US Army Corps of Engineers

Portland District - Portland, Oregon

Rogue River Sustainable Rivers Project

Literature Review

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1. Executive Summary

The U.S. Army Corps of Engineers (USACE) operates two dam and reservoir projects in the Rogue River Basin, Lost Creek and Applegate. Authorized purposes for Applegate are flood risk management, fish and wildlife enhancement, and irrigation. Similarly, authorized purposes for Lost Creek are flood risk management, power production, recreation, and irrigation. Other uses include fishery management and water quality. These projects were identified in 2020 as projects of interest for implementing environmental flow (e-flow) operations in the Rogue River Basin. Lost Creek Dam is located on the mainstem of the Rogue River at river mile 158.4. Lost Creek Dam construction was started in 1972 and was completed in 1976. Applegate Dam is located on the Applegate River, a tributary of the Rogue at river mile 45.7. Applegate Dam was completed in 1980. A third project in the Rogue River Basin, Elk Creek Dam, was not completed. Under litigation, Elk Creek construction was stopped in 1988. The dam was notched in August 2008, and USACE restored Elk Creek to its original channel in September 2008 (USACE 2019).

This literature review focuses on Water Control Manuals (WCM) and other USACE design and operational documents to 1) describe the intent and functionality of the Rogue Basin reservoirs at local and watershed levels and 2) investigate whether the introduction of e-flows, is technically feasible, both from the standpoint of infrastructure capabilities as well as identification of any water management constraints that could preclude e-flow operations. Oregon Department of Fish and Wildlife (ODFW) Information Reports and other post construction and operational documents were used to help understand if Lost Creek and Applegate water management for fisheries operations are successfully meeting the intended objectives. Additionally, interviews with experts familiar with the Rogue River Basin were used to assess need and benefit of e-flows and whether it would be feasible to implement e-flows in the Rogue River Basin.

Supplemental documents, including ODFW Information Reports and U.S. Fish and Wildlife (USFWS) reports, were valuable in helping to determine whether fishery enhancement benefits are being realized through USACE/ODFW operational measures. The USFWS Progress Reports and ODFW Information Reports documented a successful implementation of fishery enhancement operations that benefitted fish species, including Chinook and Endangered Species Act (ESA) listed Coho and other salmonid fish. Current operations appear to provide the desired fisheries enhancement target and meet the salmon abundance goals as outlined in the conservation plan recommendations. The Information Reports also acknowledged the complexity and sensitivity of the water management activities as well as the sometimes unpredictable fisheries responses.

ODFW Information Report 2020-06 documents a study of Upper Rogue River Basin “early” and “late” run Chinook salmon, which was done to understand the current nature of genetic interactions between spring and fall Chinook salmon to better inform management decisions. Data suggested that there is a proportionally high population of spring Chinook salmon in the upper reaches of the Rogue basin and that they are not swamped by early arrival of fall Chinook salmon. The current regulation to benefit spring population does not appear to adversely impact other fisheries objectives. In ODFW Information Report 2020-02, ODFW evaluated “the genetics of naturally produced Chinook salmon (Oncorhynchus tshawytscha) captured in the Lower Rogue River (OR) fishery". The focus was on the Spring Chinook salmon in the lower river. It was prepared to inform the ODFW management of spring and fall Chinook salmon as distinct species management units (SMUs). No specific water management conclusions, nor changes to operations, were drawn. The effort pointed to current regulations being protective of early run life history genetics. The following USFWS progress reports were reviewed: "Report III: Spawning Populations and Spawning Grounds in Upper Rogue River from 1949 through 1954" and "Report IV: Summary Reports Dealing with Sport Fishery, Spawning, and Population Studies for The Entire Rogue River System in 1949-1954". These reports provided useful anecdotal and semi-quantitative collection data that portrayed the condition of Rogue River fisheries pre-dam. These reports informed the operational requirements set forth in the Lost Creek and Applegate completion reports. Collectively, these OWFW and USFWS reports have been influential in guiding for post-dam implementation of fisheries enhancement operations and associated monitoring reports related to ODFW and USACE fisheries practices. Importantly, no reports or documents were found that suggest current operations are at risk of failing to meet fisheries enhancement objectives.

From this positive and encouraging starting point, the literature review then explores e-flow opportunities as potential enhancements for the existing high-quality fisheries. Findings do suggest that additional e-flows are feasible. Wintertime peaks could feasibly be returned to higher outflow rates and summertime low flows could be reduced further to match historical pre-dam conditions. Implementation would depend on expected ecological benefits and hydrology similar to past conditions; something that cannot be counted on if climate change effects (not assessed in this report) occur in the basin. Further, flood risk reduction, the primary USACE authority in the Rogue Basin, would likely diminish the range of allowable downstream flow releases. Finally, changes to Rogue River low flow minimums would be constrained by water quality temperature management as well as exercised irrigation and other water rights.

The literature review as well as communication and interviews with knowledgeable staff, both internal and external to USACE, support the determination that current fishery enhancement operations are being successfully implemented and realizing benefits in the Rogue River Basin. Examination of the literature point to complexity and uncertainty in terms of species' responses and sensitivity to any operational flow change. While technically feasible, changes for e-flows may not be desirable based on current ODFW fishery enhancement policy and associated water management operations in the Rogue River Basin. However, things could change in the future. It is recommended that the potential e-flow implementation be periodically re-examined.

2. Literature Review Purpose

The purpose of this work is to summarize literature review findings affecting potential SRP implementation of e-flows in the Rogue River Basin. Applicable reports and other documents, including interviews with experts associated with fisheries and water management in the basin, are considered and summarized. This document is intended to help inform this and future e-flow studies for the Rogue and to identify and promote promising e-flow opportunities.

3. SRP E-Flow Implementation

To investigate e-flow opportunities in the Rogue River Basin, it is useful to understand e-flow implementation in the Willamette River Basin. To that end, the following summary is provided below and is taken from "MEMORANDUM FOR Jose L. Aguilar, Colonel, EN, Commanding (CENWP-DE) Implementation of Environmental Flows in the Willamette Valley" (signed 17-July 2015).

The Sustainable Rivers Program (Willamette SRP) began in 2002 as a partnership between The Nature Conservancy (TNC) and USACE with the objective of developing, implementing, and refining a framework for beneficial flows downstream of dams. After several years of work, e-flow operations were instituted in July 2015. The final flow recommendations focused on fall flows (October-November), winter high flows (November-February), and smaller spring bankfull flows (flows at Action Stage, as identified by the National Weather Service) (March-June). Each seasonal flow is important to some aspect of ecosystem health. Fall flows enhance channel habitat and provide flows for outmigration. Winter high flows provide benefits to habitat by modifying channel features and recruiting large woody debris. Springtime flows are important for providing out-migration flows as well as scouring and flushing during bank full events. The Environmental flow recommendations were developed for the Middle Fork Willamette River, McKenzie River, and the North, South, and mainstem Santiam Rivers. The flow recommendations were defined by 1) event duration; 2) number of events per year; 3) range of flow magnitude; and 4) frequency. It is important to understand that the e-flow operations are constrained by WCM operational requirements for each project and the system as well as the Willamette Biological Opinions (BiOp) (National Marine Fisheries Service (NMFS) and USFWS) implementation. The Release More scenario was recommended as a starting point for a strategy to implement e-flow releases in the Willamette River Basin. The Release More scenario provided an overall increase in e-flow events (benefits) while affecting minimal change to flood risk reduction, water quality, hydropower, and meeting BiOp targets.

It is cautioned that e-flows cannot be guaranteed every year. The e-flow operations are 'opportunity driven' and would first be indicated by a forecast of a substantial weather system headed for the Willamette Valley and the three sub-basins of interest.

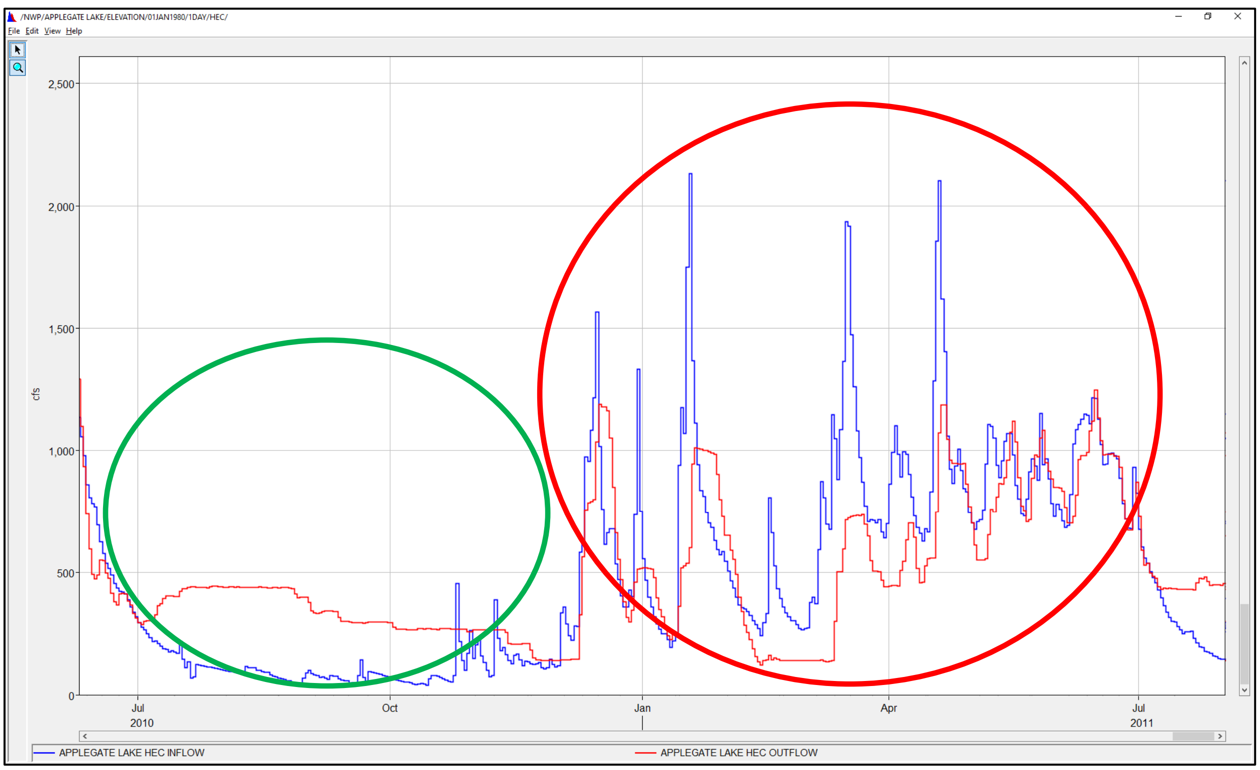
Overall, the e-flow benefit expected from the preferred e-flow operation is an increased number of wintertime events. Springtime e-flow events are expected to be minimally increased. Tables were provided that listed the range of e-flow operation goals downstream.

Maximizing e-flows is important to effectively manage aquatic habitat. The higher flows provide the mechanism for creating and managing fish spawning/incubation and other aquatic habitat needs over time. Salmon populations and other aquatic organisms are adapted to these variable flow conditions. Active management by fisheries and other technical experts should be part of the protocol.

Rogue River implementation of environmental flows was envisaged to be like Willamette River Basin SRP. There are important differences between the two watersheds. Hydrology, topography, climate, and management needs for critical species can be different, dramatically affecting water management objectives and operations. The Rogue River Basin is also unique in that its fisheries enhancement is the primary goal of water management operations. The yearly plans are developed by ODFW with USACE input and implemented by USACE.

Per authorizations, ODFW is mandated to use approximately 75% of the stored water for fishery enhancement purposes. To this end, and evidenced by various reports citing success, it may be hard to sway hesitancy to implement SRP if there is not shared agreement in e-flow benefits to fish. In fact, there is hesitancy on introducing changes that may upset fish operations that are seen as already being beneficial.

With that context, USACE examined the feasibility and the potential for e-flow operations out of Lost Creek and Applegate dams. The following graphic (Figure 1) below depicts operations at Applegate Dam and contrast inflow and outflow. Inflow is a proxy for project naturalized conditions. Red is regulated outflow and blue is inflow, at Applegate and Lost Creek dams, respectively. Data were obtained from USACE DataQuery, an online publicly accessible data source.



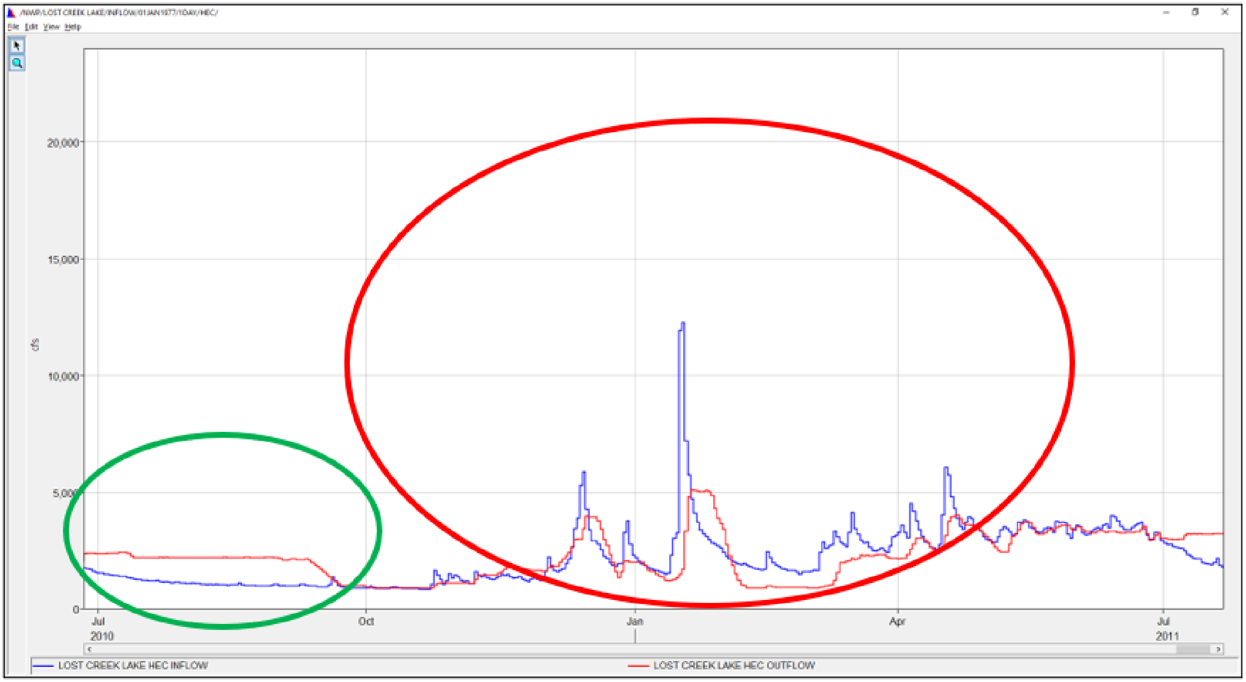


Figure 1. Inflows (blue), outflows (red hydrograph), and possible e-flow windows in summer (green oval) and winter (red oval) months for Applegate (top) and Lost Creek (bottom).

Examination of the above figure shows that management decisions could be made that would return flows to more natural conditions via increased winter flows and reduced summer flows. Mimicking natural flow patterns is a common e-flow strategy that is designed to improve the ecological condition of managed river systems. The projects' spillways and the other outlet structures would be adequate to meet most requirements. However, it is unclear whether those types of changes would be feasible within current WCM constraints.

4. Rogue River Project Water Management Overview

It is important to have a conceptual understanding of Rogue River project operations, especially as related to water management for fisheries enhancement. The Rogue projects - Lost Creek, Applegate, and Elk Creek - are authorized for flood risk management, fisheries enhancement, irrigation, and municipal and industrial water supply (Lost Creek only). Secondary authorized purposes include hydropower, lake recreation, and water quality (USACE 2017). In a normal runoff year, about 75% of stored water is allocated for fisheries enhancement. Stored water in addition to the 40,000 acre-feet may also be used to meet minimum flow requirements for fishery enhancement if it is not under contract for irrigation. A temperature release schedule is developed annually by USACE after coordination with the ODFW. Project releases are made as close to the schedule as possible. Selective withdrawal structures are not operated to meet temperature goals outside of stated operating constraints except by instructions from USACE Water Management Section.

From the “Standard Procedures for Regulation of the Rogue Basin Projects” (USACE 2017) the Rogue Basin Project consists of two multipurpose projects, Lost Creek Dam and Applegate Dam, which are operated per the authorized purposes described above. Lost Creek generates power as a secondary benefit and is not operated for power peaking. Both projects are also operated for temperature control. A third authorized project, Elk Creek Dam was not completed and has been rendered inoperable by means of a notch blasted through the dam to allow the creek to flow freely and for fish to pass. Elk Creek does not provide flood risk management or other benefits. Lost Creek controls about 13% of the entire Rogue Basin and about 28% of the basin above Grants Pass, Oregon. Applegate controls about 29% of the Applegate Basin. Figure 2 shows the Rogue River Basin and regulated subbasins.

