U.S. Fish and Wildlife Service
Columbia–Pacific Northwest
Interior Region 9

In collaboration with Bureau of Land Management, Bureau of Reclamation, National Marine Fisheries Service, U.S. Forest Service, Oregon Department of Agriculture, Oregon Department of Environmental Quality, Oregon Department of Fish and Wildlife, Oregon Water Resources Department, Crook County, Deschutes County, Jefferson County, and the Confederated Tribes of Warm Springs of Oregon

Draft
Environmental Impact Statement

FOR THE DESCHUTES BASIN HABITAT CONSERVATION PLAN VOLUME II: APPENDICES

October 2019

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$1,574,952

DRAFT ENVIRONMENTAL IMPACT STATEMENT

FOR THE DESCHUTES BASIN HABITAT CONSERVATION PLAN

VOLUME II: APPENDICES

OCTOBER 2019

Cover Photo Credits: Crane Prairie Reservoir (top photo), FWS; Crooked River (bottom photo), FWS; bull trout (top inset), Joel Satore; Oregon spotted frog (middle inset), FWS; steelhead trout (bottom inset), Oregon State University

Appendix 1-A

Glossary

Appendix 1-A
Glossary

Adverse effects: Those that exceed the stated thresholds.

Aestivate: To spend a hot or dry period in a prolonged state of dormancy.

Affected environment: Under NEPA, a description of the existing environment to be affected by the proposed action. (40 CFR 1502.15.)

Alternative: Under NEPA, a reasonable way to fix the identified problem or satisfy the stated need. (40 CFR 1502.4.)

Applicants: The applicants in this EIS include the eight irrigation districts making up the Deschutes Basin Board of Control, as well as the City of Prineville. The applicants are jointly submitting one habitat conservation plan and requesting one incidental take permit covering the nine applicants from the U.S. Fish and Wildlife Service and one incidental take permit from the National Marine Fisheries Service. The applicants are referred to as the permittees in the Deschutes Basin HCP. In the context of this EIS, the applicants will become permittees when the incidental take permits are issued.

Beneficial effects: Those effects that would improve environmental conditions.

Conservation strategy: A series of conservation measures implemented by the applicants to reduce and offset the adverse effects of covered activities on the covered species. The ITPs also authorize any take that may result from these measures and authorize monitoring measures.

Cooperating agency: Under NEPA, any federal agency with jurisdiction or special expertise with respect to any environmental issue addressed in the EIS. (40 CFR 1508.16.)

Council on Environmental Quality (CEQ): The council established under Title II of NEPA to develop federal agency-wide policy and regulations for implementing the procedural provisions of NEPA, resolve interagency disagreements concerning proposed major federal actions, and to ensure that federal agency programs and procedures are in compliance with NEPA.

C*overed activities*: The activities with the potential to result in take of covered species for which the applicants are applying for incidental take coverage*.* The covered activities for the Deschutes Basin HCP include storage, release, diversion, and return of irrigation water by the DBBC member districts and groundwater withdrawals, effluent discharges, and surface water diversions by the City of Prineville.

Covered lands and waters: The specific aquatic, wetland, riparian, and floodplain habitats affected by the covered activities and where incidental take of covered species would occur (Figure 1-1).

Covered species: Those species for which the applicants are seeking incidental take coverage. They include three species listed as threatened under the ESA—Oregon spotted frog (*Rana pretiosa*), Middle Columbia River steelhead trout (*Oncorhynchus mykiss*), and bull trout (*Salvelinus confluentus*)—and two nonlisted species—the Middle Columbia River spring Chinook salmon (*Oncorhynchus tshawytscha*), and sockeye salmon (*O. nerka*), both of which could become listed during the term of the ITPs.

Cumulative actions: Those past, present, and reasonably foreseeable future actions, the effects of which, when added to the incremental impact of the proposed action or action alternatives on the human environment, inform the assessment of cumulative effects in the study area.

Cumulative effect: Under NEPA, the incremental environmental impact or effect of the proposed action, together with impacts of past, present, and reasonably foreseeable future actions, regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time. (40 CFR 1508.7.)

Debitage: Waste material produced in the making of prehistoric stone implements.

Environmental consequences: Under NEPA, the environmental effects of project alternatives, including the proposed action, any adverse environmental effects which cannot be avoided, the relationship between short-term uses of the human environment, and any irreversible or irretrievable commitments of resources which would be involved if the proposal should be implemented. (40 CFR 1502.16.)

