	10
2012	1162	2014–15	29,167	25
2013	596	2015–16	30,443	51
2014	5,572	2016–17	33,154	6
2015	401	2017–18	18,499	46
2016	743	2018–19	44,166	59
2017	2,025	2019-20	34,963	17
2018	502	2020-21	34,116	68

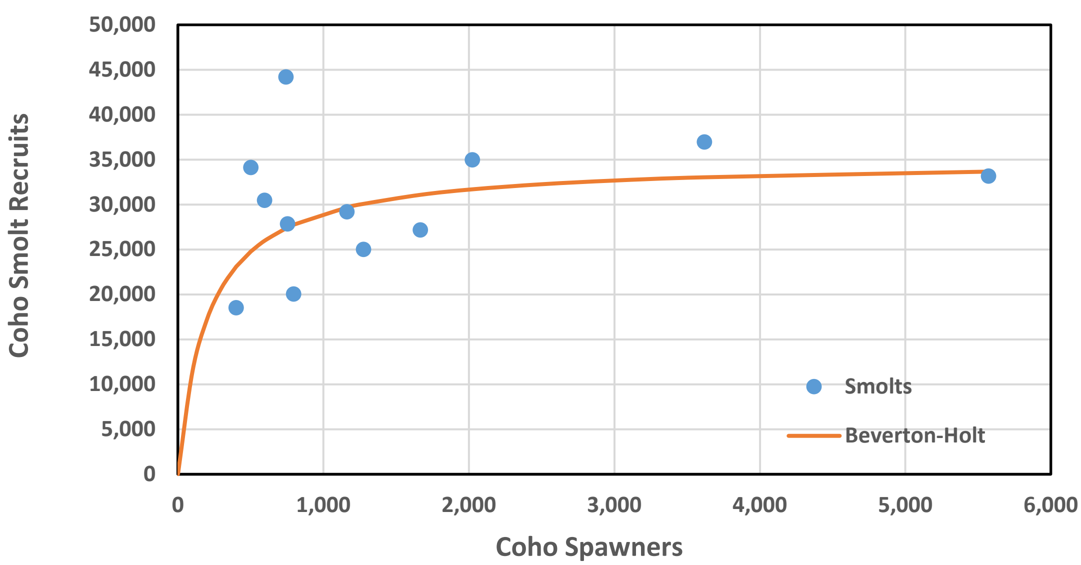


Figure 12. Coho spawners compared to resulting Coho smolts in the Sandy River Basin Index Area, spawner years 2007–2018

4.1.4 Recolonization of the Little Sandy River

Recolonization of the Little Sandy River by steelhead after the removal of Little Sandy Dam in 2008 appears to have been immediate and sustained (Figure 13). The first year that steelhead smolts were expected to result from the first steelhead adults spawning in the newly reopened portion of the stream was 2011. The Little Sandy 2011 steelhead smolt population was comparable in terms of smolts per unit length and area of stream to other streams of similar size that were never blocked to steelhead, like Gordon Creek or Still Creek. The steelhead smolts observed emigrating from the Little Sandy River in 2009 and 2010—with estimated populations of 160 and 416 fish, respectively—were evidently primarily fish that had migrated upstream from the lower river past the site of the dam after its removal.

The Little Sandy River produced the largest number of steelhead and Coho smolts in 2020 since the dam was removed. This was the eleventh year that Coho smolts could be expected in the Little Sandy trap, originating from adults that spawned upstream of the trap site after dam removal in 2008. This was the second year that the number of Coho fry caught in the Little Sandy trap in a given year has not served as an effective predictor of the Coho smolt estimate the following year, suggesting that Coho are spawning further upstream.

Spawning by Chinook salmon adults has also been documented to varying degrees in the Little Sandy River since the dam was removed in 2008. This is reflected in the variable presence of Chinook fry in the Little Sandy smolt trap.

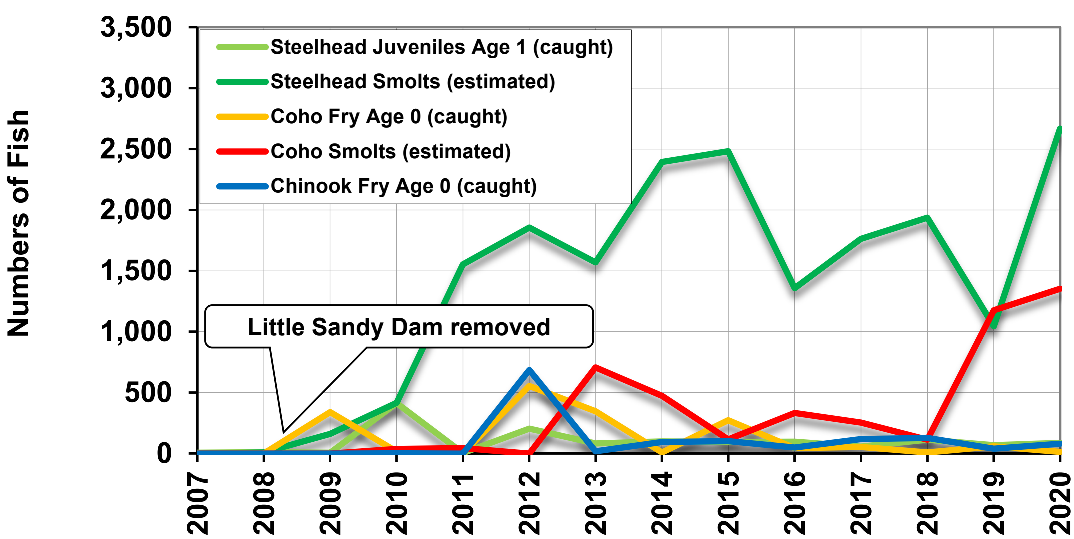


Figure 13. Recolonization of the Little Sandy River by steelhead, Coho, and Chinook after the removal of the Little Sandy Dam

4.2 Fork Lengths

Steelhead and Coho average fork lengths varied across monitored streams in 2020, as summarized in Tables 14 and 15, respectively. There were significant differences between the mean fork lengths of both steelhead and Coho smolts among monitored streams (ANOVA, α=0.05, p<<0.001 for both tests). Steelhead smolts emigrating from the Bull Run River were significantly longer than those emigrating from other monitored streams. Cedar Creek and Beaver Creek steelhead smolts were the shortest. Beaver Creek Coho smolts were significantly longer on average than those from any other stream. Little Sandy Coho smolts were the shortest.

Table 14. Steelhead weighted mean fork lengths, weighted standard deviation, and range of fork lengths of steelhead smolts captured in Sandy River Basin smolt traps in 2020

		Weighted			
Streams[a]	**n[b]**	**Mean fork length (mm)**	**St. dev. (mm)**	**Minimum (mm)**	**Maximum (mm)**
Cedar Creek	20	142	14	109	162
Little Sandy	186	161	16	126	226
Bull Run (without Little Sandy)	875	182	22	114	292
Gordon Creek	151	153	19	115	206
Beaver Creek	41	148	25	110	200

[a] Streams are presented in order from highest-elevation Cedar Creek to lowest-elevation Beaver Creek.
[b] n=Number of fish for which fork lengths were determined.

Figure 14 shows frequency distributions for steelhead smolt fork lengths. The results of the pair-wise comparisons are summarized below Figure 14.