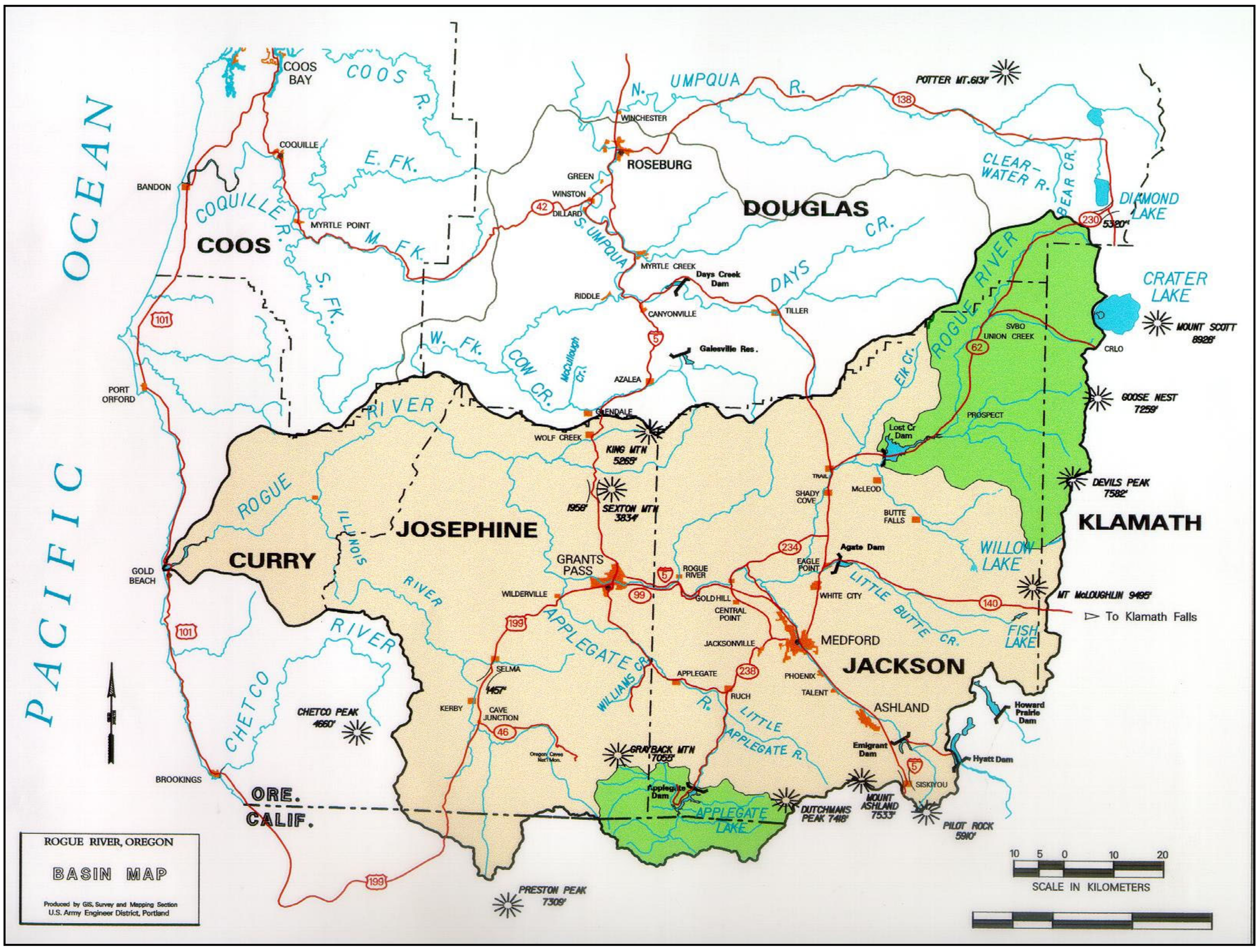


Figure 2. The Rogue River Basin with regulated portions of the watershed shown in green (from USACE Rogue basin standard operating procedures document, Figure 6).

Conservation season is from about March through October, including filling season and release season. Water levels vary between mid-April and early September, depending on inflow to the reservoir, required releases for authorized purposes, and surface evaporation. Reservoir outflows are coordinated with the State of Oregon in the spring and adjusted throughout the summer as needed to meet authorized purposes. For the reservoir to fill for maximum summer conservation use, sufficient seasonal runoff must occur above required releases and evaporation. Both projects have selective withdrawal devices and are also operated to meet release temperature targets provided by the State.

Once water reaches the highest achievable level during the filling period, the USACE operates each reservoir for conservation purposes, including fishery and environmental uses. The releases mentioned above, combined with surface water evaporation during the drier summer months, typically result in a pool “drawdown” over the course of the summer.

May and June can still bring significant runoff through rain showers when the projects are full or close to full. Both Lost Creek and Applegate projects have a minimal amount of storage above full pool for waves, but not for flood risk management. It is very important to keep an eye on the spring weather.

The fisheries goal in May and June is to keep water temperature at Agness below 66 - 70° F (increases throughout the period). This is accomplished by passing Lost Creek inflow or releasing stored water up to a specified flow (can change annually). This operation is described in the annual recommended releases supplied by the State (ODFW). Formulas were created to calculate the release needed to meet the water temperature goal based on daily high temperatures at Medford. This is used for temperature regulation. At Applegate, the typical operation is to pass inflow in May and through most of June, if possible. As inflow recedes, release of stored water to meet fisheries objectives may start in early June. This is described in the annual recommended releases supplied by the State.

The following scheduled water control diagrams for the Lost Creek (Figure 3; USACE 2013) and Applegate (Figure 4; USACE 1990) projects graphically summarize the annual operations effect on the reservoir elevations. The information is taken directly from the WCM.

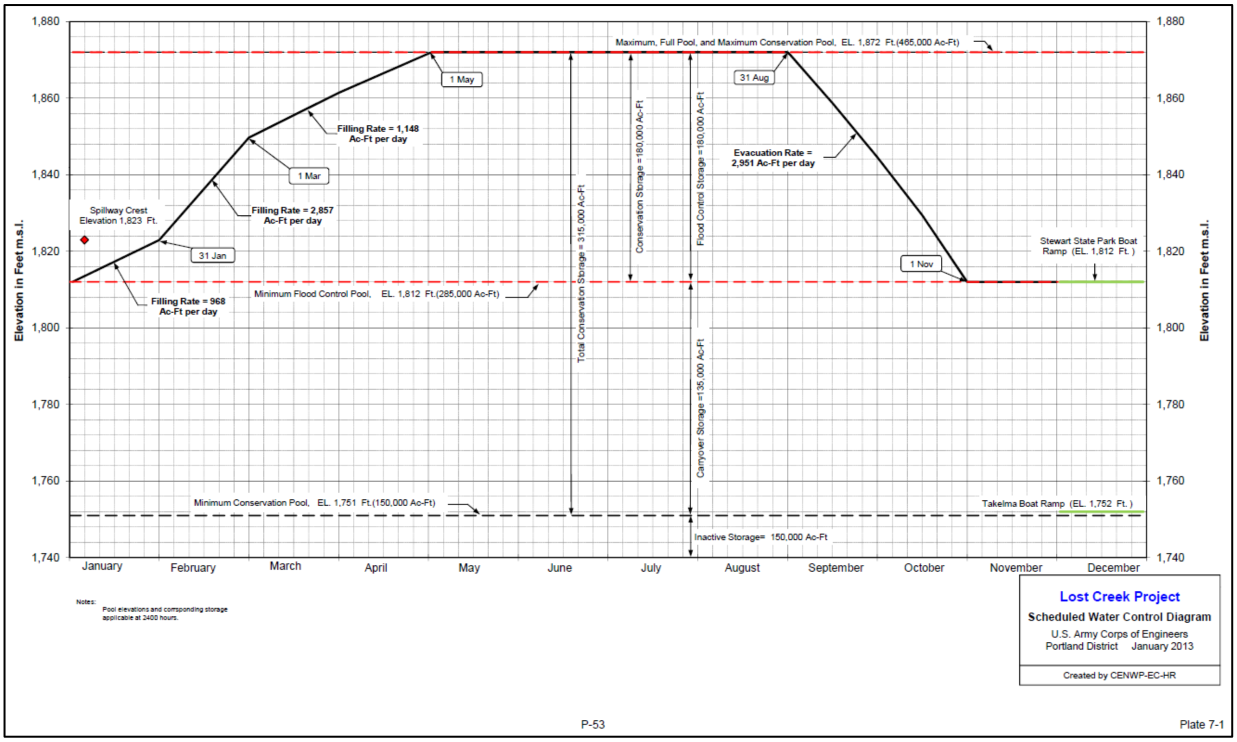


Figure 3. Water control diagram for Lost Creek (USACE 2013).

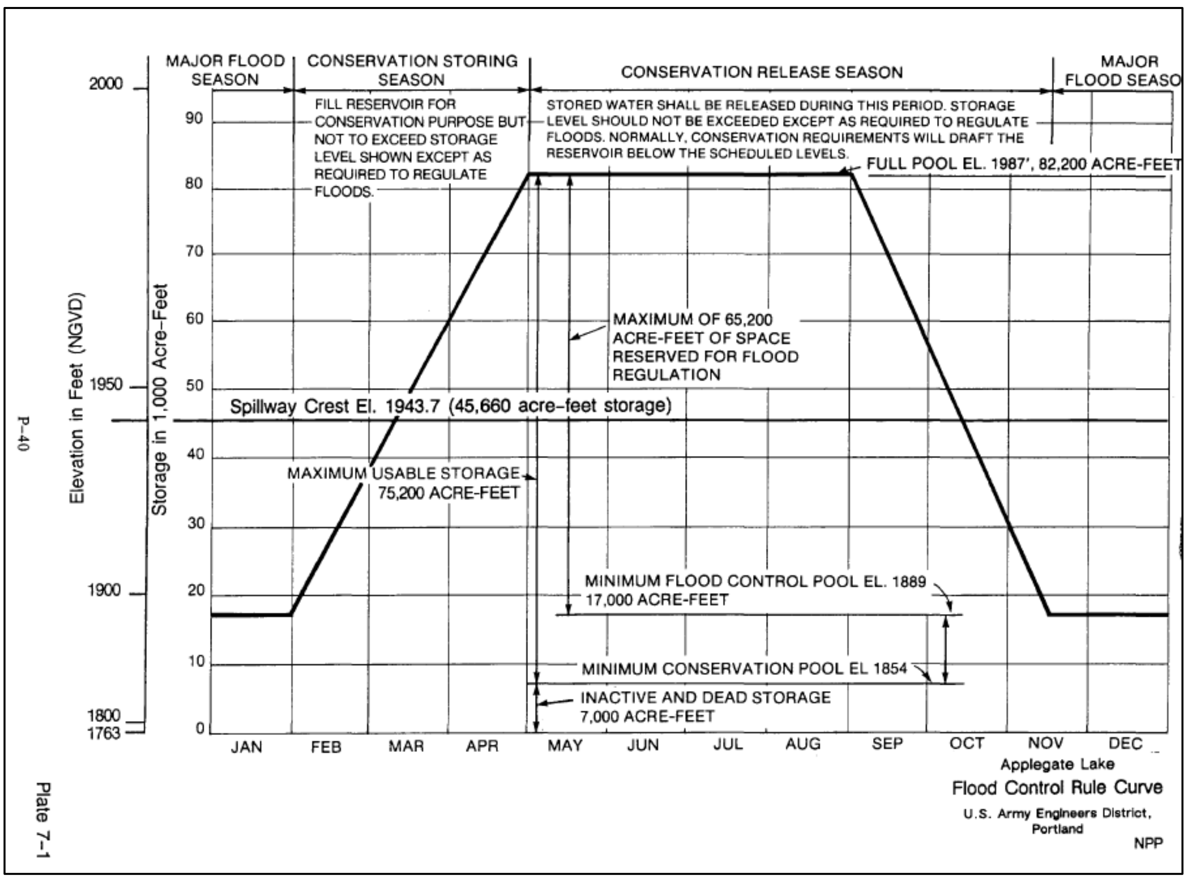


Figure 4. Water control diagram for Applegate (USACE 1990).

From basin Standard Operating Procedures (SOP):

The Rogue River can be a confusing place for fisheries. Fresh anadromous fish enter the river every month of the year. Lost Creek and Applegate are unique, compared to other basin projects, in that a large portion of the conservation storage is allocated specifically to fisheries. The projects are operated in a number of ways to maximize benefits.

One key operation is to reduce flows at as slow a rate as practical. It is much better to ramp down slower than the low flow ramp rates listed in the WCM so that fish and biota/insecta (fish food) are not stranded. ODFW is less concerned about rates that ramp up flows; however, a quick change in ramping up flows may affect downstream boaters and fishermen (safety). Regular low flow ramp rates are appropriate for ramping up at times other than when projects are operated for flood risk management. Desired ramp down rates at both projects are 150 cfs every three hours with a maximum reduction of 750 cfs or 20% of outflow (whichever is less) during a 24-hour period whenever possible (during times other than flood operations). ODFW will recommend a lesser maximum 24-hour reduction at times when juvenile salmonids are more susceptible to stranding, typically in the January to June time period. The maximum 24-hour reduction will then typically be 10% or 15% of outflow.

During flood season, project storage can be used to attenuate peak flows and reduce scour, dewatering of redds, and stranding. During conservation season, stored water is released to meet a number of fishery objectives listed below:

Lost Creek:

- Minimize pre-spawning mortality among adult spring Chinook.
- Minimize dewatering of juvenile salmonids the following spring.
- Minimize dewatering of spring Chinook redds the following filling season.
- Minimize early emergence by spring Chinook fry the following spring.
- Minimize pre-spawning mortality among adult fall Chinook.
- Increase survival rates of juvenile salmonids in summer.
- Minimize the proportion of fall Chinook that spawn above Gold Ray Dam.
- Minimize the effects of flow augmentation on the fly fishery in the canyon.

Applegate:

- Increase summer rearing area for juvenile Coho salmon, juvenile steelhead, and cutthroat trout.
- Increase spawning distribution of fall Chinook salmon.
- Minimize dewatering loss of fall Chinook eggs and fry in winter and spring.
- Enhance rearing conditions for juvenile fall Chinook salmon.

More detailed fisheries information can be found in the Completion Reports produced for the USACE by ODFW. Fisheries priorities, including goals for reservoir operation, are also outlined in the Spring Chinook Conservation Plan and the Fall Chinook Conservation Plan produced by ODFW.

5. Literature Review Documents

The following report sections summarize the literature review documents, including expert interviews.

5.1. Rogue River Regional Master Plan and Integrated EA (draft, 2019)

Recommendations at Lost Creek were recreation-centric and overall, the Master Plan had no fishery enhancement recommendations for Lost Creek. Elk Creek Master Plan recommendations to benefit fisheries included development of a comprehensive plan for disposal and/or use of gravel piles near the notched dam and completion of river mile 5.6 Coho habitat as part of ensuring the health and sustainability of natural resources at Elk Creek. Two recommendations for Applegate Project had environmental/fisheries connections: 1) to improve river access and accessibility below Applegate Dam via a partnership with U.S. Forest Service intended to further align environmental stewardship and recreation efforts and 2) to develop a plan for special status species management, including gravel augmentation below Applegate Dam to enhance spawning areas.

The draft Environmental Assessment (EA) had a draft finding of no significant impact (90% Final Draft – February 2019). The draft EA found that the "Rogue River Regional Master Plan (Master Plan) will not significantly affect the quality of the human environment and that an environmental impact statement (EIS) is not required".

From the draft EA, the purpose of the Rogue River Regional Master Plan is to serve as the overall strategic land use management document guiding USACE administration and development of recreational, natural, and cultural resources on project lands of the Lost Creek Lake, Elk Creek, and Applegate Projects. The Master Plan provides resource objectives and management and development concepts that guide the management, development, and use of project lands for the next twenty years. Although USACE updated the Elk Creek Master Plan in 2012, master plans for the other Rogue River Projects date back to the 1970s. A regional master plan is needed to integrate and update management and development planning for the Rogue River Projects in order to guide the responsible stewardship and sustainability of project resources for the benefit of present and future generations. Specifically, the Rogue River Regional Master Plan is needed to ensure management, development, and use of project lands are aligned with national objectives, regional needs, and resource capabilities and suitability; to protect and sustain project natural and cultural resources; and to provide public recreational opportunities that are consistent with authorized project purposes.

The geographic area associated with the Master Plan includes USACE-owned land around the Rogue River Project. Congress authorized the Rogue River Basin Project in the Flood Control Act of 1962. The Project as originally authorized contemplated the construction of three dams and reservoirs, William L. Jess Dam (Lost Creek Lake), Elk Creek Dam, and Applegate Dam. The Rogue River Basin Project was congressionally authorized to provide flood risk management, irrigation, water supply, recreation, fish and wildlife enhancement, and water quality control benefits. All three individual projects are in Jackson County, Oregon. Elk Creek and Lost Creek Lake are near Shady Cove, Oregon, and Applegate Dam is southwest of Medford, Oregon and five miles from the California border.

The Proposed Action evaluated in the draft EA is the adoption and implementation of the Master Plan, including the updated land classifications described and the management and development needs identified in the Resource Plans sections.

USACE requires master plans for Civil Works projects and other fee-owned lands for which USACE has administrative responsibility for management. The Master Plan provides overall resource objectives, updated land classifications for USACE-owned land, and resource plans that identify future needs and priorities and management recommendations

The Master Plan provides resource objectives and management and development concepts that facilitate the efficient and cost-effective management, development, and use of project lands for the next twenty years. The Master Plan does not address regional water quality, water level management, flow rates, shoreline management, or the operation and maintenance of project facilities.