Environmental impact statement (EIS): A detailed written statement required by section 102(2)(C) of NEPA, analyzing the environmental impacts of a proposed action, adverse effects of the project that cannot be avoided, alternative courses of action, short-term uses of the environment versus the maintenance and enhancement of long-term productivity, and any irreversible and irretrievable commitment of resources. (40 CFR 1508.11.)

Fry: Young salmon that have consumed all of the yolk sac, grown in size, and emerged from the gravel nest (redd).

Grab samples: Instantaneous sample of the water at a given time and location.

Gaining reach: A reach of a stream or river that has a channel that is lower than the groundwater table and tends to gain water from the groundwater system.

Historic property: Any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion on the National Register including artifacts, records, and remains which are related to such district, site, building, structure, or object.(16 U.S.C. Section 470(w)(5).)***Human environment***: Under NEPA, the human environment includes the natural and physical environment and the relationship of people with the environment. (40 CFR 1508.14.)

Hydrograph: A graph showing the rate of flow versus time past a specific point in a river, stream, or other conduit carrying flow. In this EIS, the rate of flow is expressed in cubic feet per second (cfs).

Impact (effect): Under NEPA, a direct result of an action which occurs at the same time and place; an indirect result of an action which occurs later in time or in a different place and is reasonably foreseeable; or the cumulative results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions. (40 CFR 1508.8.)

Irretrievable commitments: Future options that are those that are lost for a period of time.

Irreversible commitments: Decisions affecting non-renewable resources that cannot be reversed. Such decisions are considered irreversible because their implementation would affect a resource to the point that renewal can occur only over an extremely long period of time or at great expense or because they would cause the resource to be destroyed, become extinct, or removed. *Irreversible* describes the loss of future options and applies to the impacts of using nonrenewable resources or resources that are renewable only over a long period of time.

Key life history period: For Oregon spotted frog, the analysis considered breeding, summer rearing, fall (pre-winter), and overwintering periods.

Lead Agency: Under NEPA, the agency or agencies responsible for preparing the environmental impact statement. (40 CFR 1508.16.)

Lithic: Of, relating to, or being a stone tool.

Losing reach: A reach of a stream or river that has a channel that is higher than the groundwater table and tends to lose water into the groundwater system.

Lower Deschutes River: The Deschutes River downstream of and including Lake Billy Chinook.

Middle Deschutes River: The Deschutes River downstream of the city of Bend to Lake Billy Chinook.

National Environmental Policy Act of 1969 (NEPA): Requires all agencies, including the Service, to examine the environmental impacts of their actions, incorporate environmental information, and utilize public participation in the planning and implementation of all actions. Federal agencies must integrate NEPA with other planning requirements and prepare appropriate NEPA documents to facilitate better environmental decision making. NEPA requires federal agencies to review and comment on federal agency environmental plans/documents when the agency has jurisdiction by law or special expertise with respect to any environmental impacts involved. (42 U.S.C. 4321-4327) (40 CFR 1500-1508.)

Neutral reach: A reach of a stream of river that neither loses nor gains water from the groundwater system.

No effect: A determination that an effect would have no effect on the human environment.

No-action alternative: Under NEPA, the alternative where current conditions and trends are projected into the future without another proposed action. (40 CFR 1502.14(d).)

Not adverse: Effects that are not adverse are those that could occur but do not exceed thresholds.

Notice of intent (NOI): A notice that an environmental impact statement will be prepared and considered. (40 CFR 1508.22.)

Oregon spotted frog site: A habitat patch where breeding has been confirmed (breeding site), or an area where multiple Oregon spotted frogs have been detected (occupied site).

Permit term: The length of time covered by the ITPs. The permit term proposed in the Deschutes Basin HCP is 30 years.

Proposed action: Under NEPA, a plan that contains sufficient details about the intended actions to be taken, or that will result, to allow alternatives to be developed and its environmental impacts analyzed. (40 CFR 1508.23.)

Record of decision (ROD): A concise public record of decision prepared by the federal agency, pursuant to NEPA. that contains a statement of the decision, identification of all alternatives considered, identification of the environmentally preferable alternative, a statement as to whether all practical means to avoid or minimize environmental harm from the alternative selected have been adopted (and if not, why they were not), and a summary of monitoring and enforcement where applicable for any mitigation. (40 CFR 1505.2.)

Scope: Under NEPA, the range of actions, alternatives, and impacts to be considered in an environmental impact statement. (40 CFR 1508.25.)

Scoping: Under NEPA, an early and open process for determining the extent and variety of issues to be addressed and for identifying the significant issues related to a proposed action. (40 CFR 1501.7.)