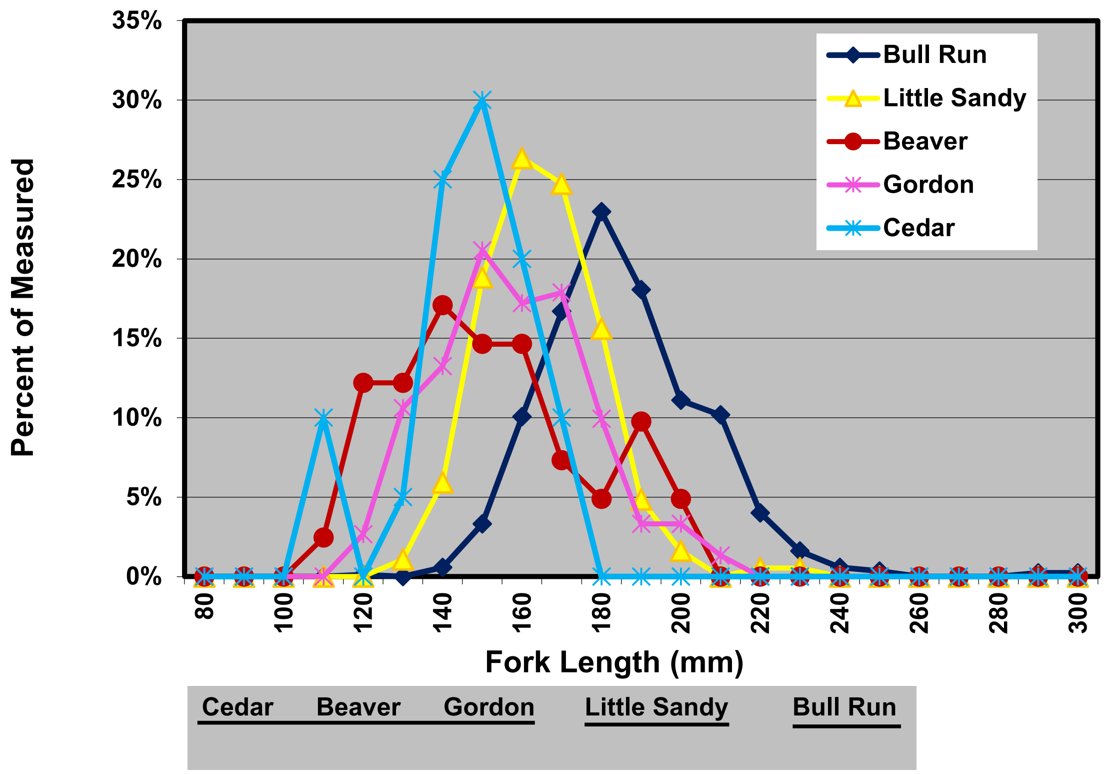


Figure 14. Steelhead smolt fork length frequency distributions for Sandy River Basin traps in 2020[a]

[a] Results of pair-wise statistical comparisons are presented from left to right, shortest to longest.

In Figure 14, streams that are grouped together by being mutually underlined are not statistically distinguishable from one another at a 95 percent level of significance (e.g., steelhead smolts from Gordon Creek are significantly shorter than those from the Little Sandy, but are statistically indistinguishable from Beaver Creek or Cedar Creek at $\alpha=0.05$). Steelhead smolts from the Bull Run River were significantly longer than steelhead from all other streams).

Smolt age information reveals that different age distributions among streams obscure differences in steelhead growth. Figure 15 compares the weighted mean fork length of age 2 steelhead in all basins and for all years for which adequate age distribution data exists, with 95 percent confidence intervals. Calculations for the weighted mean fork length of age 2 steelhead emigrating in 2020 were made using aging results from 2019 or averages from previous years. Upper-basin steelhead have comparable mean fork lengths to steelhead from lower in the basin (Figure 14), but upper-basin age 2 steelhead tend to be shorter than lower-basin age 2 steelhead. Little Sandy steelhead, which have been relatively small consistently, are an exception. The weighted average fork length of age 2 steelhead has also been declining in Gordon Creek in recent years. These patterns have been partly due to the fact that, in comparison to steelhead emigrating from lower-basin streams, a higher proportion of the steelhead emigrating from upper-basin streams are age 3. Age 3 fish are larger because they have had more time to grow. A large proportion of

Beaver Creek steelhead, in contrast, emigrate at age 1. Beaver Creek's complex steelhead fork length distribution and age distribution may also indicate that fish from other streams are entering and over-wintering in the stream.

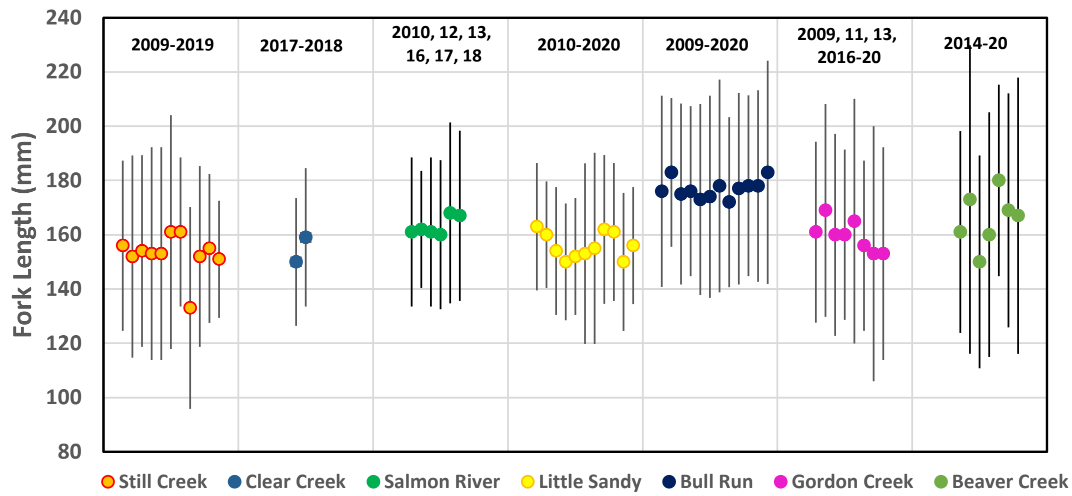


Figure 15. Weighted mean fork lengths of age 2 steelhead smolts for all Sandy River Basin streams and years for which age distribution data and fork length data exist

Table 15. Coho weighted mean fork lengths, weighted standard deviation, and range of fork lengths of Coho smolts captured in Sandy River Basin smolt traps in 2020

		Weighted			
Streams[a]	**n[b]**	**Mean fork length (mm)**	**St. dev. (mm)**	**Minimum (mm)**	**Maximum (mm)**
Cedar Creek	744	107	9	76	135
Little Sandy	106	100	13	63	226
Bull Run (without Little Sandy)	408	119	11	77	145
Gordon Creek	414	104	10	73	137
Beaver Creek	91	127	17	87	175

[a] Streams are presented in order from highest-elevation Cedar Creek to lowest-elevation Beaver Creek.
[b] n=Number of fish for which fork lengths were determined.

Figure 16 shows frequency distributions for Coho smolt fork lengths. The results of the pair-wise comparisons are summarized below Figure 16.

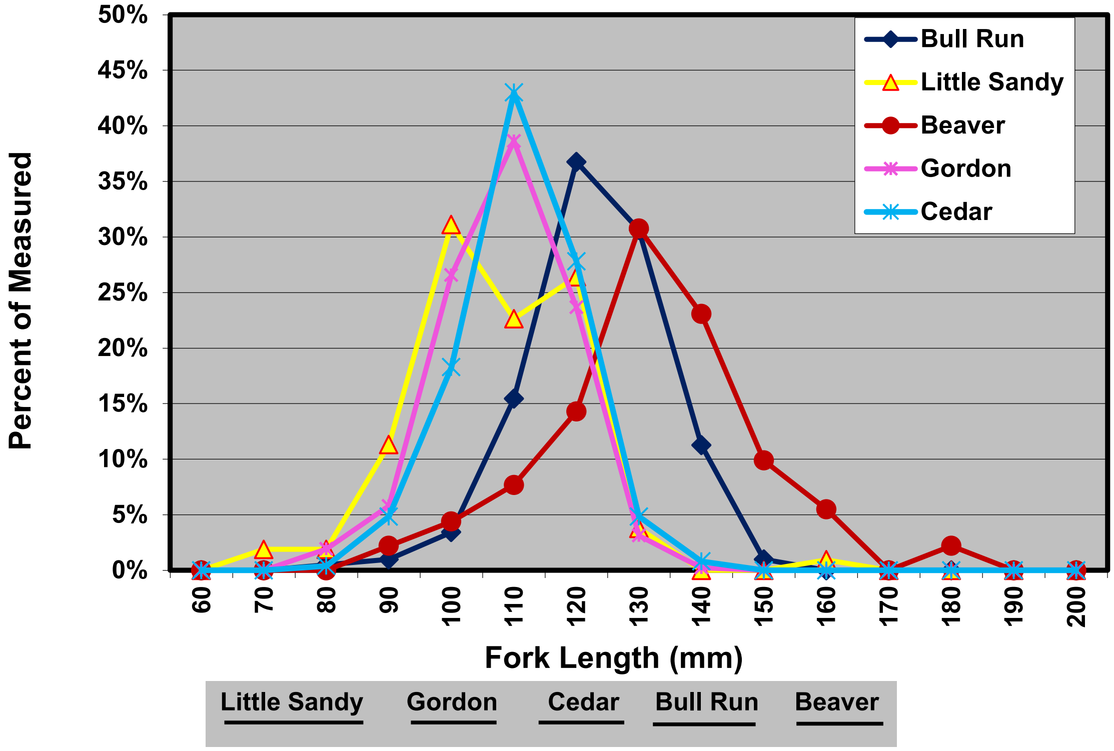


Figure 16. Coho smolt fork length frequency distributions for Sandy River Basin traps in 2020[a]

[a] Results of pair-wise statistical comparisons are presented from left to right, shortest to longest.