The Master Plan includes revisions to land classifications that respond to changes in the conditions of physical and natural resources, recreational uses, regulations, and USACE management guidance that have occurred since the original master plans were adopted. These revisions are proposed to address ongoing and anticipated management issues, including degradation of natural resources and recreational features.

The updated land classifications would also allow USACE Natural Resources Managers (NRMs) flexibility to respond to changing conditions and uses over the life of the Master Plan and ensure that actions needed to maintain USACE facilities are compliant with all relevant federal regulations.

The Master Plan also includes resource plans for Lost Creek Lake, Elk Creek, and Applegate Dam that describe how each land classification will be managed in terms of anticipated public use and resource stewardship needs. Additionally, the resource plans identify potential future development and management needs for each area. Future development and management needs identified in the Master Plan are not specific projects, but rather they represent broad categories of actions that USACE may implement over the life of the Master Plan.

5.2. USACE Water Control Manuals

There are two main projects operated by USACE in the Rogue River Basin. Lost Creek is located on the mainstem upstream of Elk Creek, while Applegate is located downstream on the Applegate River, a tributary to the Rogue (Figure 5). The projects are managed for flood risk management, water supply, hydropower, and wildlife management. USACE, state, and local agencies operate the projects to protect native fish populations and their habitat. The original design and operation of the dams focused from the beginning on beneficial fish management. Lost Creek Dam is located on Rogue River at river mile 158.4. Lost Creek construction was started in 1972 and was completed in 1976. Applegate Dam is located on the Applegate River at river mile 45.7. Applegate was completed in 1980.

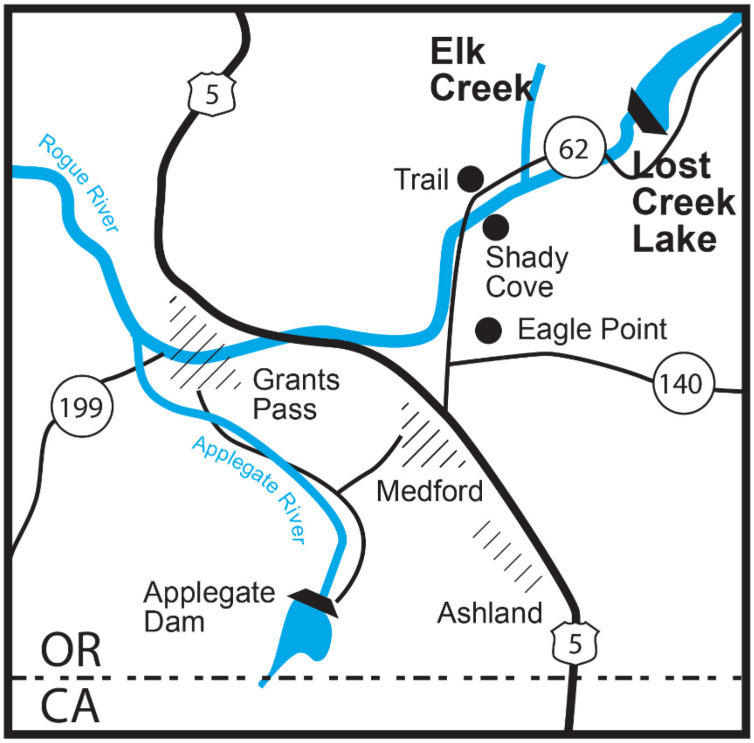


Figure 5. Schematic of the Rogue River Project, including Elk Creek, Lost Creek Lake, and Applegate Dam

Seasonal streamflows of the Rogue River Basin are such that the same reservoir storage space can be scheduled to serve both flood risk management regulation and water conservation needs effectively (USACE 1990). Flood regulation is provided by reserving storage space for flood risk management during the late fall, winter, and early spring. During the flood risk management season, pool elevations are held at minimum flood risk management pool elevation, except during flood events. Beginning in February, the storage space reserved for winter floods is filled gradually for conservation release storage, with a goal to have the project full by April 30th of each year.

At Lost Creek Lake, 180,000 acre-feet (180 kaf) of water is available to be released during the conservation release season in years when the project fills to maximum conservation pool elevation. Of this 180 kaf, 125 kaf of storage is allocated for fishery enhancement, 35 kaf is allocated for irrigation and 20 kaf for municipal and domestic use. At Applegate Lake, 66 kaf is available for release during the conservation release season of which 40 kaf is allocated for fisheries enhancement and 26 kaf is available for irrigation, provided the project is filled (USACE 1990).

5.2.1. Water Control Manual for Lost Creek, Oregon (2013)

The Lost Creek Project was planned, designed, and built by USACE, and is operated by USACE, Portland District. Recently, the Willamette Valley Operations Project Manager (OPM) was assigned responsibility for the operation of the projects in the Rogue River Basin.
Lost Creek Project is staffed 24 hours a day by power plant operators. The Applegate Project on the Applegate River is operated by remote control. The ODFW through the Oregon Water Resources Department (OWRD) has the responsibility for ensuring that minimum flows remain in the river for fisheries. The USFWS and the NOAA-Fisheries provide input to the ODFW.

Lost Creek is in southwestern Oregon, northeast of the city of Medford in Jackson County, Oregon. The lake is about 205 miles south of Portland, Oregon, at river mile 157.2 on the mainstem of the Rogue River, approximately 3 miles upstream from the confluence of Big Butte Creek. Lost Creek Lake controls 13 percent of the Rogue River drainage. Lost Creek Project, completed in 1976, was the first and is the largest of the multiple-purpose projects for the Rogue River Basin. The second project, Applegate, is located on the Applegate River. The confluence of the Applegate River with the Rogue River is at RM 96. Completed in 1980, Applegate is operated by personnel from the Lost Creek Project.

The primary purposes of the Lost Creek Project are flood risk management, irrigation, water supply, and fisheries enhancement. Secondary purposes include power generation, water quality control, wildlife enhancement, and recreation. Lost Creek Project was the first in Portland District to have water quality and fisheries enhancement as authorized project purposes.

There are only 3,310 acre-feet of water contracted, as of March 1992. The Bureau implements and manages the sale of irrigation water for the Federal government. A contract holder with the Bureau must also obtain an OWRD permit to withdraw water from an Oregon stream. The amount of storage of water in USACE reservoirs of the Rogue River Basin is based on seasonal regulation schedules established according to the individual flood risk management rule curves for each dam.

Three seasons are associated with reservoir regulation activities. The major flood season extends from early- to mid-November through January. Starting in late January/February, the conservation storing season begins and lasts until the end of April. During this period, the reservoirs are normally filled to their maximum conservation pool level. The conservation release season is 1 May through 31 October. During all seasons, water is released to meet required minimum releases. Minimum flow requirements for Lost Creek are shown in Table 1.

Table 1. Minimum flow requirements below Lost Creek Dam (USACE 2013).

4. Minimum Flow Requirements:

These flows will not be reduced except during periods of declared water shortages, by request of the state of Oregon, or when hydrologic conditions indicate that other primary authorized functions will be jeopardized.

1 Feb – 30 Apr	700 ft^3/s
1 May – 15 May	1,000 ft^3/s
16 May – 31 May	1,300 ft^3/s
1 Jun – 10 Jun	1,500 ft^3/s
11 Jun – 30 Jun	1,800 ft^3/s
1 Jul – 20 Aug	2,000 ft^3/s
21 Aug – 7 Sep	1,500 ft^3/s
8 Sep – 31 Jan	1,000 ft^3/s

A minimum release of 500 ft^3/s will be used during flood control operations.

Table 2. Lost Creek pool elevations, areas, storages, and discharge capacities (USACE 2013).

Table 2-2. Lost Creek Lake Principal Elevations, Area, Storage, and Discharge Capability.

FEATURE	ELEVATION (feet NGVD)	WATER SURFACE AREA (Acres)	STORAGE (acre-feet)	SPILLWAY DISCHARGE[1] CAPACITY (ft^3/s)	OUTLET WORKS DISCHARGE[2] CAPACITY (ft^3/s)
Top of Dam	1,882		500,000		
Maximum and Full Pool	1,872	3,430	465,000	158,000	11,460
Minimum Flood Control Pool (also Top of Carryover Conservation Pool)	1,812	2,600	285,000	0	9,860
Minimum Conservation Pool (also top of Inactive Pool)	1,751	1,800	150,000	0	8,000
Dead Storage (Top)	1,640	620	21,000	0	0
Lowest Intake (Invert)	1,595	175	3,000	0	0
Streambed	1,500	0	0	0	0

[1]Free overflow condition
[2]Two gates full open condition

Federal minimum release flows are not related to the state instream flow. If the reservoirs do not achieve their appropriate pool levels, the storage period is extended as long as there is sufficient water entering the reservoir. The conservation release season lasts from 1 May through 1 or 15 November. Water is released for all consumptive and non-consumptive, non-flood risk management purposes during this period. Releases from each dam are composed of the volume of water that is equivalent to a combination of natural flows entering the reservoir and some component of stored water. The water control diagram is shown in Figure 6.

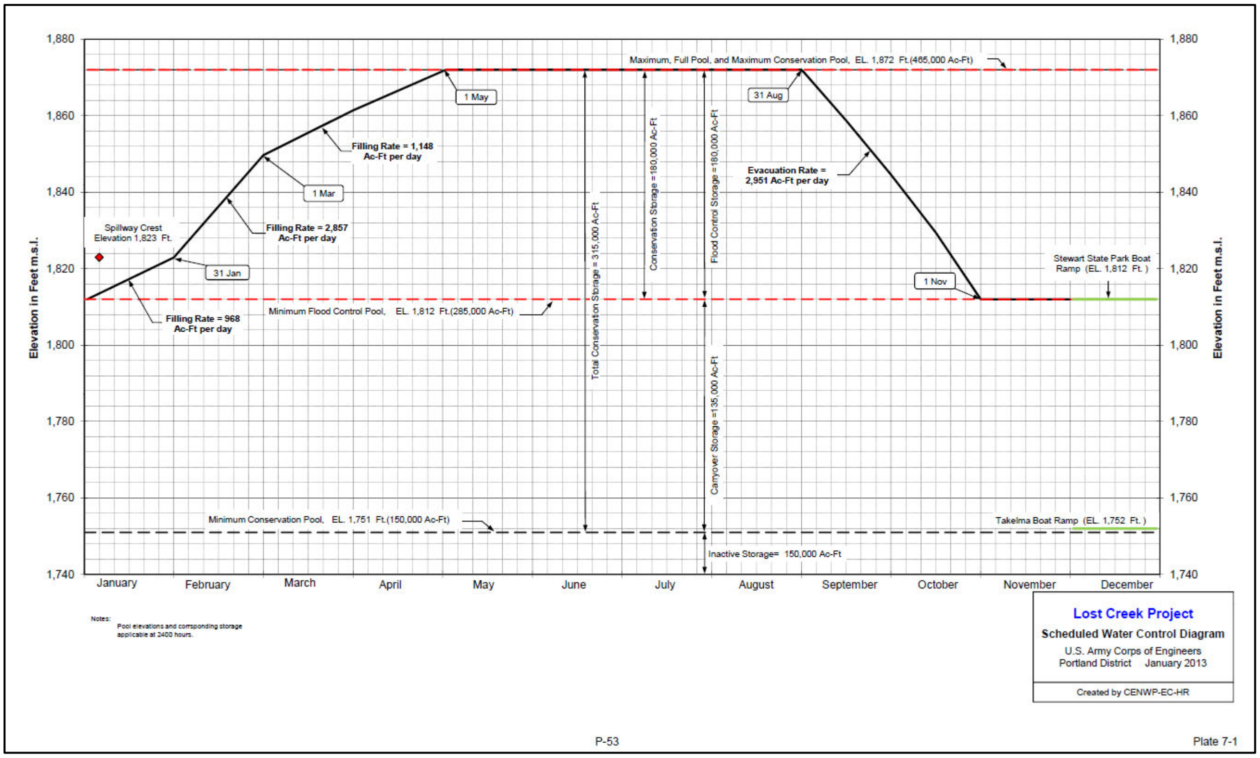


Figure 6. Water control diagram for Lost Creek Lake (USACE 2013).

Water releases above the Federal minimum flows are usually made after Labor Day through the end of the conservation release season of each dam to reduce pool levels to the minimum flood control pool. USACE is reluctant to store water above the flood risk management rule curves during the conservation storing season of February through April, even when there appears to be a seasonal drought occurring. There does not appear to be any strong correlation between a seasonal drought with below average natural stream flows and the occurrence of a spring flood.

Initially, flood risk management storage space was required to be available from 15 November to 31 January of each year. A constant maximum filling rate beginning on 1 February and ending 30 April was also specified. After analysis of the December 1964 flood, additional storage space was determined to be necessary during the entire month of November, changing the major flood risk management portion of the schedule to 1 November to 31 January. Changes in the timing of the filling portion of the flood risk management space occurred in 1977 after an unpublished hydrology study indicated there could be desirable conservation benefits. This schedule, which is presently in use, requires maximum flood risk management space to be made available 1

November to 31 December, after which non-uniform filling takes place between 1 January and 30 April. The schedule is detailed in Section 7, paragraph 7-3, of the WCM (USACE 2013).

The initial volume of storage space required at Lost Creek Lake was 105,000 acre-feet, which could be increased to a "maximum" amount of storage of 165,000 acre-feet if snowpack conditions on the watershed indicated a potentially high flood threat. After analysis of the December 1964 flood, the amount of storage allocated for flood risk management was increased to the maximum amount (165,000 acre-feet) plus an additional 15,000 acre-feet for a total of 180,000 acre-feet. This storage space was to be maintained through 31 December of the flood risk management season and is the basis for the present flood risk management rule curve.

The minimum flow release from Lost Creek Lake during flood risk management operations was originally 200 cfs. However, due to the possibility of dewatering salmon spawning areas downstream, minimum release during flooding was increased to 500 cfs. This increase only affects releases performed during flooding since releases at other times are at or above 700 cfs.

Release of stored water from Lost Creek Lake during the conservation release season, 1 May to 31 October, is scheduled to provide optimum conservation benefits consistent with water use priorities. The volume of water stored in Lost Creek Lake, streamflow conditions during the low water season, and the conservation demands for stored water vary from year to year. These variables require that a flexible conservation release schedule be developed each year. A preliminary operating plan based upon available stored water, forecasted streamflow, and current water demands is prepared each spring.

A provisional conservation release schedule is formulated in cooperation with the Rogue Basin Water Management Advisory Group. The Advisory Group has representatives from USACE, OWRD, ODFW, Oregon Department of Environmental Quality (ODEQ), Oregon State Marine Board, NOAA Fisheries, USFWS, U.S. Forest Service, U.S. Bureau of Land Management, and the U.S. Bureau of Reclamation. The OWRD acts as the representative of the State of Oregon.

Conservation season planning begins in February. By April a more definitive operating plan is presented to the advisory group for review. After the advisory group has commented, a revised plan is presented to the public in late May for comment. Public comments are then considered in adopting the final plan. The final release schedule is developed by early June. The operating plan is reviewed periodically throughout the conservation release season and revised, if necessary, to meet changing conditions and water demands. Normally the natural streamflow provides for all conservation needs through June, including prior water rights. Therefore, drafting from storage for conservation purposes is usually not significant until early July. July and August are months of greatest demand for stored water. During years with inadequate water storage when minimum flow requirements and contracted water from storage cannot be met in full, all authorized project purposes are reduced proportionally such that each function receives the same percent allocation of available stored water.

The water control plan for Lost Creek Lake includes fisheries enhancement as a primary project function. As a project function, fishery enhancement is considered equal to irrigation and water supply and subordinate to flood risk management. The Rogue River fishery is a complex system with a variety of fish species at various stages of development. Provision of minimum flows, as described in the WCM, serves to enhance the Rogue River fishery. These flows will not be reduced except during periods of declared water shortages, by request of the State of Oregon, or when hydrologic conditions indicate that other primary authorized functions will be jeopardized. The ODFW has a State of Oregon permit to use 125,000 acre-feet of water from seasonal conservation storage for fishery enhancement purposes. If this storage is insufficient the ODFW has also a joint use permit for additional storage within the carryover conservation pool which may be released to meet minimum flow requirements.

A temperature release schedule is developed annually by USACE in coordination with ODFW and ODEQ. Project releases will be made as close to the schedule as possible. Outflow temperatures during the spring and fall seasons are scheduled to be about the same as the river temperatures that occurred before the construction of the dam. Outflow temperatures in the summer are scheduled to have temperatures of 48° to 55°F (8.8° to 12.8°C). Ongoing studies by ODFW and ODEQ serve to provide USACE with the best temperature regulation plans for anadromous fish management. During the spring of each year, USACE, ODFW, and ODEQ jointly develop a temperature release schedule for the coming year. The schedule is presented to the public in May and serves as a guide to all offices concerned with water temperature.

Operation of the selective withdrawal structure to achieve temperature control is a function of both the temperature profile of the stored water and its availability due to gate limitations. USACE hydrologists monitor pool temperature and gate availability to reduce the probability of temperature fluctuations that occur as one system of gates becomes dewatered and a new set of gates, lower in elevation, is utilized. Close monitoring results in smooth transitions to new release temperatures and benefits to the fishery downstream.

The selective withdrawal structure will not be operated outside of stated operating constraints for purposes of meeting temperature goals except by instructions from USACE.