Spill return flow: Diverted irrigation water that is returned to a river or creek without being applied to irrigated lands.

Study area: The geographic area considered for potential effects on each resource. The area was defined to encompasses where the proposed action and alternatives have the potential to result in effects on the human environment.

Tailwater: Water that has been applied to irrigated lands and subsequently allowed to return to a river or creek through surface or groundwater flow.

Take: To harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct, of a listed, endangered, or threatened species.

Tribal resources: Refers to treaty-reserved rights to tribal fishing, hunting, gathering practices, and pasturing of stock including access to areas associated with a tribe's treaty rights. These resources may include plants, animals, or fish used for commercial, subsistence, and ceremonial purposes. Tribal resources includes all natural resources, including water, relevant to treaty and federally recognized tribes with ceded lands and usual and accustomed stations in the study area.

Upper Deschutes Basin: The basin upstream of Lake Billy Chinook related to the Deschutes River.

Upper Deschutes River: The Deschutes River upstream of and including the city of Bend.

Appendix 1-B
References

Appendix 1-B
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Chapter 5, Additional Topics Required by NEPA

None

Chapter 6, List of Preparers

None

Chapter 7, Distribution List

None

Appendix 1-C

Scoping Report

Scoping Report for the Deschutes Basin Habitat Conservation Plan Environmental Impact Statement

Department of the Interior
U.S. Fish and Wildlife Service
Bend Field Office
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June 2018

Contents

Acronyms and Abbreviation

CFR	Code of Federal Regulations
DBBC	Deschutes Basin Board of Control
EIS	Environmental Impact Statement
ESA	federal Endangered Species Act of 1973
ITP	incidental take permit
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOI	Notice of Intent
The Services	U.S. Fish and Wildlife Service and National Marine Fisheries Service
U.S.C.	United States Code
USFWD	U.S. Fish and Wildlife Service

Chapter 1
Introduction

1.1 Proposed Action Overview

The U.S. Fish and Wildlife Service (USFWS) is preparing an Environmental Impact Statement (EIS) to evaluate the potential impacts associated with issuance of incidental take permits (ITPs) under the Endangered Species Act of 1973, as amended (ESA), for the proposed Deschutes Basin Habitat Conservation Plan (HCP) by USFWS and National Marine Fisheries Service (NMFS), referred to collectively as the Services.

The Deschutes Basin Board of Control (DBBC)[1] and the City of Prineville, Oregon, referred to collectively as the permittees, are preparing the Deschutes Basin HCP because their activities have the potential to incidentally take species listed under the ESA in the Deschutes Basin.

The species for which the ITPs would be issued to the permittees are collectively referred to as the *covered species.* The covered species for the Deschutes Basin HCP are three species listed as threatened under the ESA (Oregon spotted frog [*Rana pretiosa*], middle Columbia River steelhead trout [*Oncorhynchus mykiss*] and bull trout [*Salvelinus confluentus*] and two unlisted species (Chinook salmon [*Oncorhynchus tshawytscha*], and sockeye salmon [*Oncorhynchus nerka*]

The activities covered under the Deschutes Basin HCP, referred to as *covered activities*, include operation and maintenance of dams and reservoirs; operation and maintenance of diversions, pumps, and intakes; diversion of water for irrigation; return of flow to a river or creek; groundwater withdrawals and effluent discharges.

The Deschutes Basin HCP also includes a conservation strategy, a series of conservation measures implemented by the permittees to reduce the adverse effects of covered activities on the covered species. The ITPs also authorize any take that may result from the conservation strategy as well as monitoring measures. Conveyance and delivery of water to patron lands is not a covered activity in the Deschutes Basin HCP and therefore is not addressed in this chapter.

The EIS will evaluate the environmental impacts resulting from the issuance of an ITP for the Deschutes Basin HCP, as well as reasonable alternatives to the proposed action.

1.2 Purpose of the Proposed Action

The purpose of the federal action is to review and approve a request for an ITP for the Deschutes Basin HCP which, if granted, would authorize the incidental take of the covered species. The purpose of the ITP issuance is to comply with the ESA by providing protection and conservation of certain listed species while enabling the permittees to conduct legally authorized activities. The ITPs would also require implementation of the Deschutes Basin HCP.

[1] The DBBC consists of eight irrigation districts—Arnold, Central Oregon, Lone Pine, North Unit, Ochoco, Swalley, Three Sisters, and Tumalo.