In Figure 16, streams that are grouped together by being mutually underlined are not statistically distinguishable from one another at a 95 percent level of significance. All streams were statistically distinguishable from one another in 2020.

Smolt age information reveals that very few emigrating Coho smolts in the Sandy River Basin are older than age 2, though most of those appear to emigrate from upper-basin streams. The proportion of age 2 Coho is too small to effect a substantial change to the overall weighted mean fork length of all emigrating Coho.

4.3 Condition Factors

There were significant differences (ANOVA, α=0.05, p<<0.001 for both tests) among the condition factors of steelhead and Coho among streams monitored in 2020. Figures 17 and 18 show the results of Tukey test multiple comparisons of condition factors for these two species across monitored streams. Little Sandy steelhead had statistically significant lower condition factors (were thinner) than steelhead from all other streams monitored in 2020. Cedar Creek steelhead had higher condition factors (were fatter) than steelhead from all other streams monitored in 2020 but there were too few to include in the multiple comparisons test. Beaver Creek Coho had significantly lower condition factors than Coho from all other streams monitored in 2020. Cedar Creek Coho had significantly higher condition factors than Coho from all other streams monitored in 2020.

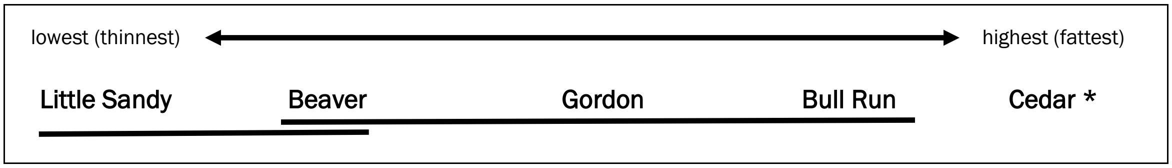


Figure 17. Steelhead smolt results of Tukey test multiple comparisons of steelhead condition factors for Sandy River streams monitored in 2020. *Cedar Creek steelhead were too few in number to include in the multiple comparisons test.

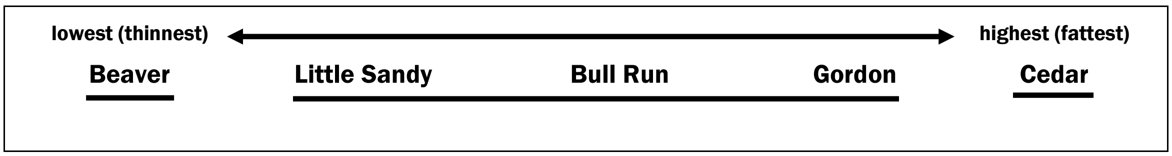


Figure 18. Coho smolt results of Tukey test multiple comparisons of smolt condition factors for Sandy River streams monitored in 2020

4.4 Emigration Dates

There was no clear pattern in any of the emigration statistics from higher to lower-elevation streams for either steelhead or Coho (Figures 19 and 20). Beaver Creek steelhead smolts and Little Sandy Coho smolts, in general, emigrated earliest in 2020, though the Beaver Creek emigration finished earliest for both species. Little Sandy steelhead and Bull Run Coho emigrated later than from other streams. The weighted mean and median emigration dates for the trapping period are summarized, along with the estimated peak emigration date(s) for the population and the dates of first and last capture, in Tables 16 and 17 for steelhead and Coho, respectively.

Table 16. Steelhead smolt weighted mean date of emigration, associated standard deviation, weighted median date of emigration, estimated peak emigration date, and earliest and latest capture dates in Sandy River streams monitored in 2020

	Weighted					
Streams[a]	**Mean emigration (trapping)**	**St. dev.**	**Median emigration (trapping)**	**Peak emigration**	**Earliest date**	**Latest date**
Cedar Creek	3-May	20	28-Apr	25, 28-May; 11-Jun	2-Apr	11-Jun
Little Sandy	30-Apr	16	6-May	16-May	10-Mar	31-May
Bull Run	29-Apr	16	27-Apr	20-Apr	25-Mar	3-Jun
Gordon Creek	22-Apr	19	27-Apr	9-May	10-Mar	27-May
Beaver Creek	19-Apr	15	25-Apr	25, 28-May	12-Mar	11-May

[a] Streams are presented in order from highest-elevation Cedar Creek to lowest-elevation Beaver Creek.

Table 17. Coho smolt weighted mean date of emigration, associated standard deviation, weighted median date of emigration, estimated peak emigration date, and earliest and latest capture dates in Sandy River streams monitored in 2020

	Weighted					
Streams[a]	**Mean emigration (trapping)**	**St. dev.**	**Median emigration (trapping)**	**Peak emigration**	**Earliest date**	**Latest date**
Cedar Creek	5-May	14	6-May	18-May	1-Apr	11-Jun
Little Sandy	22-Apr	19	26-Apr	16-May	20-Mar	2-Jun
Bull Run	10-May	14	14-May	20-May	12-Mar	3-Jun
Gordon Creek	3-May	18	9-May	17-May	10-Mar	11-Jun
Beaver Creek	24-Apr	18	30-Apr	3-May	10-Mar	24-May

[a] Streams are presented in order from highest-elevation Cedar Creek to lowest-elevation Beaver Creek.