During mid-September through October, Chinook salmon spawn in the Rogue River below Lost Creek Lake. Fisheries research indicates that conditions are favorable when there is minimal flow augmentation between 21 September and 15 November. To the extent possible, reservoir releases at this time are kept to a maximum of 1,400 cfs (if flood risk management storage requirements are satisfied) to encourage spawning at river levels which are less susceptible to dewatering later in the year. During the February through April period, a minimum release of 900 cfs is preferred to minimize dewatering during project refill. If 900 cfs is not possible, a minimum release of 700 cfs is provided except during flooding when a minimum release of 500 cfs may be performed. Through this process flow control is achieved during the most critical periods for the fishery. Overall, the Lost Creek project benefits for fishery enhancement are based on an increased downstream fishery due to reductions in stream temperature and increased streamflow during the summer and fall.

5.2.2. Water Control Manual for Applegate Lake, Oregon (1990)

The following are information and excerpts from the WCM for Applegate Dam and Lake. Excerpts were chosen that cover the fisheries flows and effect on the downstream habitat, which is the focus of this Literature Review.

Applegate Lake is in southwestern Oregon southeast of the city of Grants Pass, in Jackson County, Oregon. Applegate River is a tributary to the Rogue River, and confluence of the two rivers occurs about 5 miles west of Grants Pass, Oregon. Applegate Lake is located about 255 miles south of Portland, Oregon, near the Oregon-California state line, and at river mile 46.3 on the Applegate River.

Applegate Lake, completed in 1980, is one of three Congressionally authorized multiple-purpose projects in the Rogue River Basin. The other two projects are Lost Creek Lake (completed in 1976) and Elk Creek Lake (partially completed awaiting court resolution, 1990). The primary purposes of Applegate Lake (purposes for which specific amounts of lake storage is allocated) are flood risk management, fisheries enhancement, and irrigation. Secondary purposes (purposes for which no specific lake storage is allocated but are provided for after meeting primary purpose requirements) are wildlife enhancement, improved water quality, and recreation. Cross sections through the pool and embankment dam are shown in Figure 7 (USACE 1990).

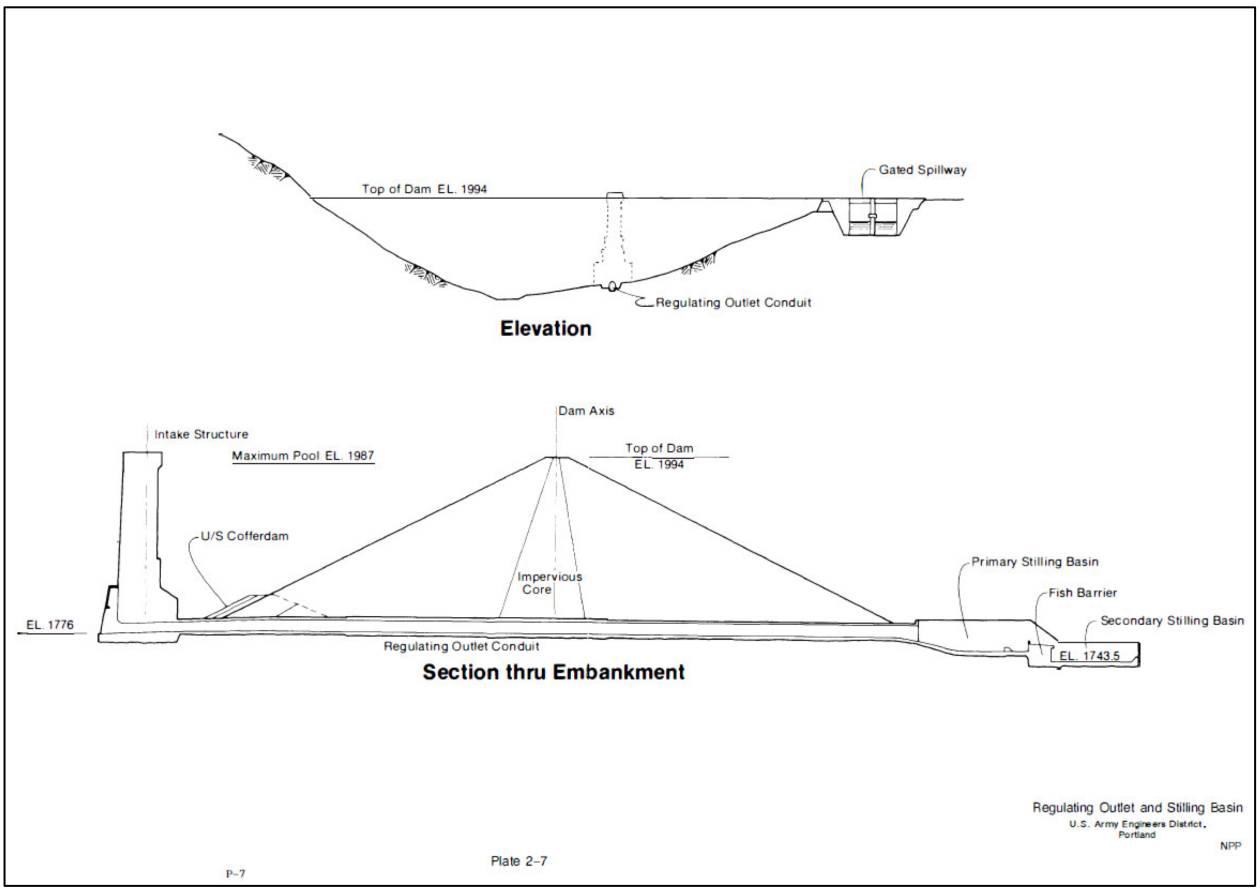


Figure 7. Cross sections of pool and embankment for Applegate Dam and Lake (USACE 1990, Plate 2-7).

Total capacity of Applegate Lake at full pool is 82,200 acre-feet. USACE has established the uses for water stored in Applegate Lake that are consistent with project authorization. Between full pool and minimum flood pool there is 65,200 acre-feet of storage space reserved for flood risk management and seasonal conservation storage for multiple purposes. Between minimum flood pool and minimum conservation pool there is another 10,000 acre-feet of storage that is referred to as "carryover conservation storage." The carryover conservation storage is normally reserved for meeting minimum flow and contracted irrigation requirements during years when natural streamflow is low, and the seasonal lake storage has been depleted.

Below the minimum conservation pool there is an additional 7,000 acre-feet of lake storage which is referred to as inactive and dead storage, which is not expected to be used for any purpose other than to maintain the fishery within the lake (Table 3).

Table 3. Applegate Lake pool elevations, areas, storages, and discharge capacities (USACE 1990, Table 2-5).

Table 2-5. Applegate Project Principal Elevations, Area, Storage, and Discharge Capability.

Features	Elevation (Ft NGVD)	Water Surface Area (Acres)	Storage (Acre-Feet)	Spillway[1] Discharge (Ft^3/s)	Outlet Works Discharge Capacity (Ft^3/s)
Top of Dam	1,994	1,041	89,300	104,400	6,080
Full Pool	1,987	988	82,200	93,600	5,900
Spillway Crest	1,943.7	706	45,660	0	5,160
Minimum Flood Control Pool	1,889	369	17,000	-	4,230
Minimum Conservation Pool	1,854	211	7,000	-	3,480
Regulating Outlet Invert and Low Point in Reservoir	1,776	0	0	-	0

[1]Free overflow condition

Two significant changes have been made to the water management plan for Applegate Lake: (1) increased flood risk management storage space from 55,000 acre-feet to 65,000 acre-feet, and (2) a corresponding increase in minimum flow requirements for fishery enhancement because of the additional storage space.

The increased minimum flow requirements for fishery enhancement below Applegate Lake resulted from the additional 10,000 acre-feet of conservation storage added after the dam site was relocated. The revised minimum flow requirements were reported in Applegate Reservoir D.M. No. 2, "Hydrology and Meteorology," September 1967, and documented and justified in Applegate Reservoir D.M. No. 3, "General Design," October 1967. The USFWS was provided revised flow and temperature release information by USACE in January 1967. The information provided was coordinated by the USFWS with the Fish Commission of Oregon and the Oregon State Game Commission (both commissions have since been combined into the Oregon Fish and Wildlife Commission). The USFWS responded to USACE's revised release information in June 1967. Their response, which had concurrence from the State Fish and State Game Commissions, verified that the revised proposed minimum flows would provide "the maximum fishery benefits consistent with other project functions and available storage." As a result of this letter, the proposed minimum flows were included in the Applegate Reservoir General Design Memorandum (GDM No. 3) which was approved by USACE in October 1967. The minimum flow requirements for Applegate Lake have remained the same since October 1967.

ODFW, through OWRD, has a responsibility of designating minimum flows to remain in the river for fisheries purposes. USFWS and NMFS provide input to ODFW.

The two most important water quality parameters in the Applegate River are temperature and turbidity because of their relationship to river fisheries. Before construction of Applegate Lake, turbid flows produced by storms were short-term events. Turbidity produced by winter storms now occurs for a longer period below the project due to the attenuation effect of Applegate Lake. This attenuation is also responsible for trapping sediments which would otherwise be passed through the river system during larger flows.

The effect of Applegate Dam on temperature is to reduce the summer river temperatures and to increase the winter river temperatures. During the spring and fall the project is usually capable of providing releases of the same temperature which occurred prior to the project being constructed. The beneficial effects of lower streamflow temperatures in the summertime are predominately realized in the reach between Applegate Dam and the community of Applegate. Below this point minimal temperature control can be affected.

Minimum project releases, exclusive of flood regulation, are constrained on the basis of fishery enhancement. Minimum flow requirements vary by month and by control point, with an absolute minimum release of 50 cfs during flood risk management operations. Table 4 shows the adopted minimum releases at Applegate Lake and downstream points for fisheries enhancement (USACE 1990). Flows released from storage for fisheries enhancement are to be regulated to comply with the most demanding flow requirement at any of the three stream gaging stations indicated. Local watermasters have the responsibility to assure that these releases remain in the entire reach of the river. In the event that there is inadequate water in storage to meet these minimum flows, storage uses for all primary authorized uses (i.e., fisheries enhancement and irrigation) will be reduced so that each purpose would receive the same percentage of full supply. Releases from Applegate Lake, except during the filling period from 1 February to 30 April, will be more than natural flows as the result of releases made in the interest of conservation purposes.

Table 4. Minimum flow requirements below Applegate Dam (USACE 1990, Table 7-4).

Table 7-4. Applegate River Minimum Discharges for Fisheries Enhancement.

River Section	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dam site to Little Applegate River[1] (Copper Gage) ft^3/s	100	100	170	170	170	200	230	200	(200 130)[2]	130	100	100
Little Applegate to Williams Creek[3] (Nr. Applegate gage) ft^3/s	200	200	265	265	265	265	230	200	200	240	240	200
Williams Creek to Mouth[4] (Wilderville gage) ft^3/s	300	300	340	340	360	360	120	120	120	360	360	300

[1]Measured near Copper, Oregon.
[2]One-half month for each of the flows shown.
[3]Measured near Applegate, Oregon.
[4]Measured near Wilderville, Oregon.

The fisheries agencies state that an increase in downstream flows improve habitat for anadromous and resident fish if adequate temperature control is achieved. The multiple-level withdrawal structure allows water to be withdrawn from five levels in the reservoir and mixed to regulate the temperature of released water for several miles downstream of the dam. Flows for temperature enhancement are regulated to release water from Applegate Lake at or close to temperatures listed in Table 5.

Regulation changes based on water temperature considerations have a significant impact on anadromous salmonid migration and reproduction and on catch rates in various reaches of the river. Communicating to fisherman the importance of temperature regulation for the fishery is a key objective of Project operations. Although flows gradually warm immediately following downstream release, water in the river reach between Applegate Lake and community of Applegate is cool enough to provide an enhanced aquatic habitat in the river. Available storage is limited, however, and optimum water temperatures do not occur in all years. There is an increase in usable spawning area for fall chinook salmon resulting from increased flows in the Applegate River. In addition, the fish ladder at Murphy Dam has increased the spawning distribution of fall chinook salmon. Murphy is classified as a barrier dam and part of the Applegate dam and reservoir project. Through improved rearing conditions, productivity of the fish population has increased. The winter steelhead trout fishery was the only major anadromous salmonid fishery that existed in the Applegate River before the construction of Applegate Dam and Lake. With increased flows and decreased water temperatures provided by Applegate Lake during the late spring and summer months, winter steelhead trout survival has improved. In summary, benefits for fisheries enhancement are based on an increased downstream fishery due to the following reasons: (a) reduction in stream temperature, (b) increased streamflow during the summer and fall months, (c) increased recreational opportunities, and (d) a newly provided reservoir fishery.

Table 5. Outflow temperature targets, Applegate Dam (USACE 1990, Table 7-5).

Table 7-5. Applegate Lake Target Release Temperatures.

MONTH	DATE	°F	°C	MONTH	DATE	°F	°C
September	1	55.0	12.8	March	1	42.1	5.6
	7	55.0	12.8		7	42.4	5.8
	14	55.0	12.8		14	43.1	6.2
	21	55.0	12.8		21	43.7	6.5
October	1	50.0	10.0	April	1	44.2	6.8
	7	46.4	8.0		7	45.0	7.2
	14	46.2	7.9		14	46.4	8.0
	21	46.0	7.8		21	47.8	8.8
November	1	45.5	7.5	May	1	48.2	9.0
	7	45.0	7.2		7	48.7	9.3
	14	41.9	5.5		14	50.4	10.2
	21	41.9	5.5		21	52.5	11.4
December	1	41.4	5.2	June	1	55.0	12.8
	7	40.3	4.6		7	55.0	12.8
	14	39.7	4.3		14	55.0	12.8
	21	38.5	3.6		21	55.0	12.8
January	1	37.4	3.0	July	1	55.0	12.8
	7	37.8	3.2		7	55.0	12.8
	14	38.5	3.6		14	55.0	12.8
	21	39.2	4.0		21	55.0	12.8
February	1	39.7	4.3	August	1	55.0	12.8
	7	40.6	4.8		7	55.0	12.8
	14	41.4	5.2		14	55.0	12.8
	21	41.7	5.4		21	55.0	12.8

5.3. Applegate Dam Completion Report (1989)

Applegate Dam was completed in 1980. The Applegate Dam Completion Report was completed under the Rogue Basin Fisheries Evaluation Program. The report summarizes the effects of Applegate Dam on Steelhead in the Applegate River and provides recommendations for dam operations. Fishery enhancement benefits were ranked second only to flood risk management benefits from Applegate Dam. The purpose of this report is to present results and recommendations from research done by ODFW on steelhead populations and fisheries in the Applegate River. Data were collected during 1979-85 with funds from USACE. The research addressed four objectives:

1. Determine the effects of Applegate Dam on downstream changes in flow, temperature, and turbidity in the Applegate River.

2. Determine the effects of Applegate Dam and develop criteria for its operation as related to the sport fishery for steelhead.

3. Determine the effects of Applegate Dam and develop criteria for its operation as related to the biology of wild adult steelhead.

4. Determine the effects of Applegate Dam and develop criteria for its operation as related to the biology of wild juvenile steelhead.

Overall, the document summarized findings about the effectiveness of Applegate Dam at augmenting summer flow volumes in Applegate Creek as well as providing useful water-cooling effects downstream of the project.

The largest percentage effect of Applegate Dam on river flow during 1981-84 was during July through October when augmentation from storage increased average flow throughout the river by 40%-86%, depending on month and location. August was the month of lowest average flow (211 cfs} and December was the month of highest average flow (2,895 cfs} during the 4-year period. The dam reduced average flow throughout the river each month by 14%-44% from February through April when the reservoir was refilled. The dam reduced peaks in winter flow, reducing the highest potential peak flow at a point 19 river miles downstream by over 50% each season.

During the first 4 years of operation, maximum outflow temperature was reduced below maximum inflow temperature from mid-May through mid-September with the largest average difference (11°C) being in August. At a point 19 river miles downstream, the biggest reduction from natural maximum temperature during 1981-84 was estimated to be an average of 3.1°C during 16-31 July. This was also the period of highest average in maximum temperature (19.7°C) at this middle river location. The period 1-15 January had the lowest average in maximum temperature (5.6°C) during the 4-year period. During October through December, maximum outflow temperature exceeded maximum inflow temperature by several degrees because of heat storage in the reservoir. At a point 19 river miles downstream, the biggest increase from natural maximum temperature during 1981-84 was estimated to be an average of 2.0°C during 1-15 November. Increases of 0.3°-0.8°C in the maximum temperature at this location were also estimated during January through April, possibly because reductions in flow when the reservoir was being refilled allowed greater daytime warming downstream.

Applegate project funds ODFW to conduct studies to determine the effects of Applegate Dam on anadromous salmonids in the Applegate River and to recommend operating criteria for the dam that would enhance anadromous salmonid production and increase fishery benefits. Overall, it was difficult to sample and analyze juvenile steelhead. ODFW was therefore restricted to examining growth and rearing distribution in the main river. Sporadic catch of emergent-sized steelhead fry indicated that they were emerging from May through June. This corresponds with the estimate that peak spawning of Applegate River winter steelhead occurs between mid-April and mid-May, based on wild adults that were spawned as hatchery broodstock. They were unable to determine the effects of Applegate Dam on juvenile steelhead abundance and migration. Efforts were unsuccessful to build a mathematical model to predict fish sizes, etc. with only 7 years of data.