Section 9 of ESA (16 United States Code [U.S.C.] 1531 et seq.) and its implementing regulations prohibit the take of animal species listed as endangered or threatened. The term *take* is defined in the ESA as: "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in such conduct" (16 U.S.C. 1532(19)). *Harass* is further defined in the Service's regulations as "an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering" (50 Code of Federal Regulations [CFR] 17.3). *Harm* is further defined in the Service's regulations as "an act which actually kills or injures listed wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, and sheltering" (50 CFR 17.3).

Under Section 10(a) of ESA, the Service may issue permits to authorize incidental take of listed animal species. *Incidental take* is defined by the ESA as take that is "…incidental to, and not the purpose of, the carrying out of an otherwise lawful activity" (50 CFR 17.3). Section 10(a)(1)(B) of ESA contains provisions for issuing ITPs to non-federal entities for take of endangered and threatened species, provided the applicant prepares a conservation plan (ESA Section 10(a)(2)(A)) and satisfies the issuance criteria provided in ESA Section 10(a)(2)(B), which require that:

- The taking will be incidental.
- The applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such taking.
- The applicant will ensure that adequate funding for the HCP and procedures to deal with unforeseen circumstances will be provided.
- The taking will not appreciably reduce the likelihood of survival and recovery of the species in the wild.
- The applicant will ensure that other measures that the Service may require as being necessary or appropriate will be provided.
- The Service has received such other assurances as may be required that the HCP will be implemented.

1.3 NEPA Compliance

The National Environmental Policy Act (NEPA) states that any federal agency undertaking a "major federal action" likely to "significantly affect the quality of the human environment" must prepare an EIS (42 U.S.C. 4332(2)(C)). Significance is determined by evaluating the context and intensity of impacts, as defined in 40 CFR 1508.27. Based on these guidelines, the USFWS, as lead federal agency, has determined that issuance of an ITP under the proposed Deschutes Basin HCP may have significant effects on the human environment and requires preparation of an EIS before a decision to issue federal permits is made.

The EIS will consider the impacts of the proposed action—the issuance of an ITP—on the human environment. The EIS will also include analysis of a reasonable range of alternatives to the proposed action. Alternatives considered in the EIS may include, but are not limited to, variations in the permit term permit structure; the quantity of take permitted; the amount, location, and/or type of conservation, monitoring, or mitigation provided ; the scope of covered activities; or a combination of these. Additionally, a no-action alternative will be evaluated in the EIS. The no-action alternative provides a baseline for comparing the effects of the proposed action and other action alternatives considered in the EIS.

The first formal step in the NEPA process is the scoping phase. The primary purpose of the scoping process is to provide interested parties such as the public, organizations, and agencies an opportunity to assist in developing the scope of the EIS analysis by identifying important issues and alternatives related to the proposed action that should be considered in the NEPA document.

This report summarizes comments, feedback, and input received during the 60-day scoping period for the Deschutes Basin HCP EIS. The scoping period for this effort began July 21, 2017, and closed on September 22, 2017.

Chapter 2
Scoping Activities

2.1 Scoping Notification

The scoping period was announced through a Notice of Intent (NOI) to Prepare a Draft Environmental Impact Statement for the Deschutes Basin HCP and to hold scoping meetings. The NOI was published in the Federal Register, a news release distributed to regional and local media, and public notice as described below. As noted above, the scoping period began July 21, 2017, and closed on September 22, 2017.

2.1.1 Notice of Intent

The Service published an NOI in the Federal Register (www.federalregister.gov) on July 24, 2017 (82 FR 34326). The NOI provides background information on the proposed action, as well as information on how to participate in the EIS scoping process. A copy of the NOI is provided in Appendix A, *NEPA Notice of Intent*.

2.1.2 News Release

A news release announcing the initiation of the scoping process and the four public meetings was sent to 878 media outlets throughout Oregon via Meltwater, a service company contracted by the Service for distribution of news bulletins and releases. Materials used for the news release are provided in Appendix B, *Scoping Display Advertisements, and Informational Flyer*.

2.1.3 Public Notice

Public notice of the initiation of the scoping process and the four public meetings was put on various community calendars in Central Oregon. The Deschutes Basin HCP Applicants also informed their patrons regarding the scoping meetings and the 60-day comment period. Materials used for the public notice are provided in Appendix B, *Scoping Display Advertisements, and Informational Flyer*.

2.2 Public Scoping Meetings

Four public scoping meetings were held in August 2017. The locations, dates, and times of the scoping meetings are as follows.

- August 14, 2017, Inn at Cross Keys Station, 66 NW Cedar Street, Madras, Oregon
  - 2:00–4:00 p.m.
  - 6:00–8:00 p.m.
- August 15, 2017, U.S. Forest Service, 63095 Deschutes Market Road, Bend, Oregon
  - 2:00–4:00 p.m.
  - 6:00–8:00 p.m.