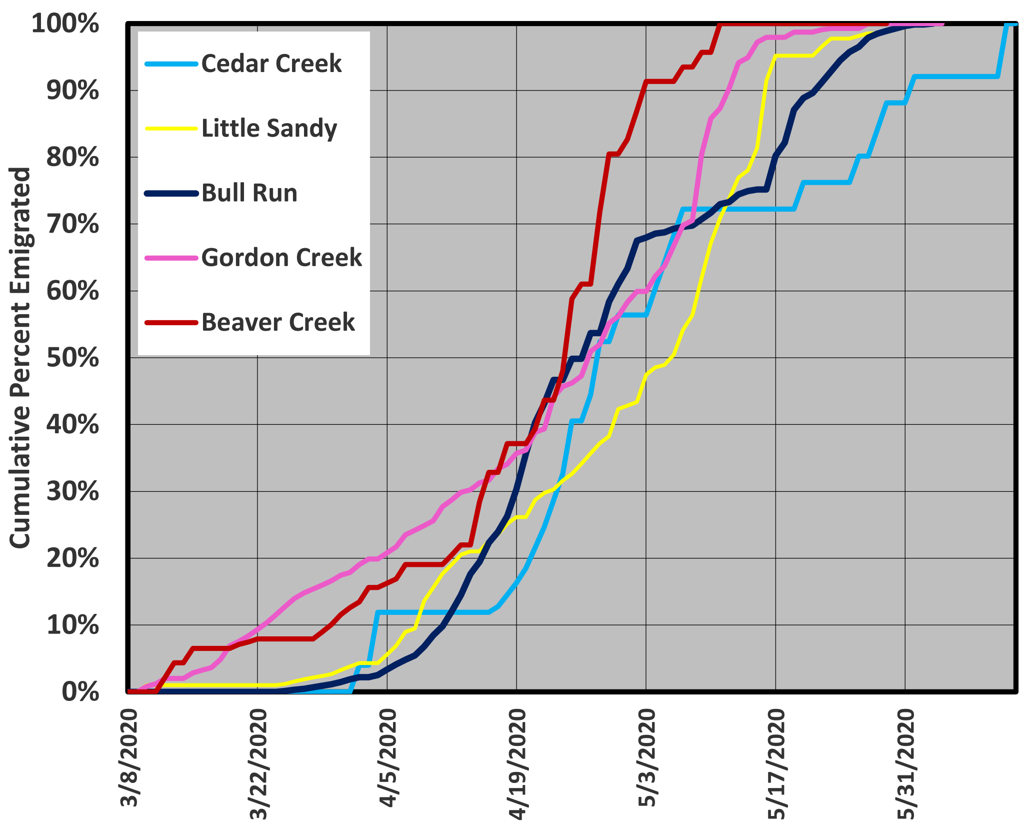


Figure 19. Steelhead smolt cumulative percentage of total emigration from Sandy River streams monitored in 2020. Steepest portions of each curve indicate peak capture periods

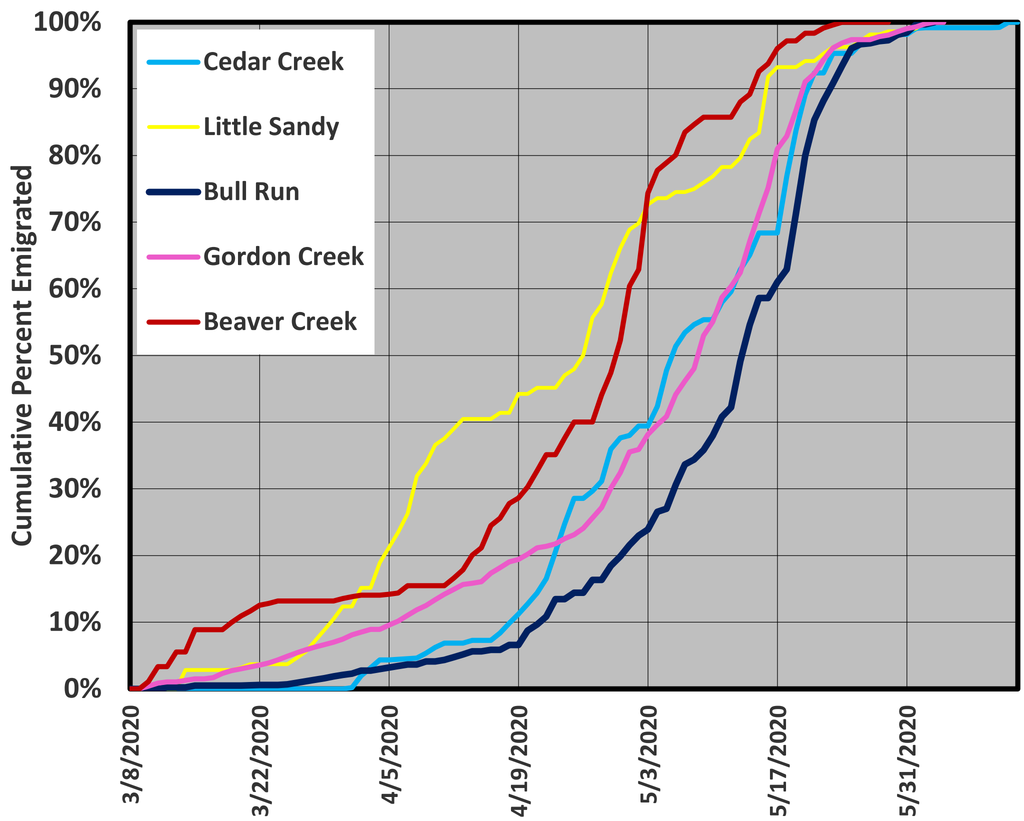


Figure 20. Coho smolt cumulative percentage of total emigration from Sandy River streams monitored in 2020. Steepest portions of each curve indicate peak capture periods

4.5 Age Distribution

Steelhead smolts are, on average, slightly older at time of emigration from upper-basin streams than smolts from lower-basin streams. Coho smolts do not consistently show this pattern. Steelhead smolts from the Little Sandy are, on average, older than expected given Little Sandy's mid-elevation. Tables 18 and 19 summarize the weighted mean age and age distribution for each stream in the Sandy River Basin Index Area for which adequate age data exist. Age data are averaged across all years of aging data. Coho smolts were systematically sampled in 2019, but ages were not determined for most of those sampled individuals due to contractual limitations. Those scales will be analyzed at a future time.

Table 18. Steelhead smolt weighted mean age and age distribution for Sandy River streams, 2009–2019

Stream	Weighted average age	Age 1	Age 2	Age 3	Age 4
Zigzag River	2.68	4.2%	23.6%	72.2%	0.0%
Still Creek	2.35	4.4%	58.1%	35.3%	2.2%
Clear Fork	2.46	1.3%	51.6%	47.1%	0.0%

Table 18. Steelhead smolt weighted mean age and age distribution for Sandy River streams, 2009–2019

Stream	Weighted average age	Age 1	Age 2	Age 3	Age 4
Clear Creek	2.11	4.7%	80.0%	15.0%	0.3%
Salmon River	2.15	4.2%	76.8%	18.4%	0.6%
Cedar Creek	1.57	43.2%	56.3%	0.4%	0.0%
Little Sandy	2.24	2.4%	71.2%	26.5%	0.0%
Bull Run River	2.10	4.4%	81.4%	13.9%	0.3%
Gordon Creek	1.96	21.8%	60.9%	17.1%	0.1%
Beaver Creek	1.43	59.8%	37.4%	2.7%	0.0%

Table 19. Coho smolt weighted mean age and age distribution for Sandy River streams, 2009–2019

Stream	Weighted average age	Age 1	Age 2	Age 3	Age 4
Zigzag River	1.95	4.8%	95.2%	0.0%	0.0%
Still Creek	2.03	1.4%	94.2%	4.4%	0.0%
Clear Fork	1.91	9.0%	91.0%	0.0%	0.0%
Clear Creek	2.00	2.3%	95.5%	2.2%	0.0%
Salmon River	2.00	0.0%	99.5%	0.5%	0.0%
Cedar Creek	2.04	0.1%	95.4%	4.5%	0.0%
Little Sandy	2.00	0.3%	99.7%	0.0%	0.0%
Bull Run River	1.99	0.6%	99.4%	0.0%	0.0%
Gordon Creek	1.97	3.2%	96.8%	0.0%	0.0%
Beaver Cr	2.00	1.9%	96.7%	1.4%	0.0%

5. Discussion

5.1 Smolt Population Estimation

Fewer streams were monitored in 2020 than anticipated. The inability to monitor certain streams in 2020, however, could not be avoided as a consequence of the COVID-19 pandemic. Since some streams could not be sampled, the evaluation of trends was affected in the individual streams and in the greater Sandy River Basin Index Area. Missing a year of monitoring in any individual stream delays the discernment of trends where they exist, especially in those streams that are already not monitored annually. The detection of trends on the scale of the Sandy River Basin is hindered by the increased reliance on gap estimates. Currently, the multiyear average for each trap site is used for the gap estimate. This conservative method tends to flatten any data trends that might exist. Monitoring fewer streams in 2020 reduced data collection in that year but did not significantly affect the evaluation of trends for the Sandy River Basin Index Area.

Record-high population estimates were calculated for steelhead in the Little Sandy River and for Coho in Cedar Creek, Little Sandy, and the Bull Run River. Cedar Creek had an unusually low steelhead smolt population estimate. Other steelhead and Coho tributary smolt population estimates were within the range of estimates during the previous eleven years of the Sandy River Basin Smolt Monitoring Program. The Bull Run River continued to produce large numbers of steelhead.