Based on the study results, flow management, temperature, and other recommendations for future research were made. There were 4 flow management recommendations. The recommendations likely drove subsequent ODFW and USACE funded fish studies, some of which are cited later in this literature review.

1. Use an alternative filling schedule that will allow up to 1,200 cfs in the middle river from 15 February through 31 March to provide optimum flow for steelhead angling. The dam will have a negative effect on water conditions for winter steelhead angling unless alternatives, such as faster filling before 15 February, can be adopted for years with relatively low runoff.

2. Use storage in excess of the spring and fall needs for chinook salmon to maintain a constant flow as high as possible during 1 July through 30 September for juvenile steelhead growth and survival. This recommendation is expected to result in a release flow of 100-300 cfs, depending on reservoir storage and inflow each year.

3. Limit peak flow to the greatest extent possible (unless such action threatens flood risk management capability) during 31 March through 30 June to increase survival of eggs and fry of steelhead that spawned in the main river below Applegate Dam (based on other studies and professional judgment).

4. Limit the rate of decrease in outflow to an average of 50 cfs per hour with individual adjustments limited to 150 cfs (e.g., 150 cfs decrease every 3 hours) to minimize stranding of juvenile salmonids, unless such action threatens flood risk management capability.

Temperature recommendations:

1. Gradually increase the temperature of release water from 3.0°C to 12.8°C from 1 March to 1 June, closely following the historic rate of temperature increase at the damsite before the dam was built. This rate of increase would mimic the historic rate of increase encountered by incubating steelhead eggs in the main river and allow emergence from the gravel on historic dates. See pages 18 and 21 (based partly on other studies and professional judgment).

2. Maintain temperature of the release water at 12.8°C from 1 June to 15 September to provide the best rearing temperature for steelhead in the middle and lower sections of the river without causing suboptimal temperature for the growth of juvenile steelhead that are concentrated in the upper sections of the river. If this action is expected to deplete cold water storage to the extent that the temperature requirements for chinook salmon spawners and eggs cannot be met during October-February, allow warmer water to be released in July 15.0°C limit), August (17.2°C limit), and early September (15°C limit).

Research recommendations related to the operation of Applegate Dam.

1. Determine whether reduced catch of adult steelhead after completion of Applegate Dam persists. If it does, determine if it is caused by a decline in angling conditions, fewer fish in the population, or other causes.

2. Determine the beneficial contribution of Applegate River steelhead to the sport catch in the Rogue River.

3. Determine upper limit of flow during the winter steelhead spawning period (March through May) and lower limit of flow during April-June that will prevent dewatering of eggs and alevins remaining in the gravel.

Research recommendations related to Fish Management.

1. Develop accurate, precise, and efficient methods of determining the abundance of steelhead spawners (a) entering and (b) escaping to spawn in the Applegate River basin.

2. Develop accurate, precise, and efficient methods of determining abundance of (a) emergent fry and (b) juvenile outmigrants of steelhead in the Applegate River.

3. Using data from lb, 2a, and 2b above, determine optimum spawning escapement for production of outmigrants, and determine if juvenile production is being limited anywhere in the egg-to-outmigrant life stage.

4. Determine the mortality and harvest of juvenile steelhead in the Applegate River attributable to trout anglers.

5. Develop and evaluate methods of maintaining the genetic integrity and diversity of wild steelhead in the Applegate River basin, and methods of maintaining genetic diversity within the hatchery program for steelhead released in the Applegate River basin. The maintenance of wild populations and the maintenance of genetic diversity within wild and hatchery populations is considered to be important in providing sustainable production in a changing environment.

6. Monitor the abundance and distribution of the recently introduced smallmouth bass (*Micropterus do1omieui*) and northern squawfish (*Ptychocheilus oregonensis*) and determine their effects on steelhead.

5.4. Effects of Lost Creek Dam on Coho Salmon in the Rogue River (1989)

This report was prepared by ODFW and funded by USACE. The report was the culmination of 12 years of research and evaluated the effects of Lost Creek Dam on coho salmon (*Oncorhynchus kisutch*) in the Rogue River. Field sampling occurred between 1975 and 1985. Lost Creek closed during February 1977, but the reservoir did not fill until the spring of 1978. The findings below are excerpts from the report.

Adults:

1. Freshwater returns of wild fish averaged about 800 age 2 jacks and about 3,600 age 3 adults annually. Landings of Rogue Basin origin wild fish in the ocean fisheries averaged about 2,700 fish annually.
2. There was no detection of any influence of Lost Creek or Cole M. Rivers Hatchery on the wild adults returning to areas upstream of the counting station at Gold Ray Dam.
3. Freshwater returns of hatchery fish averaged about 800 jacks and 3,200 age 3 adults annually after the program for Coho salmon at Cole M. Rivers Hatchery reached production goals of about 200,000 smolts. Annual landings of hatchery fish in the ocean fisheries averaged about 3,600 fish during the same period.
4. Anglers harvested few coho salmon in the Rogue River. During 1979-1986, freshwater harvest averaged about 40 wild and 200 hatchery fish annually.
5. Construction of Lost Creek Dam blocked little if any spawning habitat used by coho salmon.
6. Flow during autumn affected the migration timing of adults that passed Gold Ray Dam. Adults migrated earlier during years of high flow and later years of low flow.

Juveniles:

1. There was no detection of any influence of Lost Creek Dam on the production of wild juveniles. Juveniles reared in the tributaries, primarily within the Illinois basin, rather than in the Rogue River.
2. The area upstream of the Grants Pass produced few wild juveniles. Annual yields of wild smolts averaged 1,200 fish during 1976-1980 and 6,400 fish during 1981-86. Increased smolt production in later years was probably the result of hatchery fish that stayed to spawn naturally.
3. Yearlings migrated downstream during May through July. Analyses of scales taken from returning adults indicated that all juveniles entered the ocean as yearlings.
4. Flow during the spring affected the migration timing of yearlings that passed through the middle river. Juveniles migrated earlier during years of low flow and later during years of high flow.

Effect of Reservoir operations:

The effects of reservoir operation on coho salmon were considered minimal because (1) few juveniles reared in the mainstem and (2) juveniles and adults migrated at times when the reservoir operation had little influence on water temperature and flow in the downstream areas.

Recommendations:

Reservoir Management and Operation of Lost Creek Dam

Management strategies for the operation of Lost Creek should be directed to species other than coho salmon. The Rogue River is critical habitat for steelhead and chinook salmon but is only important to coho salmon when yearlings migrate to the ocean during the spring and when adults migrate upstream during autumn. Strategies for reservoir management during 1978-1985 did not appear to affect the migration timing of yearling or adult coho salmon.

5.5. Lost Creek Dam Phase II Completion Report (1994)

The USACE prepared this report in February 1994. It was part of the Fisheries Evaluation program and documented the effects of Lost Creek Dam on Summer Steelhead in the Rogue River. A summary of the report is reproduced below. In the report, effects of Lost Creek Dam on summer steelhead Oncorhynchus mykiss in the Rogue River were assessed and summarized. Field sampling began in 1975 and ended in 1991. Lost Creek Dam closed during February 1977, but the reservoir did not completely fill until the spring of 1978. The summary of findings is reproduced below.

Adults:

1. Seining at Huntley Park produced reasonable estimates of the number of summer steelhead that entered the Rogue River in 1976-91. Estimated freshwater returns of hatchery adults were highly correlated with returns of late-run adults of hatchery origin to Cole M. Rivers Hatchery. Estimated freshwater returns of wild adults were highly correlated with passage estimates of wild late-run adults at Gold Ray Dam.

2. Freshwater returns of wild fish averaged 59,000 (range= 18,600-146,600) half-pounders and 19,100 (range= 3,200-34,000) late-run adults in 1976-91. Freshwater returns of hatchery fish averaged 46,600 (range= 6,500-105,000) half-pounders and 5,500 (range= 2,500-15,200) late-run adults in 1976-91.

3. Freshwater returns of wild late-run adults were positively related to freshwater returns of cohorts in the previous year. Residual variation was negatively related to peak flow of the Rogue River. It is estimated that reductions in peak flows attributable to reservoir operation increased freshwater returns by an average of 2,400 wild late-run adults in 1978-86.

4. Primary factors that affected the abundance of wild half-pounders could not be determined, although freshwater returns from the 1975-87 brood years were positively correlated with tributary flow in late spring when juveniles migrated into the Rogue River.

5. Annual return rates of hatchery half-pounders to the Rogue River averaged 12% (range= 3-28%) in 1976-91. Return rates were correlated with ocean temperature. Similarity in annual returns of wild and hatchery fish among late-run adults suggested that ocean factors may be primary determiners of freshwater returns.

6. Hatchery fish composed an average of 43% of the half-pounders and 22% of the late-run adults that entered the Rogue River in 1975-91. Hatchery fish were more common among half-pounders because proportionally more hatchery fish matured as winter steelhead or early run summer stee1head. The percentage of hatchery fish among half-pounders increased in 1975-91because of increased releases of juvenile winter steelhead.

7. Life history patterns of summer steelhead in the Rogue River are diverse. Fifteen (15) life history patterns were identified on scales taken from wild fish.

8. Fish that previously made a half-pounder run accounted for an average of 95% of the wild late-run adults that returned in 1976-91. There were no detections of any change in the tendency of summer steelhead to migrate as half-pounders after operation of Lost Creek Dam.

9. There were no detections of any changes in the lengths of half-pounders or late-run adults on their first spawning migration after operation of Lost Creek Dam. Lengths at freshwater return were most affected by juvenile age at ocean entry.

10. There were no detections of any change in the time of river entry by half-pounders and late-run adults after operation of Lost Creek Dam. Entry time was correlated with ocean parameters, but not freshwater parameters. Among late-run adults, hatchery fish entered fresh water earlier than wild fish. Time of river entry also differed among adults of different life histories.

11. Returns of wild summer steelhead to the upper river decreased in 1942-68 for an unknown reason(s). An average of 6,700 (range = 1,700-13,000) wild summer steelhead passed Gold Ray Dam annually in 1969-91. Early-run fish that passed Gold Ray Dam by 15 September accounted for an average of 35% (range = 7-56%) of the wild summer steelhead that returned to the upper river annually in 1969-91.

12. There were no detections of any significant change in the mean number of wild summer steelhead that returned to the upper river after operation of Lost Creek Dam. Returns of wild fish to the upper river, relative to returns of wild summer steelhead to the North Umpqua River, also did not change significantly after operation of Lost Creek Dam.

13. The increase in returns of hatchery fish to the upper river was most evident among early-run fish that passed Gold Ray Dam from the middle of May through the middle of September. Passage estimates of early-run hatchery fish averaged 600 fish in 1970-80 and 3,800 fish in 1981-91. Increased releases of smolts and changes in spawning practices at Cole M. Rivers Hatchery were responsible for the increase in returns of early-run hatchery fish. Passage estimates of late-run hatchery fish averaged 1,300 fish in 1970-80 and 1,500 fish in 1981-91.

14. Hatchery fish accounted for an average of 41% of the early-run fish and 22% of the late-run fish that passed Gold Ray Dam in 1970-91. The percentage of hatchery fish increased through time among early-run fish, but not among late-run fish.

15. Early-run fish averaged 32% of the pre-impoundment returns and 36% of the post-impoundment broods among wild fish that passed Gold Ray Dam. Passage timing was correlated with river flow in summer. It was estimated that increased flow attributable to reservoir operation in 1978-86 increased the percentage of wild fish that passed Gold Ray Dam by 15 September from an average of 29% to an average of 42%.

16. The migration timing of wild late-run fish at Gold Ray Dam was related to water temperature in autumn rather than summer. It is estimated that increased water temperature attributable to reservoir operation in 1978-86 increased the percentage of wild fish that passed Gold Ray Dam by 30 November from an average of 32% to an average of 36%.

17. There was no detection of any change in the race composition of wild steelhead that returned to the upper river after operation of Lost Creek Dam.

18. Operation of Lost Creek Dam caused summer steelhead of hatchery origin to mature earlier because water temperature of the Rogue River increased in winter. The effects on the maturation time of wild fish remain unknown.

19. Return rates of hatchery summer steelhead on the first spawning run averaged 1.6% (range • 0.7-3.9%) for the 1973-88 brood years. Return rates of first spawners were not correlated with ocean parameters.

20. Return rates of hatchery summer steelhead on the first spawning run averaged 1.6% (range • 0.7-3.9%) for the 1973-88 brood years. Return rates of first spawners were not correlated with ocean parameters.

Juveniles:

1. Subyearlings seined at sites in the middle river and in the canyon during late summer were larger after operation of Lost Creek Dam, but analyses of adult scales did not detect a change in mean lengths at annulus one. Indexes of subyearling growth were not correlated with river physical factors or abundance indexes of juvenile salmonids.

2. Yearlings seined in the lower river and in the canyon during late summer were larger after operation of Lost Creek Dam. Mean lengths at these sites were negatively related to water temperature in summer. Scale analyses also indicated that yearlings grew faster in fresh water after operation of Lost Creek Dam. However, yearling growth was not related to river physical parameters or to abundance indexes of juvenile salmonids.

3. There was no detection of any change in the spring growth of smolts prior to ocean entry after operation of Lost Creek Dam. Plus-growth was positively related to water temperature of the Rogue River in spring. Reservoir operation had minimal effect on water temperature in spring.

4. There was no detection of any change in the weights of juvenile steelhead after operation of Lost Creek Dam. Mean weights of 8 cm sub yearlings were not related to river physical parameters or indexes of juvenile abundance. Mean weights of 15 cm yearlings were positively related to summer flow.

5. Wild late-run adults were composed of an average of 42% age-1 smolts, 55% age-2 smolts, and 3% age-3 smolts. There was a greater proportion of age-3 and age-4 smolts among half-pounders, probably because older smolts matured as winter steelhead.

6. There was no detection of any change in the age at ocean entry after operation of Lost Creek Dam. However, small sample sizes and variable age composition among preirnpoundment broods limited the power of the analysis. Faster growth by yearlings could have affected age at smolting.

7. There was no detection of any change in catch rates of subyearling and yearling steelhead seined in the Rogue River after operation of Lost Creek Dam.

8. ***Study concluded that operation of Lost Creek Dam probably had minimal effect on the production of juvenile summer steelhead because adults spawned in tributaries of the Rogue River. Study results were unable to detect any relationships between indexes of juvenile abundance and river physical parameters.***

Reservoir management recommendations:

1. Allocation of reservoir storage to enhance habitat of juvenile steelhead in summer should be scaled to predictions of prespawning mortality between spring and fall chinook salmon. In years of low water yield, reservoir storage should be mostly used to minimize the risk of extensive prespawning mortality. In years of high water yield, reservoir storage should be allocated to maintain a relatively constant flow at Grants Pass in summer to enhance rearing habitat for juvenile steelhead.

2. Outflow from Lost Creek Dam should be managed to minimize the intensity of peak flows in downstream areas from November through March. Reductions in peak flows were associated with increased survival rates of summer steelhead (see Abundance, page 35). Present strategies for reservoir operation decrease peak flows during operational seasons of flood risk management and conservation storage. The intensity of peak flows can be decreased further in years of high water yield.

   Authorizing documents for the Rogue River Basin project designate flood risk management as the first priority for reservoir management. Storage in excess of the rule curve decreases reservoir capability for flood risk management. However, maintenance of the reservoir level below the rule curve can provide for additional reductions in peak flows.

   Consideration should be given to further refine the criteria for reservoir level during operational seasons for flood risk management and conservation storage. The reservoir level can be scaled to estimates of water yield in the area upstream of the reservoir. The reservoir level should be decreased when water content of the snowpack is great. Implementation of this recommendation would increase reservoir capacity for flood risk management and decrease intensity of peak flows in downstream areas.

3. Release of water stored in the reservoir during freshets should be managed so flow in downstream areas does not exceed the peak flow that previously occurred during the flood risk management season. It is recognized that this recommendation may conflict with flood risk management operations. For example, managers may seek to return the reservoir level to the authorized rule curve for short periods between large storms. However, when the potential for further flooding is minimal, the reservoir level could be returned to minimum pool for flood risk management (or lower) so as not to produce a new peak flow in downstream areas.

4. Outflow from Lost Creek Dam should be managed so there is minimal flow augmentation after 21 September. This recommendation is designed to minimize the effect of augmented flow on the fishery for summer steelhead in the Rogue River canyon. However, limitations to flow augmentation in early autumn will increase flow in summer and will affect the fishery for early-run summer steelhead in the upper river.

   The fishery for summer steelhead in the Rogue River canyon usually begins around Labor Day weekend. It is not recommended that minimal flow augmentation occur between Labor Day and 21 September because flow augmentation is needed to minimize prespawning mortality among fall chinook salmon (ODFW 1992).

5. Strategies for release temperature at Lost Creek Dam should be directed to management of anadromous salmonids other than summer steelhead. Water temperature directly affects the production and harvest of spring chinook salmon (Satterthwaite 1987). In contrast, the study was unable to detect any effects of water temperature on the production and growth of summer steel head in the area upstream of Gold Ray Dam.