The scoping meeting presentations are provided in Appendix C. Scoping meeting materials are presented in Appendix D.

Fifty-two written comments were received during the scoping period. Comments were received from the National Park Service and the Environmental Protection Agency; the Oregon Department of Fish and Wildlife and the Oregon Department of Environmental Quality; and the Crook County Court, Crook-Wheeler County Farm Bureau, the Jefferson County Farm Bureau, and the Oregon Farm Bureau. Appendix E present the comments received from public agencies. The Service did not receive comments from any Tribe.

Chapter 3
Summary of Comments Received

During the scoping period, 52 written comment submissions were received. Comments were received via letter and email. The Service identified 11 categories that encompassed the concerns and recommendations in the scoping comments. Comments are summarized in the sections below by each of these categories.

3.1 Management Issues and Goals

Sixty percent of commenters addressed management issues and goals.

3.1.1 Flows

Comments related to instream flows included the following suggestions and statements.

- The NEPA analysis should assess what flows are necessary in covered stream reaches to ensure recovery of the HCP's covered species.
- The objective and function of the HCP should be to achieve the minimum instream flow needs for the five covered species (Oregon spotted frog, bull trout, steelhead, sockeye salmon, and spring Chinook salmon).
- Flow needs must be identified in the Draft EIS and should include, but should not be limited to, instream water rights already set by the Oregon Department of Fish and Wildlife (ODFW) and the Oregon Water Resources Department.

3.1.2 Water Conservation

Comments related to water conservation included the following suggestions and statements.

- The HCP should require that all conserved water resulting from the HCP conservation measures be returned to the river and its tributaries.
- The HCP should describe in detail and mandate the process of transferring water rights to instream water rights. It should also require the DBBC districts and patrons to transfer their most senior water rights to instream flows.
- The HCP and ITP package of measures should include some provisions that require improvements in on-farm efficiencies as conservation measures, especially in Central Oregon Irrigation District (COID) and other low-efficiency districts.
- In addition to requiring improvements in on-farm efficiencies, the HCP could also use flow requirements for each of the covered parties to compel on-farm efficiencies.
- On-farm efficiency measures could include fallowing unproductive fields, planting less water-intensive crops, installing more efficient water application methods, and piping and/or lining private conveyances. These projects could be funded in part by grants through the Natural Resources Conservation Service's PL-566 program.

3.1.3 Water Quality

Comments related to water quality included the following suggestions and statements.

- The HCP must include conservation measures that result in improved water quality throughout the Basin. The HCP should condition the issuance of an ITP on the covered parties' maintenance of water quality standards pertinent to the health and survival of the covered species (e.g., dissolved oxygen, total dissolved gases, pH, and water temperature), including current Oregon Water Resources Department targets and future Total Maximum Daily Load standards set by the Oregon Department of Environmental Quality for the Deschutes River and its tributaries. Substandard water quality conditions in the Deschutes River Basin are largely caused by the activities of the covered parties, including warm surface water caused by artificial storage and release and agricultural run-off.
- The Draft EIS must consider impacts on water quality in the Deschutes Basin. This should include impacts not only to the upper Deschutes River and its tributaries, but also impacts on the river's lower 100 miles, which is a federally designated Wild and Scenic River and a treasured recreation destination. The Draft EIS should examine how these water quality impacts will affect resident and anadromous fish, birds, and other wildlife throughout the Deschutes Basin.
- The Draft EIS must take a close look at how water quality above and below the Pelton Round Butte Project will be impacted by management changes made pursuant to the HCP.
- The EIS analysis should include water quality in the covered reservoirs, including the Crane Prairie, Wickiup, Crescent, Prineville, and Ochoco reservoirs.

3.1.4 Groundwater

Comments related to groundwater included the following suggestion.

- The HCP should include an analysis of the conservation measures' impacts on groundwater and springs. This analysis should include local effects of conservation measures (including piping projects) on nearby springs and groundwater tables, as well as basin-wide effects on aquifers and springs.

3.1.5 Non-Essential Use

Comments related to non-essential water use included the following suggestions and statements.

- All unnecessary or nonessential designations of water should be eliminated to meet the goals of the HCP.
- The 2016 historical listing of a section of the Pilot Butte Canal by the National Park District is an example of a non-essential use of water that is detrimental to meeting the needs of ranchers, farmers, fish and wildlife, local residents, visitors, and a healthy/vibrant Deschutes River Basin.
- Additional non-essential uses of Deschutes River Basin water include preservation of property values, preservation of private water features, and preservation of open canal water views to private property owners bordering irrigation canals.