The moderate numbers of steelhead smolts observed emigrating from streams monitored in 2020 are at odds with the large adult return of spawning steelhead two years previous. The relatively large numbers of Coho smolts emigrating from streams monitored in 2020, on the other hand, corresponded to a low adult return two years previous. The relatively high production of Coho by Cedar Creek and steelhead and Coho by the Little Sandy River are evidence of a strong recovery in both streams since fish passage was restored in recent years and may also be related to fish habitat restoration efforts.

The description of smolt production by various streams in the Sandy River Basin could be complicated to an unknown degree by movement of fish between subbasins either before or during the time of smolt emigration. Two and one hatchery (adipose-clipped) steelhead smolts were captured in the Bull Run and Beaver Creek traps, respectively. These fish would have entered the stream of capture after being released, swum upstream beyond the trap, and then been captured on their way back downstream. Although these fish were not included in the respective population estimates, their presence and the captures of some hatchery smolts in previous years highlight the possibility of similar behavior in wild fish.

When making inferences about the effect of fish habitat conditions on smolt production, studies generally assume that the majority of fish emigrating from monitored streams had their origin in those streams. This is, in part, borne out by observed significant differences in characteristics such as fork lengths and condition factors. A large degree of movement among all streams would tend to equalize these population characteristics among streams. In the past, steelhead and Coho marked in tributaries upstream of Bull Run using paint marks have never been recaptured in the Bull Run, Gordon Creek, or Beaver Creek traps, lending further credence to the assumption that such movement between streams is at least not occurring to a significant degree during the spring smolt emigration. Moderate to large numbers of hatchery steelhead also have been observed straying into the Bull Run River in 2014, 2015, and 2018. It is possible that the movements of hatchery steelhead in 2014, 2015, and 2018 do not reflect the movements of wild fish. Without further study, however, it cannot be discounted that such movement could occur to some degree and that the differences between the physical characteristics observed between smolts from different streams would have been even larger without it.

It is possible that movement into tributaries may involve younger fish, such as age 1 steelhead displaced from their natal streams by intraspecific competition. A genetic analysis of 1,560 tissue samples collected from steelhead smolts caught in nine smolt traps across the Sandy Basin in 2017 (Bohling 2019) showed no sibling relationships between steelhead caught in the Bull Run River and any other stream other than the Little Sandy River (which is an upstream tributary to the Bull Run). This result argues against the movement of large numbers of juvenile steelhead across large distances in the Sandy Basin, although some evidence of movement was observed between streams nearer one another (Still Creek and Clear Creek). Movement may also be occurring from the adjacent Sandy River into the Bull Run, for example, to seek refuge from the glacially turbid conditions of the main stem river.

Unequal trap avoidance by different groups of fish is a perennial concern with studies such as this that rely on mark–recapture methodologies. Trap avoidance could have affected the estimation of smolt population sizes in the Sandy River in 2020. If marked individuals become "trap-shy" (i.e., are caught a second time at a rate lower than fish passing the trap for the first time), this results in an inflated population estimate. Steelhead marked at the upstream Little Sandy trap were recaptured at lower rates at the Bull Run trap than steelhead marked at the Bull Run trap in 2020 (2.2 percent compared with 7.8 percent efficiency, respectively, averaged over the season). If this difference reflects "trap-happy" behavior on the part of steelhead that encountered the Bull Run trap rather than reflecting error in the efficiency estimate, it could result in a deflation of the Bull Run estimate. This difference between recapture rates of Bull Run and Little Sandy smolts, however, varies greatly from year to year in the Bull Run.

Large fish of a given species are probably also stronger swimmers than small fish and may have a greater ability to avoid capture when they recognize a trap in their downstream path. Were this effect to occur equally during the initial capture and subsequent recapture of fish, the result would be an underestimated population size.

Were it to happen during both phases of capture, but more strongly during the recapture phase, the result would vary depending on the strength of the effect but could result in an inflated estimate. Consequences of this effect are discussed more fully in Strobel 2010.

The initial estimates of steelhead productivity (smolts per adult) were hampered in 2014 and 2015 by difficulties encountered generating adult steelhead spawner estimates in previous years. No estimates of the number of steelhead spawners in the Sandy River basin were generated in 2008 or 2009. The steelhead spawner estimates in 2011 and 2012 were probably biased toward the low end due to poor survey conditions (Eric Brown, ODFW, pers. comm., 2013). Confidence in the Sandy River steelhead spawner estimates from 2013 and beyond is higher. Steelhead productivity estimates are also complicated by the fact that an unknown proportion of steelhead smolts may be summer steelhead. For instance, roughly 10 percent of steelhead smolts emigrating from Bull Run in 2012, 2013, and 2014 were summer steelhead (Smith et al. 2015). The percent of steelhead smolts that were summer run in 2017 ranged from 2% and 3.2% in Beaver Creek and Cedar Creek, respectively, to 6.7% and 9.4% in the Salmon River and the Bull Run River (Bohling 2019). Although there is some likelihood that summer steelhead redds are being counted during winter steelhead spawner surveys, the extent to which this is happening is unclear.

The Sandy River Basin Index Area smolt estimates calculated for steelhead and Coho were conservative in 2020. Less than half of the streams included in the index area were monitored due to issues related to the COVID-19 pandemic. The use of multiyear averages to fill in data gaps tends to hide trends where they exist. In particular, Still Creek, one of the largest producers of Coho, and the Salmon River, the largest producer of Coho and the second largest producer of steelhead, were not monitored in 2020. The Salmon River has not been monitored as a result of the randomized schedule since 2018. Still Creek has shown a significantly increasing trend in Coho smolts and the Salmon River had shown a significantly increasing trend in steelhead smolts. The Sandy River Basin Index Area estimates would have been larger if these observed trends continued in 2020.

Steelhead and Coho smolt populations for the final Sandy River Basin Index Area, the trends in smolt numbers over time, and Sandy River Basin freshwater productivity (smolts per adult) will be calculated after 20 years of annual smolt monitoring, in 2029. The calculations made in 2020 and those to be made in future years will improve with the collection of additional data.

5.2 Fork Lengths

The observed differences in fork length distribution for steelhead and Coho smolts among Sandy River Basin streams monitored in 2020 did not reflect the geographical patterns observed in other years, which may be due to the fact that only lower-elevation streams were sampled. Average observed fork length, especially of steelhead, is due to the interplay of two factors: (1) how rapidly fish are able to grow in each stream (which is related to stream productivity), and (2) how long they have had to grow. Steelhead and Coho weighted mean fork lengths have shown a correlation with water temperature (Strobel 2012). Steelhead smolts also vary in age from 1 to 4 years (Table 18). Their fork lengths, therefore, can reflect varying growth conditions over multiple years, as well as variations from stream to stream in the average length of time spent growing. Coho smolts also vary in age, though to a much lesser degree (Table 19). Scale samples are collected annually from steelhead and Coho smolts to determine the proportions of emigrating smolts of various ages. The continued determination of ages from these scale samples will provide an improved ability to discern between the effects of growth and age.

Cedar Creek and Beaver Creek steelhead smolts showed bimodal fork length distributions in 2020. This pattern, unusual among streams in the Sandy River basin, is not unusual for Beaver Creek, which has consistently shown a bimodal or even trimodal steelhead fork length distribution. This phenomenon could be a result of Beaver Creek steelhead being of diverse histories, including fish reared in Beaver Creek and other fish overwintering in

Beaver Creek from elsewhere in the Sandy River basin or even from outside the basin (Bohling 2019). The Cedar Creek steelhead smolt fork length distribution could be due to chance and the small number of fish sampled.

5.3 Condition Factors

In 2020, average condition factors for both steelhead and Coho smolts were generally not strongly correlated with average fork length, as has been observed in previous years. This departure from past patterns may be, in part, due to the fact that fish from the upper basin were not sampled. It is unlikely that lower condition factors in fish reflect, in general, poor rearing conditions throughout the year. If lower condition factors reflected poor rearing conditions, then the low condition factors would tend to correlate with low fork lengths overall, which is not the case. A general negative relationship between condition factor and fork length observed frequently in the past for both Coho and age 2 steelhead could arise from warmer winter temperatures in low-elevation streams in the months prior to capture. Higher metabolic rates and possibly even growth in generally inactive overwintering fish associated with warmer water temperatures could result in greater use of fat stores. It is also possible that the decline in condition factor with increasing fork length could be an artifact of the fact that smolts in all streams tend to show a similar relationship and there are observed differences in average fork length among streams.