5.6. Lost Creek Dam Phase II Completion Report Volume I (2000)

This report outlines the effects of Lost Creek Dam on Spring Chinook Salmon in the Rogue River. Information below are pertinent excerpts from the report and documents the effects of Lost Creek Dam on spring chinook salmon Oncorhynchus tshawytscha produced in the Rogue River upstream of Gold Ray Dam. Summary items apply only to wild spring chinook salmon. An appendix was prepared and contains extensive Spring Chinook data supporting the findings and the recommendations, summarized below.
Recommendations were made for USACE reservoir management and operation. It was acknowledged that cooperation of other state and federal agencies is needed to implement the recommendations.

1. Plans for reservoir releases should be developed seasonally and should incorporate estimates of the projected water yield from the Rogue River Basin and objectives identified by state and federal agencies responsible for management of fishery resources.

2. The simulation model described in the report can be used to help evaluate the responses of wild chinook salmon to alternative strategies of reservoir management.

3. Additional simulations for water temperature of the Rogue River under varied strategies of reservoir management should be developed. These simulations are needed to better allocate reservoir storage for the maintenance and possible enhancement of salmonids in areas downstream of Lost Creek Dam. At a minimum, water temperature should be simulated for years of low, average, and high-water yield; and should also be simulated under alternative management strategies of (l) use of hypolimnetic storage in summer, (2) use of hypolimnetic storage in autumn, and (3) equal use of hypolimnetic storage in summer and autumn.

4. The reservoir should be managed so that daily maximum water temperature does not exceed 18°C (65°F) at Agness in May-June. This recommendation is designed to minimize prespawning mortality among adult spring chinook salmon (see Prespawning Mortality of the subject report).

   Additional simulations of water temperature are needed to determine the flow that is required to attain the recommended water temperature. In the interim, the USACE should continue to coordinate annual efforts to identify the minimum flow at Agness needed to protect spring chinook salmon. Current information indicates that a flow of 4,000 cfs is sufficient. This interim target flow may change as more information becomes available.

5. The reservoir should be managed to minimize intensity of peak flows in downstream areas during November-March. This recommendation is designed to increase the survival rates of eggs and alevins that incubate in the gravel (see Abundance, page 67). Present strategies for reservoir operation decrease peak flows during operational seasons of flood risk management and conservation storage. It is thought that the intensity of peak flows can be further decreased in years of high-water yield.

   Authorizing documents for the Rogue River Basin project designate flood risk management as the first priority for reservoir management. Storage in excess of the rule curve decreases reservoir capability for flood risk management; however, maintenance of the reservoir level below the rule curve can provide for additional reductions in peak flows.

   Consideration should be given to development of criteria for reservoir level during operational seasons for flood risk management and conservation storage. It is believed that the reservoir level can be scaled to estimates of water yield in the area upstream of the reservoir. The reservoir level should be reduced when water content of the snowpack is great. Implementation of this recommendation would increase reservoir capacity for flood risk management and decrease intensity of peak flows in downstream areas.

6. Release of water stored in the reservoir during freshets should be managed so flow in downstream areas does not exceed the peak flow that previously occurred during the season. This recommendation is designed to increase survival rates of eggs and alevins that incubate in the gravel.

   This recommendation may conflict, at times, with flood risk management operations. For example, managers may seek to return the reservoir level to the authorized rule curve for short periods between large storms. However, when potential for further flooding is minimal, the reservoir level could be returned to minimum pool for flood risk management (or lower) so as not to produce a new peak flow in downstream areas.

7. Release of water stored in the reservoir during flood risk management operations should be managed so that the rate of decrease in reservoir outflow does not exceed the rate of decrease in reservoir inflow following the freshet. This recommendation is designed to reduce the number of juvenile salmonids, including spring chinook salmon, that are stranded and killed as a result of flood risk management operations.

8. Release of water stored in the reservoir during operations other than flood risk management should be managed so that the rate of decrease in reservoir outflow does not exceed maximum incremental rates of 150 cfs every three hours and 750 cfs daily. This recommendation is designed to reduce the stranding mortality of juvenile fish. Transect surveys to determine the relationship between discharge and gravel coverage may produce more effective recommendations for the reduction of stranding mortality.

9. The reservoir should be managed so that there is minimal flow augmentation between 21 September and 15 November. This recommendation is designed to (1) minimize the probability that eggs and alevins of spring chinook salmon will be dewatered and killed during the subsequent filling of the reservoir, (2) reduce the proportion of fall chinook salmon that migrate to spawning areas upstream of Gold Ray Dam (ODFW 1992), and (3) conserve cold hypolimnetic storage to reduce early emergence of spring chinook salmon fry.

10. Reservoir storage that is not released to minimize prespawning mortality among fall chinook salmon (ODFW 1992) and spring chinook salmon should be released so as to decrease the water temperature to the greatest degree possible in the area downstream of Grants Pass during July-August. This recommendation is designed to provide more optimal water temperatures for juvenile salmonids resident in the area and to decrease the number of juvenile salmonids, including spring chinook salmon, that are consumed by Umpqua squawfish.

11. Recommendations for water temperatures to be released from Lost Creek Dam in March-October should be considered as interim recommendations that need to be evaluated upon the completion of additional simulations of water temperature by the USACE. These recommendations are designed to (1) minimize prespawning mortality among spring chinook salmon in the area upstream of Gold Ray Dam (see Prespawning Mortality, page 162), (2) minimize the risk of disease outbreaks among fish rearing at Cole M. Rivers Hatchery, and (3) conserve cold hypolimnetic storage for release in autumn, as described in the succeeding recommendation.

12. The temperature of water released from Lost Creek Dam should be as cold as possible during November-February. This recommendation is designed to minimize early emergence by fry of spring chinook salmon (see Emergence Timing, page 64) and should be evaluated upon the completion of additional simulations of water temperature by the USACE.

13. The USACE should monitor the quality and quantity of salmon and steelhead \ spawning habitat downstream of Lost Creek Dam. Reservoir construction terminated the recruitment of gravel from areas upstream of the dam and the recruitment of gravel, from an unknown distance downstream of the dam, may not be sufficient to prevent the additional loss of spawning habitat.

Recommendations were also made for ODFW, the lead agency for management of fishery resources.

1. Management objectives, in order of priority, should be developed annually by agencies responsible for the management of anadromous salmonids in the Rogue River Basin.

2. The simulation model described in the report can be used to help evaluate the responses of wild and hatchery chinook salmon to differing strategies of fisheries management.

3. Management plans and activities should recognize that wild and hatchery spring chinook salmon differ in life history and also differ in contribution rates to recreational and commercial fisheries.

4. Management plans and activities should recognize that modification of the current hatchery program to reflect life history parameters of the present population of wild spring chinook salmon will decrease the contribution rates of hatchery fish to recreational and commercial fisheries.

5. Management plans and activities should recognize that it is unlikely that the life history parameters of wild spring chinook salmon will be completely restored to pre-impoundment conditions unless Lost Creek Dam is removed.

6. Management plans and activities should recognize three populations of chinook salmon in the Rogue River upstream of Gold Ray Dam: (l) wild spring chinook salmon that pass Gold Ray Dam before 16 August, (2) early run fall chinook salmon that pass Gold Ray Dam after 15 August, and (3) spring chinook salmon of hatchery origin.

7. All spring chinook salmon of hatchery origin should be marked with fin clips so that adult fish can be identified at Gold Ray Dam and so that known wild fish can be collected for hatchery broodstock.

8. Representative samples of each group exposed to differing hatchery practices should be marked with adipose fin clips and coded-wire tags in order to monitor and evaluate survival rates, maturation rates, and contribution rates to the ocean fisheries.

9. Maturation rates of the production group raised at Cole M. Rivers Hatchery should not exceed: 0.01 for age 2 fish, 0.10 for age 3 fish, 0.70 for age 4 fish, and 0.95 for age 5 fish in order to optimize contribution rates to the fisheries. Changes in broodstock selection practices may be needed to meet these targets.

10. Fall chinook salmon of hatchery origin should not be released in the area upstream of Gold Ray Dam.

11. Management of spring chinook salmon should be brought into compliance, or exempted from, the Wild Fish Management Policy that was adopted by the Oregon Fish and Wildlife Commission in 1992. Current management strategies are not in compliance with the policy because (1) hatchery fish now appear to compose more than 10% of the natural spawners, (2) wild fish compose less than 30% of the hatchery broodstock, and (3) wild-type phenotypes of the present population of wild fish are not maintained in hatchery fish.

    Fishery managers have five options by which to bring management strategies for spring chinook salmon into compliance with the Wild Fish Policy: (l) release no hatchery fish, (2) limit the number of hatchery fish to less than 50% of the naturally spawning population and establish hatchery practices to include at least 30% wild fish in the broodstock and establish wild-type phenotypes among hatchery fish, (3) limit the number of hatchery fish to less than 10% of the naturally spawning population, (4) classify the production of hatchery fish as a special rehabilitation program, and (5) exemption from the policy. Implications associated with each of these options are discussed in the report.

12. We recommend no adjustments to the management of the ocean fisheries for chinook salmon, except as outlined in the succeeding recommendation. Current programs designed to manage fall chinook salmon produced in the Klamath River Basin of northern California should provide sufficient protection to spring chinook salmon of Rogue River origin because both populations exhibit similar patterns of distribution in the ocean and contribute to the ocean fisheries at similar rates.

13. Management plans should identify a minimum spawning escapement for age 4-6 spring chinook salmon and should regulate harvest as needed to meet the goal. The management option selected under the Wild Fish Policy will probably affect any goal chosen for minimum spawning escapement. Our findings are insufficient for identification of specific spawning goals because we found a linear, rather than a curvilinear, relationship between spawning escapement and resultant juvenile production.

14. Habitat projects designed to maintain or increase the production of spring chinook salmon should be directed at gravel quality and quantity in the Rogue River and in Big Butte Creek.

15. Management plans for public and private lands in the Rogue River Basin should identify and minimize activities that may increase the intensity of peak flows in autumn-winter and may increase water temperature in summer.

16. Continual removal of Umpqua squawfish from the Rogue River should be supported to the greatest possible extent to reduce predation losses of juvenile chinook salmon.

17. Information related to the impact of Umpqua squawfish on anadromous salmonids in the Rogue River should be publicized in order to decrease the chance that the species is

unintentionally introduced into other coastal basins in southwest Oregon and northern California.

The subject document concluded that the operation of Lost Creek Dam was associated with a decrease in the production of, and a change in the life history of, wild spring chinook salmon in the Rogue River. In contrast, we concluded that the operation of USACE dams in the Rogue River Basin was associated with an increase in the production of wild fall chinook salmon.

Impacts of USACE dams on the abundance and life history of wild steelhead and wild coho salmon were hardly evident or could not be detected, probably because those species tend to spawn in tributary streams unaffected by USACE dams. Reservoir operations changed the physical parameters of the Rogue River. Some of those changes were associated with changes in life history parameters of wild spring chinook salmon and a change in the composition of wild chinook salmon produced in the upper river. Among wild spring chinook salmon, the relative abundance of fish that migrated early decreased while the relative abundance of fish that migrated late increased. In addition, the relative abundance of wild fall chinook salmon also increased. These changes, coupled with other changes in life history parameters, decreased fishery yields of wild fish because of changes in migration timing and age at maturity.

The decrease in the production of wild spring chinook salmon is not unique to the Rogue River. Assessments completed by various parties concluded that populations of wild spring chinook salmon on the Pacific coast have decreased relative to coastal populations of wild fall chinook salmon. Maintenance of remaining populations of wild spring chinook salmon, including that of the Rogue River, is therefore a high priority for resource managers.

Maintenance of a productive population of wild spring chinook salmon is particularly important in the Rogue River, because of the associated social and economic benefits. After consideration of the findings reported in this document and findings reported for the other races of anadromous salmonids produced in the Rogue River, it was concluded that reservoir management strategies should be directed primarily at maintaining, and if possible, enhancing the population of wild spring chinook salmon. Recommendations for reservoir releases and reservoir management strategies were developed accordingly.

Enhancement of wild spring chinook salmon in the Rogue River has been a goal of ODFW and the USACE for more than 20 years. However, as described in the report, experimental releases of reservoir storage have yet to restore the life history or abundance of wild spring chinook salmon. Consequently, it was thought to be unlikely that implementation of the recommendations for reservoir releases would restore the abundance and life history parameters of wild spring chinook salmon to pre-impoundment conditions. Consequently, fishery managers should consider restoration measures other than reservoir releases.

By one measure, hatchery fish have compensated for the loss of wild spring chinook salmon. It was found that the decreased production of spawning habitat was successfully mitigated by the production of hatchery fish based on a mitigation goal of 13,000 adult hatchery fish passing Gold Ray Dam. The large returns of hatchery fish can be attributable to (1) improved spawning, rearing, and release practices at Cole M. Rivers Hatchery, (2) younger ages at maturity among hatchery fish, and (3) decreased harvest rates in the ocean fisheries. Success of the hatchery program, coupled with a decrease in the production of wild fish, resulted in runs of spring chinook salmon that have averaged about 75% hatchery fish since 1990.

However, the increased abundance of hatchery fish and the decreased abundance of wild fish poses challenges for fishery managers that were not foreseen when the USACE project was authorized by the United States Congress in 1962. Two primary issues are that spring chinook salmon of Rogue River origin (1) do not meet requirements of the Wild Fish Policy adopted by the Oregon Fish and Wildlife Commission in 1992 and (2) generate concern among recreational and commercial fishers because of the large numbers of unneeded hatchery fish that return to Cole M. Rivers Hatchery. In addition, resource agencies are shifting management priorities from individual species of animals, that have commercial and recreational importance, towards a more generalized priority of ecosystem management. Many concerns have been raised about the effects of hatchery fish on sympatric or proximal populations of wild fish. Potential problems associated with the production of hatchery fish include alteration of gene pools of wild fish, predation on wild fish, competition with wild fish, transmission of disease, and reductions in stock productivity.

It is estimated that about 5% of the spring chinook salmon of hatchery origin spawned naturally, with most of the strays spawning in the vicinity of Cole M. Rivers Hatchery. Assuming that (1) hatchery fish will continue to compose about 75% of the adult spring chinook that pass Gold Ray Dam, (2) harvest rates upstream of Gold Ray Dam will be about 10% on hatchery fish and 20% on wild fish, (3) negligible prespawning mortality, and (4) that 5% of the hatchery fish spawn naturally, we estimate that hatchery fish will account for 13% of the naturally spawning spring chinook salmon.

"With hatchery fish among the natural spawners, one would suspect that the life history parameters of wild fish would become more similar to those of wild fish". Instead, it was found that the life history parameters of wild fish changed coincidentally with the construction and operation of Lost Creek Dam.

The spring chinook salmon program at Cole M. Rivers Hatchery is important for numerous reasons that include: (1) production mitigates for spawning habitat blocked by Lost Creek Dam, (2) some of the important life history characteristics of the hatchery fish are more similar to that portion of the endemic population of spring chinook salmon that spawned upstream of Lost Creek Dam, (3) the broodstock was developed from wild fish that entered the hatchery when upstream spawning areas were blocked by reservoir construction in the early 1970s, (4) no genetic material from stocks outside of the Rogue River Basin has been incorporated into the broodstock, and (5) spawning practices have been managed in an attempt to maintain genetic diversity and to minimize potential genetic drift.

However, it was also found that wild and hatchery fish differed in multiple life history attributes even though the hatchery stock was developed from endemic fish with no intentional infusion of genetic material from other chinook stocks and with diversified selection of spawners. Changes in the life history parameters of wild fish that resulted from reservoir construction and operation are at least partially responsible for the divergence of wild and hatchery fish, but that does not necessarily mean that the two populations differ genetically. Even if there are significant genetic differences between the two populations, as compared to the current population of wild fish, the current stock of hatchery fish may better represent the genetic history of wild spring chinook produced in the upper river prior to reservoir operation. However, as even a short period of domestication may result in the development of genetically based behavioral differences in wild and hatchery salmonids, annual incorporation of genetic resources from wild fish seems advisable.

These findings, coupled with current hatchery practices, indicate that current ODFW management practices are not in compliance with the Wild Fish Management Policy adopted by the Oregon Fish and Wildlife Commission in 1992. Current management strategies are not in compliance with the policy because hatchery fish probably compose more than 10% of the natural spawners, wild fish compose less than 30% of the hatchery broodstock, and wild-type phenotypes are not maintained in hatchery fish.

Fishery managers were given five options by which to bring management strategies for spring chinook salmon into compliance with the Wild Fish Policy: (1) release no hatchery fish, (2) limit the number of hatchery fish to less than 50% of the natural spawners, (3) limit the number of hatchery fish to 10-50% of the natural spawners, (4) classify the production of hatchery fish as a special rehabilitation program with ongoing releases, and (5) an exemption from the policy. Implications associated with each of these options were discussed in the following text. It will not be repeated here, for brevity.

Regardless of which Wild Fish Management Policy options are selected by fishery managers, or even whether spring chinook salmon are protected by the ESA, management activities should interface with ecosystem processes in order to have a good chance of success.

Ecosystems are dynamic and constantly responding to changes in the environment. Construction and operation of dams and reservoirs changed the Rogue River Basin ecosystem. Consequently, management plans and activities should recognize that for the near future, it is not likely that the reservoirs will be managed so that water yields and water quality conform to pre-impoundment conditions. Instead, management plans and activities should be developed that attempt to produce optimal biological and social benefits within the current operational parameters.