3.1.6 Piping

Comments related to piping included the following suggestions and statements.

- Piping canals and laterals for the purpose of conserving water and restoring flows to the Deschutes River should be supported. However, the water conserved from the projects should stay in the river so that the river and associated riparian ecosystems can be restored.
- Piping and/or lining of canals and laterals could have a negative effect of preventing the critical groundwater recharge service these conveyances currently provide. The Draft EIS analysis should include both local effects of conservation measures (including piping projects) on nearby springs and groundwater tables, as well as basin-wide effects on aquifers and springs.
- The current emphasis by the irrigation districts on big pipes is too narrow. While some piping of larger canals may be appropriate, it should not dominate the HCP and end up sinking the effort with its unrealistic cost. A diverse solution that draws on all approaches is best.
- The HCP should prioritize the piping and pressurization of smaller, on-farm laterals that serve individual users or small groups of users. Such projects are more cost-effective and they allow for continued spring and groundwater recharge from the larger, first-order canals and diversions while promoting efficient water use by individual users. Piping and pressurizing first-order diversions will only benefit those users whose laterals and on-farm irrigation systems are also pressurized.
- All piping projects should be designed to meet delivery needs. No extra diversion should be engineered or permitted.
- Water is not "lost" through leaking irrigation canals; rather, it recharges groundwater aquifers. Cold springs that are essential to threatened species (e.g., steelhead, bull trout) could be impacted if water is not able to seep into the ground from canals and ditches.
- Senior rights holders may lose incentive to conserve water through measures such as those currently employed by farmers in Jefferson County. Conservation measures must be developed and implemented. These measures could include use of drip irrigation, sprinklers, or pumpback systems; demand-based delivery; and a metered system that rewards irrigators for efficiency and conservation through lower bills.
- The HCP should condition the issuance of an irrigation district's ITP on the transfer of all rights to water conserved through PL-566 piping projects to instream flows.

3.1.7 Recreation

Comments related to recreation included the following suggestions and statements.

- The HCP should take into account the impacts of river recreation as flow regimes are altered.
- The HCP should assess adverse impacts on some forms of recreation, such as reservoir fishing, which is an important part of the local economy.

3.1.8 Hydropower

Comments related to hydropower included the following suggestions and statements.

- The HCP should include an analysis of the impacts of a hydropower plant being installed on Wickiup Dam—especially the possibility of invasive fish that prey on OSF being released from the reservoir into the river below the dam.
- The HCP should address effects of hydropower production, including accelerated degradation of channel morphology and wetland habitat affecting covered species, and how economic gain for irrigation districts related to hydropower production is an incentive for higher flows.
- The Draft EIS must note whether the Proposed Action includes facilities that generate hydropower and, if so, it must describe all facilities and infrastructure (both anticipated new construction and modifications to existing works) that are related to or necessary for power generation.
- On-farm deliveries should be metered and measured to ensure that extra water isn't diverted for hydropower. No extra diversion for hydropower should be engineered or permitted.
- Development of hydroelectric power facilities and revenue will create a disincentive to implement conservation systems, as drawing more river water would produce more revenue for the irrigation districts.

3.1.9 Diversion

Comments related to diversion included the following suggestions and statements.

- The Draft EIS should detail the status of fish screens, along with upstream and downstream passage facilities at each diversion. This should include the status of the Crescent Lake dam, Crane Prairie Reservoir dam, and Wickiup Reservoir dam fish screens and fish passage facilities.
- The Draft EIS should include information that confirms those facilities currently equipped with screens are sufficient to safely exclude juvenile and adult OSFs. The Draft EIS should also present the impacts associated with those diversions and dams that are not screened or adequately screened, including the North Unit Irrigation District North Canal Diversion screen.

3.1.10 Conservation

Commenters addressed several categories of conservation activities that include water, fish and wildlife, and economic resources.

3.2 Economics

Forty-four percent of commenters addressed analysis of economic impacts or sources of funding for the HCP.

3.2.1 Applicant Funding Mechanisms

Comments related to applicant funding mechanisms included the following suggestions and statements.