The statistically significant decline in condition factor with increasing fork length observed consistently among fish from a single stream is an indication of a change in body shape as smolts grow, a change that has been observed visually in the field. Large smolts appear to be more slender than small smolts. The contribution of some excess water potentially transferred with each measured fish to the weighing scale tray—which would affect the weights of smaller fish more than larger fish—might also contribute to the negative relationship.

5.4 Emigration Dates

Unlike in many previous years, neither steelhead nor Coho smolts showed a tendency to emigrate earlier from lower-elevation streams than from higher-elevation streams in 2020. Steelhead smolts emigrated early, while Coho smolts emigrated late from the Little Sandy. The reason for this unusual pattern is unknown.

5.5 Age Distribution

The weighted average age of smolts is probably related to stream elevation by way of water temperature. Higher-elevation streams tend to have colder water temperatures, which slow the metabolic rates of fish. In an environment with plentiful food, growth rates are slower in colder streams. It is likely that the portion of fish that fail to reach a sufficient size by the time of smolt emigration have a survival incentive to remain an additional year to grow larger. Conversely, in warmer, low-elevation streams, fish may grow large enough one year early to confer a survival advantage to individuals that avoid an additional year of risk in the stream environment before seeking the rewards of an ocean migration.

Little Sandy smolt age distributions tend to resemble those of fish from higher-elevation streams than lower-elevation streams. This corresponds with their generally shorter length-at-age.

6. Findings, Conclusions, and Recommendations

- Population estimates or approximations could be generated for steelhead and Coho smolts in five streams in 2020.
- Steelhead and Coho smolt estimates in 2020 were generally within the range of previous years' estimates. Little Sandy had a record high steelhead estimate. Cedar Creek, Little Sandy, and the Bull Run River had record-high Coho estimates.
- Estimates of steelhead and Coho smolt production were generated for the entire Sandy River Basin Index Area for years 2009–2020. Steelhead show an increasing trend at a 99% level of statistical confidence. Coho show an increasing trend at a 91% level of statistical confidence. More accurate estimates will be attempted once additional years of smolt monitoring data are available.
- Estimates of freshwater productivity (smolts per adult) were generated for steelhead for parental years 2010–2018 and for Coho for parental years 2007–2018.
- Steelhead and Coho smolt fork lengths showed significant differences among monitored streams in the Sandy River Basin in 2020. There was no clear relationship between average fork length and position of streams in the Sandy watershed.
- Steelhead and Coho smolts from different streams in the Sandy River Basin showed significant differences in the average condition factor in 2020. In general, there was no correlation between average condition factor and average fork length.
- Steelhead and Coho smolts did not appear to emigrate earlier in general from low-elevation streams than from high-elevation streams in 2020. Little Sandy steelhead began migrating early relative to steelhead from other streams whereas Little Sandy Coho emigrated later than Coho from other streams. Beaver Creek smolts of both species emigrated over a shorter period of time than smolts from other streams.
- A larger proportion of both steelhead smolts emigrating from upper-basin streams were of older ages than smolts emigrating from lower-basin streams. Coho smolts, which have shown a similar pattern in the past, have not done so with more recent data.

7. Acknowledgments

The Sandy River Partners would like to acknowledge the efforts and financial support that made the Sandy River Basin Smolt Monitoring Project possible. Smolt monitoring efforts were funded by the involved agencies (the Portland Water Bureau, US Forest Service, and Oregon Department of Fish and Wildlife). Special thanks to the dedicated field crews that installed, maintained, and removed the numerous traps and checked them on a daily basis in all weather and flows. Crew personnel included Steve Schaaf, Jon Mueller, and Trevor Diemer from PWB; Catherine Dillon and Lindsey Jennings from USFS; and Joseph Gayaldo from ODFW.

Eleven years' worth of smolt scale samples were aged by the ODFW Fish Life History Analysis Project in Corvallis, Oregon, for this project. We are extremely grateful for their efforts. Thanks also to the ODFW Oregon Adult Salmonid Inventory and Sampling Project (OASIS) for supplying adult steelhead and Coho spawner estimates.

8. Works Cited

Bjorkstedt, Erik P. 2005. DARR 2.0: Updated Software for Estimating Abundance from Stratified Mark-Recapture Data. NOAA/NMFS technical memorandum. NOAA-TM-NMFS-SWFSC-368.

Bjorkstedt, Erik P. 2010. DARR 2.0.2: DARR for R code. National Oceanic and Atmospheric Administration. http://swfsc.noaa.gov/textblock.aspx?Division=FED&id=3346.

Bohling, JH. 2019. Genetic characteristics of juvenile steelhead (Oncorhynchus mykiss) collected from the Bull Run River and the surrounding Sandy River Basin, OR. AFTC Final Report 353.

Hutchinson, Matthew W., Jessica L. Vogt, and Alex Neerman. Winter Steelhead of the Clackamas and Sandy Rivers: Spawning Ground Surveys 2006-2007. Oregon Department of Fish and Wildlife, Salem, Oregon. 2007.

Portland Water Bureau. Bull Run Water Supply Habitat Conservation Plan for the Issuance of a Permit to Allow Incidental Take of Threatened and Endangered Species. Final Draft. Portland Oregon. 2008.

Scace, Justin G., Benjamin H. Letcher, and John Noreika. "An Efficient Smolt Trap for Sandy and Debris-Laden Streams." *North American Journal of Fisheries Management,* no. 27 (2007): 1276-86. doi: 10.1577/M07-036.1.

Smith, Christian, Jennifer Von Bargen, and Kieslana Wing, 2015. Genetic assignment to run of steelhead smolts captured in the Bull Run River. USFWS Abernathy Fish Technology Center. Abernathy, Washington.

Strobel, Burke. Ecosystem Responses to a Large-Scale Salmon Carcass Enrichment Project. Interim report. Mt. Hood National Forest. Clackamas River Ranger District. Estacada, Oregon. 2004.

Strobel, Burke. 2014. Sandy River Basin Smolt Monitoring, 2013. Portland Water Bureau. Portland, Oregon.

Strobel, Burke. 2010. Sandy River Basin Smolt Monitoring, 2009. Portland Water Bureau. Portland, Oregon.

Suring, Erik J., Eric T. Brown, and Kelly M.S. Moore. 2006. Lower Columbia River Coho Status Report 2002 – 2004: Population Abundance, Distribution, Run Timing, and Hatchery Influence; Report Number OPSW-ODFW-2006-6. Oregon Department of Fish and Wildlife. Salem, Oregon.

Thedinga, John F., Michael L. Murphy, Scott W. Johnson, K.V. Koski, and J. Michael Lorenz. 1994. Determination of salmonid smolt yield with Rotary-screw traps in the Situk River, Alaska, to predict effects of glacial flooding. N. Am. J. Fish. Manag. 14: 837-851.

Volkhardt, Gregory C., Steven L. Johnson, Bruce A. Miller, Thomas E. Nickelson, and Davd E. Seiler. 2007. Rotary Screw Traps and Inclined Plane Screen Traps. Pages 235-66 in D. H. Johnson et al. *Salmonid Field Protocols Handbook: Techniques for Assessing Status and Trends in Salmon and Trout Populations.* American Fisheries Society. Bethesda, Maryland.