5.7. Rogue Spring Chinook Salmon Conservation Plan (2007)

Adopted by the Oregon Fish and Wildlife Commission September 7, 2007, this document is the cornerstone for Spring Chinook management in the Upper Rogue Basin. The following are excerpts from the document that were selected to summarize the main points of the plan that have implications for the SRP related aspects of this literature review. ODFW (2006) designated a Species Management Unit (SMU) for spring Chinook salmon (CHS) that covers the portion of the Rogue River Basin located upstream of Gold Ray Dam. Gold Ray Dam is located near Medford, at river mile 126 (Figure 8).

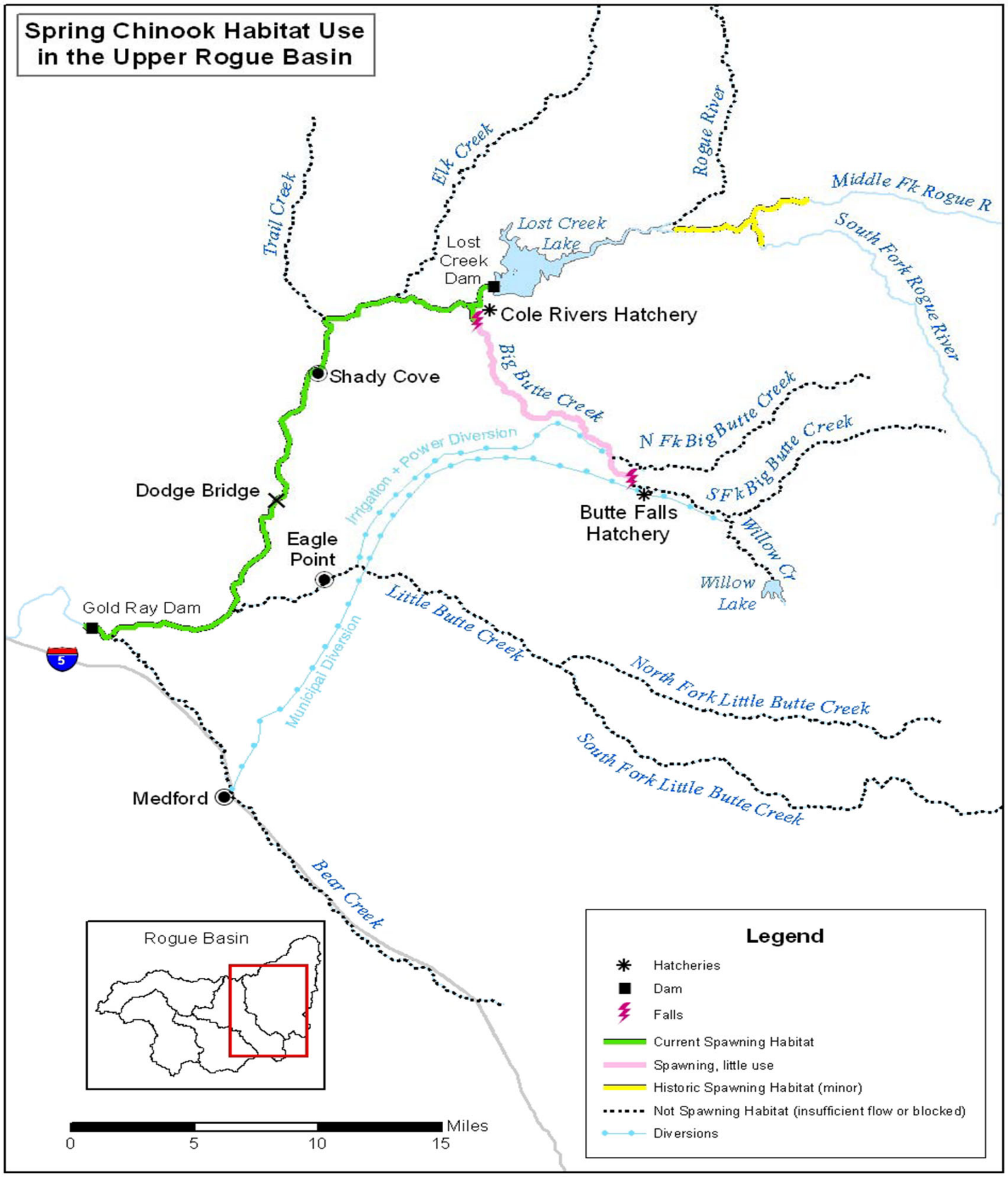


Figure 8. Map of the Rogue River Basin with reaches identified in the Rogue Spring Chinook Conservation Plan.

The purpose of the conservation plan document is to present a conservation plan for naturally produced spring Chinook salmon, NP CHS, (Oncorhynchus tshawytscha) that inhabit the Rogue Species Management Unit (SMUs) of southwest Oregon. Conservation plans are to be developed for each SMU of native fish in the state of Oregon, as outlined by the Native Fish Conservation Policy. This policy was adopted by the Oregon Fish and Wildlife Commission in 2003 to ensure the conservation and recovery of native fish in Oregon.

Chinook salmon may enter the Rogue River on any given day of the year. Based on the findings of ODFW (1992), CHS are defined as those mature Chinook salmon that enter freshwater during the period of February through 15 July, and also pass the counting station at Gold Ray Dam before 16 August. Fall Chinook salmon (CHF) is defined as those mature Chinook salmon that enter freshwater after 15 July, and pass Gold Ray Dam after 15 August.

The conservation plan discusses issues that are relevant to the historical and current status of these animals, defines current and desired status, identifies limiting factors, identifies assessment needs, and outlines a variety of management options to be considered by the Oregon Fish and Wildlife Commission. The plan's management options are a focus for this literature review. A variety of actions are described in the plan, but not all may be implemented because of funding uncertainties.

Monitoring, evaluation, and research needs are identified in the latter portions of the conservation plan and provides a guide for the ODFW information reports, summarized and discussed below. Adaptive management is identified as the approach to mitigate inherent uncertainty associated with quantitative estimates of cause-and-effect relationships. Adaptive management would be employed as a means to identify and implement revisions to management actions adopted as plan components. Other actions may be revised to improve performance, or actions may be terminated or be replaced by other actions that are determined to be more effective.

5.8. BA for Coho Salmon and Lost Creek and Applegate Dams (1997)

This biological assessment (BA) was prepared by NMFS (1997). The following are experts from that assessment.

NMFS listed coho salmon as a threatened species under the ESA on May 6, 1997, for the Southern Oregon/Northern California Coast, Evolutionarily Significant Unit (ESU). The ESU includes the Rogue River and associated tributaries. USACE operates two major Dam Projects in the Rogue Basin. This biological assessment covers the operation of the Rogue River Project.

Populations of coho salmon (Oncorhynchus kisutch) have historically been located in the upper third of the Rogue, Applegate, and Illinois rivers and some of their tributaries. ODFW found that few if any coho were blocked by construction of Lost Creek Dam and that for the areas above Gold Ray Dam, the primary areas for coho spawning are Big Butte, Little Butte, and Elk creeks. Coho spawning historically did occur above Applegate Dam and mitigation by hatchery production at Cole M. Rivers Hatchery is for replacement of 500 adults for areas inundated by the dam and reservoir. Operation of Lost Creek and Applegate Dams has the potential to affect (both beneficially and negatively) coho populations downstream of the projects.

Lost Creek Dam is located on the mainstem of the Rogue River at river mile 158.4. Lost Creek construction of the main dam was started in 1972 and was completed in 1976. Applegate Dam is located on the Applegate River, which is a tributary of the Rogue at river mile 45.7 (Applegate). Applegate was completed in 1980.

The authorizing document provided fisheries enhancement as primary project purposes for both Lost Creek and Applegate Projects as fisheries in the Rogue River Basin were recognized as having "national significance." Within the fisheries enhancement framework, several actions were taken to ensure fisheries enhancement was achieved for long term maintenance of wild runs in the basin.

Fishery provisions were established that include water storage and temperature regulation facilities for releases to provide downstream fishery enhancement, facilities for restitution from inundation and loss of spawning and rearing habitat, and facilities to mitigate losses associated with blocking of natural migration routes for anadromous fish. In addition, the authorizing document indicated that detailed fisheries studies should be conducted to ensure operation of the projects was consistent with the fisheries goals. Fisheries studies began in 1974 and have continued through the present. The primary focus of these studies was to evaluate effects of the projects on each of the stocks and to recommend the most effective flow and temperature operating strategy to provide fisheries enhancement for maintenance of anadromous fish runs in the Rogue River Basin.

Mitigation for lost spawning and rearing areas has been provided by hatchery production for both Lost Creek and Applegate Dams. Based on a report by the USFWS titled Detailed report on Fish and Wildlife Resources Affected by USACE of Engineers Water Development Plan (1961), few if any coho would be impacted by construction of Lost Creek Dam. This resulted in no hatchery mitigation for coho at or above the Lost Creek Dam Site. For the Applegate River, the USFWS report (1961) suggested that most of the coho spawn in the lower tributaries downstream of the Applegate Dam damsite. The report suggested that approximately 500 coho spawned historically above the damsite and this was the level adopted for hatchery mitigation. Based on the Applegate fisheries evaluation reports, little information was available on coho in the Applegate system.

Prior to the construction of dams in the Rogue River Basin, coho salmon stocks had virtually collapsed, with less than 200 adults returning to areas above Gold Ray Dam in the 1960's and 70's (ODFW 1991). The report suggested this was primarily due to poor ocean survival and ocean harvest. The authors suggested they were not able to detect any influence of Lost Creek Dam nor Cole M. Rivers Hatchery on the return of wild adults to areas upstream of Gold Ray Dam.

The ODFW evaluated the effects of Lost Creek and Applegate Dams on coho salmon as well as other anadromous species in the basin. The studies were initiated in 1974 and field sampling was completed for the Applegate system in 1989 and 1995 for the Lost Creek portion. Coho salmon studies were concluded in 1989 (ODFW 1991). Relevant findings from those studies included:

1. Operation of Lost Creek Dam increased river flow levels during the migration period which resulted in adults passing Gold Ray Dam earlier than pre-dam periods. A two percent difference was noted (60% regulated versus 58% unregulated) in passage timing past Gold Ray Dam by November 15th. The report suggested the two percent had a negligible effect on the harvest and production of coho in the upper Rogue River.

2. The authors did not detect any influence of Lost Creek Dam or Cole Rivers Hatchery on return of wild adult coho to the upper Rogue River.

3. Construction of Lost Creek blocked little if any spawning area upstream of the project.

4. Coho salmon eggs developed at a faster rate immediately downstream of Lost Creek Dam due to higher water temperatures (1.7 degrees C). The report suggested that this was a minor effect as few coho spawn in the mainstem of the Rogue and the timing of emergence was similar to other coastal streams.

5. The study could not detect any influence of Lost Creek Dam on the production of coho salmon. This was due to most of the juvenile rearing occurred in the tributaries.

6. Effects of reservoir operation on coho were minimal because juvenile and adult salmonids migrate when reservoir operations had little influence on temperatures and flow in the system.

The NMFS determination of Effects is summarized below.

Coho salmon are present in the Rogue and Applegate Rivers year around. Adult coho salmon are present from September through January with spawning occurring during November and January. Juveniles emerge from the gravel between late March to early June and reside in tributaries or the mainstem Rogue until the following spring with outmigration occurring from late March through mid-July. Since coho salmon are present year around, flow regulation from both Lost Creek and Applegate Projects has the potential to affect coho salmon survival.

Research studies evaluating the effects of the projects on salmonid stocks including coho were conducted from 1974 through 1989. Physical factors including flow, water temperature, and turbidity were evaluated for their effects on coho production, growth rates, migration timing, pre-spawning mortality, and harvest.

Based on the results of these studies, operation of Lost Creek and Applegate Dams under the current strategy for flow management, are not likely to adversely affect coho salmon or their habitat. Effects of the flow management on coho salmon were minimal because few juveniles rear in the mainstem Rogue, adults migrate at times when reservoir operation have little effect on water temperatures and flow, and coho juveniles migrate at similar times as chinook when flows are provided for protection of juveniles of both species during their outmigration.

5.9. Rogue Spring Chinook Salmon Conservation Plan (2018)

The Rogue Spring Chinook Salmon Conservation Plan Comprehensive Assessment and Update (Review Draft, 11/15/18) was prepared by ODFW. The version referenced by this literature review is dated 15 November 2018 and was a draft for public review. The subject assessment document is the first comprehensive assessment, of the September 2007, Rogue Spring Chinook Salmon Conservation Plan, summarized above. The 2018 document summarizes progress towards implementing the management strategies adopted in the conservation plan. Excerpts from the assessment are presented below summarizing some the important aspects of this document.

The assessment determined that the 2007 conservation plan's implementation had been successful, with Naturally Produced Spring Chinook Salmon, NPCHS, returns increasing, desired status criteria either improving or being met, and major actions completed or on-going. No major revisions to the plan's desired status or management strategies were deemed warranted or proposed with the Comprehensive Assessment and Update (2018).

The Comprehensive Assessment and Update does however call for ODFW to continue plan implementation actions, improve several aspects of monitoring, evaluation, and research, and adaptively manage the fishery for improvements through:

1. A cautious abundance-based increase in fishing opportunity on NPCHS consistent with not having reached a desired status to date.
2. Changes to the hatchery spring Chinook program to strengthen performance.

The 2018 assessment concludes that ODFW believes that in the context of environmental conditions experienced during Plan implementation, progress has been achieved, with positive signs observed in abundance and indications of a rebuilding early run component of the population.

Post-plan returns began in 2012, so only one complete brood has returned to date. More returns are needed to evaluate the effectiveness of management strategies to achieve desired status. In fact, in the Plan it was stated that desired status should be attainable between 2019 and 2025.

Because progress has been made, ODFW does not propose to modify management strategies or key elements in the Plan. Instead, ODFW proposes to increase habitat restoration, add additional harvest opportunity while building toward desired status, and continuing to improve the harvest of in-clipped hatchery spring Chinook (HCHS) on the Rogue. ODFW believes this approach will provide the best strategy to sustain desired status, restore the early run life history of the population, and protect genetically pure spring Chinook. The 2018 assessment indicates that the current plan, including Applegate and Lost Creek fish operations, are moving in the right direction.

5.10. ODFW Information Reports

ODFW is the lead agency for formulating fish management operations in the Rogue River Basin. USACE has collaborated on preparation of the Information Reports. The main purpose behind the reports has been to document follow-up studies that were aimed at validating the current fish operations and documenting whether expected benefits were being achieved for the species of interest. Overall, the studies appear to show that current operations meet expectations. It is unknown what the next round of information reports will focus on.

5.10.1 ODFW Information Report 2020-06

This information report was written by ODWF to study Upper Rogue River Basin "early" and "late" run alleles Chinook salmon. The study was conducted within the context of the management goals and strategies for naturally produced spring Chinook salmon (NPCHS) in the Rogue SMU that are documented in the Rogue Spring Chinook Salmon Conservation Plan (referred to as "Plan"). Flow augmentation from William Jess Dam and Lost Creek Reservoir in the summer, intended to improve pre-spawn survival of early run NPCHS, has allowed fish expressing the late run life history phenotype to migrate further upriver, resulting in increased overlap in spawning distribution between spring and fall run fish. Given this, it was important for ODFW to understand the current nature of genetic interactions between spring and fall Chinook salmon to better inform management decisions.

Given advancements in genetics and increased understanding how genetics drive the Spring and Fall Chinook run behaviors; it was of interest to conduct a study to identify the genetic makeup of the separate allele types found in the Upper Rogue Basin, during the Spring timeframe (February thru mid-July). That is, was there disproportionate representation by Fall Chinooks versus Spring Chinook salmon found in the upper basin during the springtime? Were the higher regulated flows in the spring contributing to more Fall Chinooks migrating upstream?

ODFW implemented the study beginning in 2016 to collect and analyze samples from across the entire spawning period in survey reaches below Cole Rivers Hatchery. Samples were also collected from a subset of the 2018 Cole Rivers Hatchery spring Chinook broodstock to determine the genetic composition of the fish based on run-timing markers. The objectives of the study were to:

1. Evaluate the spatial and temporal patterns of "early" and "late" run alleles in Chinook salmon spawning below William Jess Dam in the Rogue River watershed.
2. Determine the number of homozygous Spring, heterozygous, and homozygous fall Chinook salmon in a subsample of the 2018 Cole Rivers Hatchery broodstock.

The results of the study found for all three sample years (2016-2018) homozygous spring fish were frequently found in the upstream survey reaches. "The data suggest there is significant temporal and spatial separation among spring and fall Chinook salmon spawning, and, to a lesser extent, among spring Chinook salmon and heterozygotes in the upper Rogue River. In most instances (~65%), spring fish constitute >70% of all spawners collected within a reach per week across all three years."

The findings had an implication for monitoring, in that it could serve as baseline numbers for future studies and as adjustments for future abundance estimates. The data suggest that there is a proportionally high population of spring Chinook salmon in the upper reaches of the Rogue basin and that they are not swamped by early arrival of fall Chinook salmon. The current regulation to benefit spring population does not appear in an adverse impact on this dynamic.