- As the entities largely responsible for the historic take of covered species in the Deschutes River Basin, as well as the entities seeking protection from liability under the ESA through this HCP and ITP, the eight DBBC irrigation districts should be the primary source of funding to implement the HCP's conservation measures.
- Any funding made available to the DBBC districts through the PL-566 program should actually benefit the Deschutes River or its tributaries, and not be used to meet the districts' other obligations, including the potential "firming up" of supply to junior irrigation districts.
- The HCP should consider more than just high-cost large capital projects, such as first-order canal and lateral piping projects, to increase water conservation to meet flow requirements.
- The HCP should consider "bottom-up" water conservation projects where smaller laterals and diversions are piped and pressurized.
- The HCP should consider market-based solutions where some irrigation district patrons can voluntarily reduce their water use for a small cost, leading to low-cost transfer of irrigation water rights to instream water rights.
- Prineville and the irrigation districts and/or individuals within the districts could earn water reduction credits that can be sold or traded between irrigation districts or to third party investors. Credits would be earned as water usage reduction projects are completed.
- The preferred method of the districts for achieving needed mitigation appears to be, as reflected in PL-566 proposals, big pipes which will cost nearly $1 billion. That is not practical or cost effective, as contrasted with piping of private laterals which was found by COID and the Farmers Conservation Alliance to be both cheap and effective. The COID and Farmers Conservation Alliance found that piping of COID's main canals would cost $700 million and conserve 89,500 acre-feet of water per year. The same study found that modernizing the district's private laterals would cost $36.5 million and conserve 35,284 acre-feet of water per year. Piping smaller private laterals in COID achieves 39% of the water savings at only 5% of the cost of main canal piping projects.

3.2.2 Effect on Local Economy

Comments related to effects on the local economy included the following suggestions and statements.

- The Draft EIS should consider the economic impacts of changes in management or irrigation availability caused by the HCP. Even slight changes in management can have serious consequences for local businesses, and economic information needs to be accurate, comprehensive, and on a scale that truly considers all farmers, businesses, and community members who are impacted by management changes.
- The U.S. Fish and Wildlife Service should do a thorough and comprehensive evaluation of the economic impacts that the proposed conservation measures could have on the overall economy of the Deschutes Basin The Draft EIS must analyze the socioeconomic impacts and benefits of its alternatives.

3.3 Environmental Conditions and Issues

Twenty-seven percent of commenters addressed concerns about environmental conditions and issues including but not limited to the environmental baseline, covered species, the ecology and life history of the covered species, ecosystem services, and climate change.

3.3.1 Environmental Baseline

Comments related to the environmental baseline included the following suggestions and statements.

- The HCP must set a baseline of current conditions that includes conservation measures already adopted by the DBBC districts, against which additional conservation measures required by the HCP will be measured. This is in addition to the setting of proper, biologically defensible instream flows.
- The HCP should not use current environmental and climate conditions as a baseline for stream flows. Instead, the HCP should anticipate these projected hydrological conditions in its analysis of the effect of proposed conservation measures on stream flows.
- The Draft EIS should be clear what flow regime constitutes the hydrologic baseline for purposes of assessing impacts and should describe the surface water/groundwater interaction in the scope area.
- The Draft EIS must use a technically credible and substantiated hydrologic baseline that is developed for changed climate conditions and that is not simply based on past hydrology.

3.3.2 Covered Species

Comments related to covered species included the following suggestions and statements.

- The EIS should include other sensitive species in the area of NEPA analysis, including redband trout.
- The HCP EIS must have a description of covered species habitat conditions and how each species' habitat conditions change with project operations, or how each species responds to those changes. Without this comprehensive discussion of changing habitat conditions and responses, there is no basis for analysis of impacts on covered species or their habitat.

3.3.3 Ecology/Life History of Covered Species

Comments related to the ecology/life history of covered species included the following suggestions and statements.

- The life history of native species should be addressed in the HCP.
- Very little is known about OSF biology and ecology in a reservoir environment, and a more comprehensive understanding of the frog's needs within the Applicant's managed irrigation delivery system is needed.
- The HCP should ensure that the timing of reservoir releases relates to and supports the life history of the OSF as well as listed and native fish species.

- There need to be binding minimum flows in the Crooked River system and Upper Deschutes River system that sustain and benefit all life history stages of those species for which the ITP is being proposed.
- Measures to address, contribute, and or otherwise meet biological objectives/needs for all life history stages of steelhead trout and Chinook salmon in Whychus Creek should be analyzed.
- Summer flows must be reduced and winter flows increased to meet all of the life history needs of the OSF and listed fish species and to improve habitat conditions. Summer flows also need to be reduced to approximate a more natural hydrograph.
- Information on the life history of the Oregon spotted frog in particular must be thoroughly provided, including the interrelated habitat needs of the Oregon spotted frog in relation to the other four covered species.