Exhibit A. All species and life stages captured at smolt traps in the Sandy River Basin in 2020

	Clear Creek	Cedar Creek	Little Sandy River	Bull Run River	Gordon Creek	Beaver Creek
Bluegill	0	0	0	0	0	21
Catfish	0	0	0	0	0	2
Chinook Fry	1	52	81	406	316	539
Chinook Smolts (Wild)	0	0	0	0	0	2
Chinook Smolts (Hatchery)	0	0	0	6	0	0
Chiselmouth	0	0	0	0	0	11
Coho Fry	0	830	13	50	66	6
Coho Smolts (Wild)	5	769	103	420	420	92
Cutthroat Juveniles	0	1	1	0	0	0
Cutthroat Smolts	0	2	0	0	8	3
Cutthroat Adults	0	13	2	0	1	0
Longnose Dace	4	0	181	661	457	48
Green Sunfish	0	0	0	0	0	26
Speckled Dace	0	0	0	10	7	651
Banded Killifish	0	0	0	0	0	1
Pacific Lamprey Adult	0	1	0	1	7	17
Lamprey Ammocoete	0	199	4	1	282	177
Northern Pikeminnow	0	0	0	0	0	142
Oriental Weatherfish	0	0	0	0	0	1
Peamouth	0	0	0	0	0	67
Pumpkinseed	0	0	0	0	0	8
Rainbow Trout	1	0	9	0	0	0
Redside Shiner	0	0	0	0	5	268

	Clear Creek	Cedar Creek	Little Sandy River	Bull Run River	Gordon Creek	Beaver Creek
Sucker	0	0	5	32	50	48
Salmonid Fry, Unidentified	6	21	47	854	3,872	0
Sculpin	1	3	3	3	11	280
Steelhead Fry	0	9	55	158	748	0
Steelhead Juvenile	13	15	88	9	201	2
Steelhead Smolts (Wild)	6	22	198	876	153	41
Steelhead Smolts (Hatchery)	0	0	0	2	0	1
Steelhead Adult	0	0	0	0	1	0
Stickleback	0	0	0	0	0	9

[a] Chinook, Coho, and steelhead fry were too numerous to identify individually in most streams. Salmonid fry were subsampled. Where no subsampling occurred, species was listed as “unidentified.”

Appendix D

Bull Run HCP Research Report

Western Toad Monitoring for Reservoir Operations Measure R-3

July 2021

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Contents

Figures

1. Summary

The City of Portland Water Bureau (PWB) was in full compliance in 2020 with its Bull Run Water Supply Habitat Conservation Plan obligations for reservoir operations Measure R-3, Reed Canarygrass Removal.

Measure R-3 is intended to benefit western toads (*Bufo boreas*) and northern red-legged frogs (*Rana aurora*), and the HCP measure has a simple approach. It was assumed that removal of reed canarygrass in known areas of amphibian breeding along the shore at the upper end of Bull Run Reservoir 1 would result in improved breeding habitat. Based on years of monitoring, PWB determined that has not been the case. In addition, only western toads have been observed and they have been the focus of the monitoring efforts.

Evaluating the effectiveness of PWB's efforts to improve toad and frog breeding habitat at the three areas was not part of the original measure. However, in 2016, PWB chose to begin monitoring water temperature and toad breeding site selection to determine whether the measure was having the desired outcomes for toads. In 2019, based on four years of monitoring, primarily toad breeding occurred at untreated sites that have abundant reed canarygrass and flotsam. 2019 was the fourth consecutive year that most eggs were laid in the grass. The 2019 appendix summarized the results for all previous years of monitoring. Unlike previous years, the reed canarygrass was not cut and raked off the areas along the north bank of the upper end of Bull Run Reservoir 1 and this appendix summarizes results for 2020.

For future years, reed canarygrass will not be cut or removed at the toad breeding areas. Instead, toad breeding outcomes will be monitored when more vegetative structure is present at the breeding areas. In addition, PWB plans to conduct additional late-summer surveys for toadlets at the Reservoir 1 shoreline.

2. Introduction

PWB committed through Measure R-3 in its Bull Run Water Supply Habitat Conservation Plan (HCP; Portland Water Bureau 2008) to attempt to improve breeding habitat for western toads (*Bufo boreas*) and northern red-legged frogs (*Rana aurora*) at designated areas along the north bank of the upper end of Bull Run Reservoir 1. To fulfill the HCP commitment in past years, PWB staff annually cut and raked reed canarygrass away from the areas. While the measure is intended to benefit both amphibian species, the focus of the measure has been on toads, because toads are considered to be uncommon in the Bull Run Watershed and breed only at the upper end of Reservoir 1. Also, northern red-legged frogs have not been observed at the upper end of Reservoir 1.

Measure R-3 is based primarily on the premises that (1) toad eggs need warm water to develop properly, and (2) shade from the tall, invasive canarygrass could potentially lower the water temperature where eggs are laid. Cutting and raking away the grass was intended to allow sunlight to penetrate and warm the water so that eggs can develop properly.

Beginning in 2016, PWB began investigating whether implementation of the measure was having the desired outcomes for toads, even though evaluating the effectiveness of the measure was not part of the measure. The 2019 appendix describes in detail monitoring objectives and results for 2016–2019. It also describes the rationale behind the change in the management strategy for this species.

3. Objectives

The objectives of western toad monitoring for 2020 were:

- To monitor for toads coinciding with water temperatures around 14°C
- To determine the magnitude of the breeding effort (minimum number of breeding adults, points of oviposition) during that time
- To assess where breeding occurred in relation to prior years' breeding
- To assess the number of breeding pairs in relation to prior years' monitoring

Prior years of monitoring have shown that cutting and removing the reed canarygrass has not resulted in warmer water (see 2017 Appendix).

An overarching goal of monitoring is to determine how management of the Reservoir 1 water level may affect toad breeding. Specifically, PWB wants to learn if and how the reservoir could be managed to allow toad breeding to persist and succeed at the upper end of the reservoir each spring without interfering with water supply requirements and goals or with the requirements of the HCP.

To achieve these objectives, PWB is monitoring toads at the areas they are known to breed.

4. Monitoring Methods

Survey Timing, Frequency, and Locations

Toad surveys were conducted in the spring, coinciding with water temperatures of 14°C. The month of May was the focal period because May is (1) when off-channel waters first reach the temperature threshold required to initiate breeding, and (2) when breeding adults and eggs have been observed in prior years.

In 2020, the untreated areas were surveyed, including shoreline between the areas that were cut in previous years. The focal areas were Area 1, Area 2, and the area between the two units, where most toad breeding and egg deposition have been observed in prior years. See Figure 1 for the locations of the areas and boundaries of the treated sites.

Breeding Site Selection

A site was considered a breeding site if eggs or breeding pairs in amplexus (mating position) were observed there.

Breeding site selection was examined in the current year and prior years (2016–2019) to determine whether toads are selecting the same areas each year for breeding and to compare the magnitude of breeding effort at each area. In prior years, there were three discrete breeding areas that were monitored separately. In 2020, the reed canarygrass was not cut. For this reason, survey data were not collected by location, but rather over the entire site. For 2020, the uppermost area where all breeding occurred is a mix of two uppermost areas where we had previously cut the grass, and the area between them.

Breeding Onset, Duration, and Magnitude

Toads are known to initiate breeding when the water at their communal breeding sites reaches 14°C (Marc Hayes, Washington Department of Fish and Wildlife, personal communication). This water temperature threshold is an important indicator of breeding onset and is important for egg and larval development. Therefore, during each field survey day, water depth was measured at a permanent stake at each treatment site, and, if sufficient water was present at the stake, water temperature was collected at 10 cm and 30 cm depths. These data assisted in determining when toads would initiate breeding. Data from recent years in the Bull Run Watershed have confirmed that toads begin breeding when the water at their preferred breeding areas rises to 14°C in spring (Portland Water Bureau 2016).

The onset of breeding was the first survey when eggs or pairs in amplexus were found. The duration of breeding began with breeding onset and ended with the last date when new points of oviposition were found.

During each survey, adult toads, pairs in amplexus, new points of egg oviposition, and juvenile toads (tadpoles and metamorphs) were counted. Adult male and adult female toads were tallied separately or as "unknown sex" when identification was not possible. The sexes were identified by size (females much larger) and amplexus position (males on top).

The magnitude of breeding effort was assessed qualitatively. The magnitude was based on the minimum number of breeding adults, the estimated quantity of eggs observed, the number of points of oviposition, and the size (area and quantity of eggs) of the points of oviposition.

Productivity is defined as the number of toadlets produced. Because we used noninvasive observational methods to attempt to detect toadlets, productivity can be described only qualitatively (e.g., “none,” “few,” or “many”). The qualitative descriptions are relative to the many thousands of toadlets that are detected dispersing from other regional breeding sites, and sometimes historically at Reservoir 1.