5.10.2 ODFW Information Report 2020-02

This information report is titled "Evaluating the genetics of naturally produced Chinook salmon (Oncorhynchus tshawytscha) captured in the Lower Rogue River (OR) fishery". The focus was on the Spring Chinook salmon in the lower river, defined as those "adult Chinook salmon that enter freshwater during the period February through mid-July, and also pass Huntley Park (RM 8) by the end of Julian Week 29". It was prepared to inform the ODFW management of spring and fall Chinook salmon as distinct species management units (SMUs). This is documented in the "Rogue Spring Chinook Salmon Conservation Plan" which was adopted by the ODFW Fish and Wildlife Commission in September 2007. ODFW's management strategy for the spring Chinook fishery in the Lower Rogue River protects the early run "spring" Chinook while providing harvest opportunity during this period on hatchery spring Chinook. More recently, ODFW completed a Comprehensive Assessment and Update of the Conservation Plan in January 2019. ODFW concluded that the status of naturally produced spring Chinook relative to these targets had improved because of the management actions that were implemented. As a result of the improved status, ODFW proposed a framework for providing additional fishery opportunities if population abundance continued to increase. The proposed regulation changes would shift the date at which wild Chinook can be retained from June 1 to May 21, May 11, or April 1.

The purpose of this study was to "assess how the current and future angling regulations aligned with the genetic composition of Chinook at the run timing markers. ODFW initiated this study in 2019 using angler captured fish in the Lower Rogue River. The study objective statement was:

"Determine the genetic composition, based on two run timing markers, of naturally produced Chinook salmon captured in the lower Rogue River fishery in 2019."

The study period was conducted from March 1 thru July 15, 2019. Volunteer anglers were asked to take tissue samples from any naturally produced Chinook salmon captured during this period. The volunteer anglers were issued sampling kits containing written instructions, individually labeled vials containing ethanol, and a paper hole punch for extracting caudal fin tissue.

Figure 9 shows a map of the ten sample locations in the lower Rogue River.

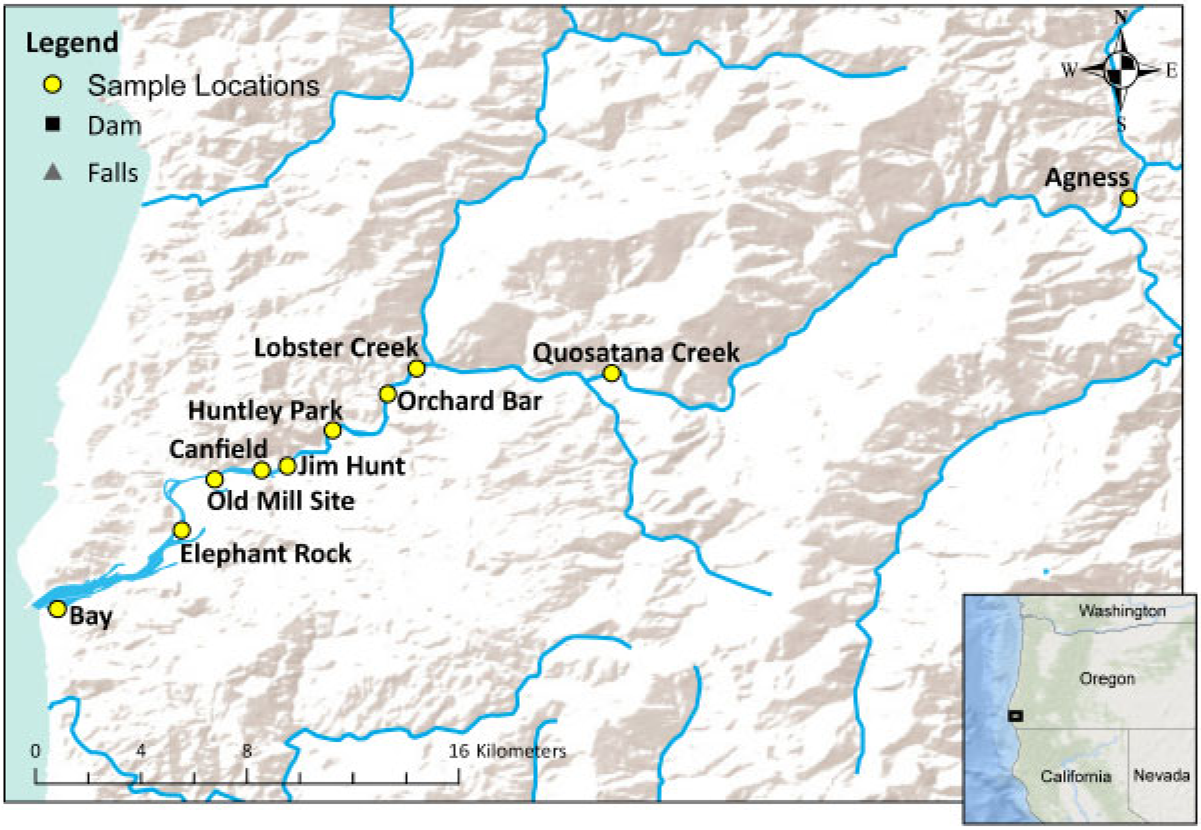


Figure 9. Map of Chinook sampling locations in the lower Rogue River (ODFW 2020a).

No specific management conclusions were drawn from the study. The effort was focused on collecting lower river Chinook genetic data. The main findings as summarized in the report are reproduced below:

1. All except one naturally produced Chinook salmon caught on or before May 23rd were homozygous spring at both Greb1L SNPs
2. Based on Greb1L SNP1, the majority of naturally produced homozygous spring Chinook salmon (83.8%; 98 out of 119 fish) genotyped in this study were captured during the period when retention of unmarked Chinook salmon was prohibited (Mar 1-Jun 1). Thus, the current angling regulations are protective of the early run life history genetics.
3. Based on Greb1L SNP1, anglers were primarily capturing and retaining heterozygous fish during the period June 1 - July 8 (31 out of 52 fish: or 59.6% of total catch). Of the remaining fish, 19 were homozygous spring and two were homozygous fall.
4. The sample collection protocol, which primarily relied upon volunteer anglers, was an effective way to collect fin clips from naturally produced Chinook salmon in the lower Rogue River.
5. A single seasonal employee was able to collect and manage samples with assistance from District personnel.

5.11. U.S. Fish and Wildlife Service Progress Reports

There are four USFWS Progress Reports, but only two were available for review. The two reviewed were:

- Report III: Spawning Populations and Spawning Grounds in Upper Rogue River from 1949 through 1954.
- Report IV: Summary Reports Dealing with Sport Fishery, Spawning, and Population Studies for The Entire Rogue River System in 1949-1954.

These reports are dated but were useful for providing anecdotal and semi quantitative data collection that portrays the Rogue River fisheries conditions, pre-dam, mid-twentieth century. It is likely that these reports informed the operational requirements for the Rogue River Basin projects.

5.12. USGS Open-File Report 2011–1280 (2012)

The U.S. Geological Survey (USGS) published the "Preliminary assessment of channel stability and bed-material transport in the Rogue River Basin, southwestern Oregon, open file report 2011-1280, in 2012 (Jones et al. 2012). The report identifies the reaches with gravel mining.

A reconnaissance-level study of channel condition and bed-material transport relevant to the permitting of instream gravel mining on the Rogue River and its largest tributaries, the Applegate, and Illinois Rivers is summarized in the report.

The study reviewed existing datasets (such as bridge inspection surveys, watershed analyses, and instream gravel-mining records), delineated bar and channel features from aerial and ortho-photographs taken in multiple years and made field observations and particle size measurements in July and September 2010. Findings from these datasets and observations were used to:

(1) assess the vertical and lateral stability of river segments in the Rogue River Basin and identify locations where the channels may be incising, aggrading, prone to migrations, or stable, and

(2) identify key datasets and issues that are relevant to understanding channel condition and bed material transport as well as the potential effects of in-stream gravel mining on channel condition and bed-material transport in the basin.

The overall objective of the report was to characterize areas of stable and dynamic river reach segments. Seasonal factors such as high winter flow, mobilized certain segments, depending on bed material size and type. Human (anthropogenic) activities such as river flow regulation, gravel mining, and changing land cover, were also considered in the report's survey assessment.

On the Rogue and the Illinois rivers, as well as tributaries, confined and unconfined reaches were identified. The confined channels contain few bars and had stable planforms except for locally wider segments. Where the segment was active and dynamic, stream flows often passed over primarily finer alluvial material and could contain extensive gravel bars. Tidal reaches could be unconfined and dynamic as well. Tidal Reaches contain some of the most extensive bar deposits within the Rogue River study area.

"Together, these observations and findings indicate that (1) the size, area, and overall position of bars in the Rogue River study area are determined largely by valley physiography, such that unconfined alluvial sections have large channel-flanking bars, whereas confined sections have fewer and smaller bars, (2) segments within the Grants Pass, Merlin, Tidal, Upper Applegate River, and Lower Applegate River Reaches are prone to vertical and/or lateral channel adjustments, and (3) the balance between transport capacity and sediment supply varies throughout the study area.

High winter flows and the steep, confined character of much of the Rogue River within the study area result in a river corridor with a high capacity to transport bed material. In the Grants Pass and Galice Reaches, the extensive in-channel bedrock as well as the sparse number and coarse texture of bars indicate that these reaches are likely supply-limited, meaning that the river's transport capacity exceeds the supply of bed material. In contrast, the Lobster Creek and Tidal Reaches and perhaps portions of the Merlin Reach receive bed-material inputs that more closely balance or even exceed the river's transport capacity."

The report is a useful barometer for assessing geomorphic conditions in the Rogue basin. The report's survey quantifies stable and unstable bed segments in the basin. Identification of beneficial gravel beds, bars, etc., will aid species management on the Rogue and other river tributaries. The survey could also point to how current operations could be improved to maximize beneficial habitat areas. The reports provided information on where additional studies could be implemented to continue this survey work. The significant findings are shown below.

"More detailed investigations of bed-material transport rates and channel morphology would support assessments of channel condition, longitudinal trends in particle size, the relation between sediment supply and trans-port capacity, and the potential causes of bar area loss (such as vegetation establishment and potential changes in peak flow patterns). The reaches most practical for such assessments and relevant to several management and ecological issues are (1) the lower Rogue River Basin, including the Lobster Creek and Tidal Reaches of the Rogue River as well as the Illinois River Reach and (2) the Lower Applegate River Reach."

5.13. Ecohydrology West and USACE Report (2008)

The report is titled "Recent and Historic Spatial Distribution of Redds and Spawning Gravels in Relation to Geomorphic Features on the Upper Rogue River" and was prepared in 2008. The text as provided has editorial comments and appears to be draft. That being said, the document is still useful in adding to the overall understanding of the redd distributions in relation to spawning gravel areas in the basin. The report does have useful geomorphic feature maps overlapping important spawning information with orthoimagery, from 2005. There are also interesting hand drawn map depictions from United States Department of the Interior, Fish and Wildlife Service, Portland, Oregon, showing spawning grounds and populations in the upper Rogue River.

The study was conducted to better understand how USACE reservoirs have affected spring Chinook (*Oncorhynchus tshawytscha*) spawning on the Upper Rogue River. The objectives of this study were to discern spatial patterns of redd locations in relation to geomorphic features downstream from Lost Creek Dam. The study encompassed the Upper Rogue River from just below Lost Creek Dam at the Cole M. Rivers Fish Hatchery (RM 156.5) downstream approximately 17.95 river miles to Dodge Bridge (RM 138.5).

The report summary is reproduced below.

- For the spatially explicit surveys of 1954, 2006 and 2007, the majority of redds or spawning gravels were located within straight sections of main channel: 66% of the redds in a 2007 USACE survey, 74% of the spawning gravels in a 2006 USACE survey and 45% in a USFWS 1954 survey.
- None of the spatially explicit surveys found relatively large amounts of redds or spawning gravels associated with geomorphic features such as gravel bars, side channels, islands, or backwaters. Of these features, redds or spawning gravel were more prevalent around island margins (including side channels and island attached bars).
- Two significant differences between the 1954 USFWS and 2007 USACE redd surveys were found. In 1954 more redds were observed at tributary junctions than 2007 (13% vs 0%). In 1954 proportionately more redds were located within meander bends than 2007 (29% vs 12%).
- Comparing graphs of cumulative number of redds or gravel area with distance downstream from Lost Creek Dam shows differences in the longitudinal spatial distribution between all of the surveys (Figure 4).
- The USACE 2007 redd survey and 2006 spawning survey found a large fraction of the surveyed feature within a segment of river between 7 and 13 rivers miles downstream from Lost Creek Dam. A graph of water surface slope may help explain part of this observation.

5.14. 9-August Meeting: Applegate E-Flow Implementation (2022)

A meeting was held with USACE staff to discuss the feasibility and need for e-flow implementation at the Applegate Project.

Hydrograph comparisons show differences between upstream inflows representing unregulated/naturalized conditions and the regulated outflow. Figure 10, as also shown in Figure 1, shows inflow and outflow operations at Applegate Dam. Current regulated outflow mutes the wintertime and springtime high flows and increases downstream baseflows in the summer, conservation season. Red is regulated outflow and blue is inflow to Applegate Dam. Data were obtained from USACE DataQuery, an online publicly accessible data source.

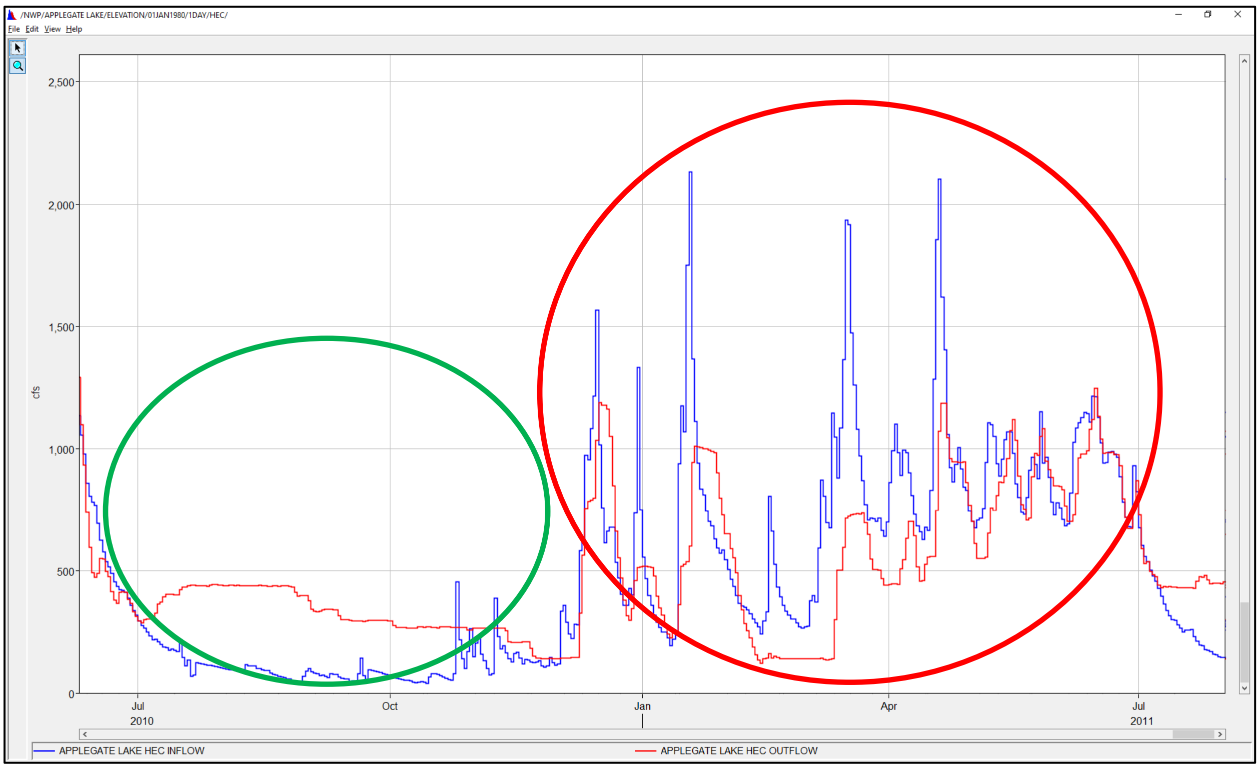


Figure 10. Inflows (blue), outflows (red hydrograph), and possible e-flow windows in summer (green oval) and winter (red oval) months for Applegate Dam.

The green oval denotes the increase in summer and conservation season flows under current water management and the red oval encompasses the wintertime difference between regulated and what would be the pre-project condition unregulated (in)flow.

The driver for the meeting was a question of whether water releases from Applegate Dam could be shaped differently to benefit the environment and, if so, would those potential changes be supported by stakeholders.

As noted above, the difference between inflows and outflows, suggest changes to dam operations are feasible, but meeting dialogue also indicated that current water management in the Rogue Basin was successfully meeting fisheries enhancement objectives, which limits need for any operational changes.

5.15. 2-March Phone call: Experience and history of fishery operations (2022)

A teleconference was held on 2-March 2022. The meeting attendees were Jim Buck (retired, USACE), Tom Satterthwaite (retired, ODFW), and Keith Duffy (USACE, Hydrology Section). Meeting objectives were to gather information from the attendees on the history and issues for Rogue River Basin fish operations, and to document lessons learned from past fisheries operations.

USACE and ODFW described past fisheries operations and water management from their perspectives. Communication between USACE project operators, ODFW, and USACE reservoir regulation staff have improved based on past experiences related to water management in the Rogue Basin, including more robust protocols and additional resourcing to support communications between Rogue Project operators, planners, and stakeholders.

This information was useful from an historical context of how the fishery operations have evolved and how sensitive they are. Meeting attendees also provided valuable input on how important clear lines of communication and information sharing are between stakeholders.

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