The toadlet stage is reached when larval toads absorb their tails and move from the aquatic to the terrestrial environment. Although individual toadlets are small, the toadlets can be highly conspicuous as they disperse in huge numbers from breeding areas into the forest.

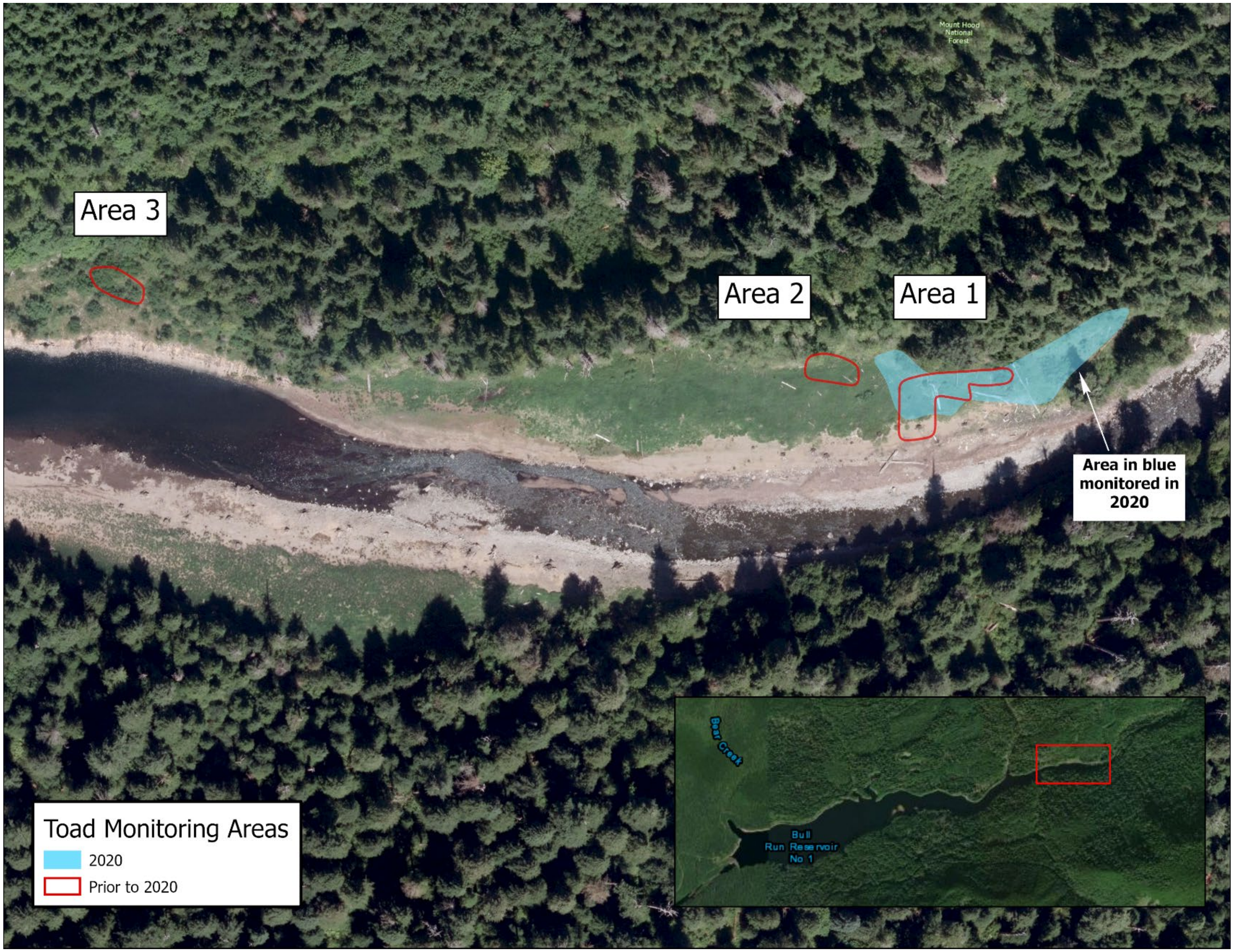

Figure 1. Toad monitoring and reed canarygrass treatment areas

5. 2020 Results and Discussion

Survey Timing, Frequency, and Locations

Four toad surveys were conducted in 2020 between mid-May and mid-June. Surveys were not done weekly as in recent years, but were instead timed to coincide with the potential for water temperatures at the breeding areas to be 14°C.

Surveys were conducted at the same locations as in prior years. Adult toads were not observed in the water on survey days in 2020 because water temperatures oscillated and hit the threshold temperature over the weekends, not on survey days. A few toads were observed in adjacent upland areas on survey days.

Breeding Site Selection

All observations of adults and all eggs were in areas with abundant reed canarygrass and flotsam, especially floating logs, bark, and sticks.

In 2020, toads focused their breeding at Area 1, Area 2, and the area in between, while not breeding at Area 3.

Breeding Onset, Duration, and Magnitude

In 2020, toad laying occurred in June. This is later than the prior five years (2015–2019), when it occurred in May. From 2008 to 2012, one observer noted that toads often bred in June in the same location. Only an estimated eight females laid eggs through June 18, which was the last survey date. All egg laying in 2020 occurred at the uppermost monitoring location.

That observation of eight females laying eggs is a decline relative to prior years. In 2016, for example, more than 20 pairs were observed in amplexus and others were certainly missed. The geographic location of eggs laid was different than prior years, when there was a broad area of egg deposition. In 2020, the distribution was limited and an aggregated egg or hatchling cluster was observed for each of the few females that laid.

Breeding Outcomes

Toad breeding during the spring of 2020 was characterized by few breeding females over a much shorter and later window than in prior years. Adult toads were not observed in the water on survey days in 2020 because water temperatures oscillated and hit the threshold temperature over the weekends and not on survey days. There were a few toads observed along the station 18 trail on survey days.

Monitoring did not continue beyond June 18, so it is possible there was additional breeding that may have been missed. There were no correlations in 2020 with dropping water levels and reduced breeding. Water levels stayed notably high during the sampling period and well into the summer. No tadpoles were observed during the monitoring period through June 18.

6. Approach for 2021 and Future Years

The four years of monitoring between 2016 and 2019 demonstrated that Measure R-3 was not achieving its goal of "improving breeding and rearing habitat" for western toads because grass cutting was not demonstrating an improvement. During the course of monitoring, adult and larval toads showed a pattern of avoiding the treated areas. Red-legged frogs attach their eggs to vegetation, including grass. Thus, the cut areas were mostly unused. In addition, data collected in prior years have shown that the original goal of a temperature benefit for larval toads (warmer water for development created by reduced shading) was not achieved by cutting the grass (see the HCP 2017 annual report).

Beginning in 2020 and continuing in future years, PWB adapted the Measure R-3 commitment to better achieve the goal of improving breeding and rearing habitat. The following changes were made beginning in 2020: (1) stop cutting the grass so that the toads and frogs have the vegetative structure they seek during laying and larval development, and (2) monitor toad breeding at the site and examine future breeding outcomes.

Monitoring during 2020 collected data that will inform potential future efforts to improve breeding outcomes for toads at the sites. We will continue monitoring in 2021. Monitoring requires greater effort and resources than the simple, one-day effort of cutting and removing the grass. The extra effort is necessary to try to gain additional information on toad productivity and retain toad breeding at the sites.

7. Works Cited

Csuti, B., O'Neil, T.A., Shaughnessy, M.M., Gaines, E.P., and J.C. Hak. 2001. *Atlas of Oregon Wildlife.* Oregon State University Press, Corvallis, Oregon. 525 pp.

Portland Water Bureau. 2008. Bull Run Water Supply Habitat Conservation Plan for the Issuance of a Permit to Allow Incidental Take of Threatened and Endangered Species. Portland, Oregon.

Portland Water Bureau. 2017. Bull Run Water Supply Habitat Conservation Plan Annual Compliance Report 2016 – Year 7. Portland, Oregon. 273 pp.