3.3.4 Ecosystem Services

Comments related to ecosystem services included the following suggestions and statements.

- The HCP's effects on ecosystem services, both positive and negative, should be analyzed and disclosed in the EIS. Of key importance in this context is the role of salmon as a provisioning species. Salmon produce highly valued food products harvested in various commercial, subsistence, and personal use fisheries across the North Pacific. Salmon are also a principal focus of the spiritual and cultural lives of diverse native communities in the Pacific Northwest.
- The ecosystem services of salmon and steelhead, which are the principal food item of many terrestrial wildlife species and a source of marine-derived nutrients to coastal lakes and streams, must be acknowledged, accounted for using quantitative (where feasible) or qualitative means, and fully considered in decision making.

3.3.5 Climate Change

Comments related to climate change included the following suggestions and statements.

- The Draft EIS must incorporate the best available science in assessing the efficacy of the alternatives in light of probable changes caused by the warming climate. To do so, the Draft EIS must include hydrologic analysis that is integrated with and based on credible and substantiated climate change modeling.
- If climate change threatens the species by impacting the quality or quantity of its habitat in the future, or increasing its vulnerability to pathogens or exotic species, this increased vulnerability should be taken into account by the EIS analysis.

3.4 Monitoring and Adaptive Management

Nineteen percent of commenters addressed monitoring and adaptive management requirements. Comments included the following suggestions and statements.

- It is important that all aspects of the HCP's conservation measures be monitored as they are implemented.

- A robust and thorough adaptive management plan should be in place to ensure that all measures achieve their stated biological goals and objectives.
- Effects monitoring should be thoroughly addressed in the EIS analysis.
- The HCP should include a comprehensive and robust monitoring program that can identify the positive and negative effects of management actions.
- HCP should plan for and implement a detailed monitoring and evaluation program. This program should be used to make adjustments to the HCP and ITP as needed in order to continually protect covered species. If the conservation measures adopted in the HCP result in reduced populations of covered species, excessive take of species, or additional loss or degradation of covered species' habitat, then the HCP and ITP should be amended during the permit period. Such loss or degradation of covered species' habitat should include, but not be limited to, reduced flows in the Deschutes River and its tributaries, and degraded water quality including increases in water temperature.
- A comprehensive monitoring program should be implemented with triggers that make changes seasonally and/or annually as needed.

3.5 Permit Duration

Twelve percent of commenters addressed permit duration. Comments included the following suggestions and statements.

- Permit durations could range from 5 to 40 years. It is important that the advantages and disadvantages of a range of timeframes be thoroughly analyzed.
- The more difficult it is to make effective and timely adjustments to the issued ITP, the shorter the duration of the ITP should be.
- The duration of the ITP should not exceed the limits of the climate change models used in the EIS analysis for assessing predicted effects. An initial short duration permit with a required review of consequences of initial provisions and execution should be issued, after which the ITP could be renewed for progressively longer periods as information and practices are refined.
- Permit length should be commensurate with the current understanding of the covered species' biology and ecology.

3.6 New Information and Current Science

Twelve percent of commenters addressed new information and current science. Comments included the following suggestion.

- The EIS should use the most up-to-date information available on covered species, and apply the most recently developed analytical methods.

3.7 Alternatives

Twelve percent of commenters addressed alternatives to the action. Comments included the following suggestions and statements.

- The EIS should evaluate alternatives that set biological goals, objectives, and conservation measures that optimize Deschutes River flows for Oregon Spotted Frog and listed fish.
- Two specific alternatives should be evaluated: “run-of-the-river” and “supply-based” proposals, which seek to maximize reservoir stability, provide early spring flows that inundate riverine wetlands used by breeding frogs, reduce the impact of fall drawdown on frogs utilizing off-channel habitats, and provide winter flows that inundate off-channel winter habitat.
- The EIS should evaluate alternatives under a standard of technological and/or implementation practicability absent cost. The EIS should analyze the full range of efficiency, management, and water transfer measures (on farm, conveyance, water management, duty reduction, etc.) that will fully avoid adverse impacts on species, absent cost, to determine practicability.
- The EIS should evaluate an alternative where avoidance of all harm to species is achieved. Additionally, the EIS should analyze an alternative where the combination of avoidance, minimization, and mitigation leaves no remaining adverse impacts on the species—in other words, all impacts are offset. Finally, the EIS should analyze an alternative where a net benefit is achieved that will enhance species chances of recovery, as the legislative record for the ESA indicates was the intent of Congress. The EIS analyses of these alternatives should not be constrained by what the applicant deems economically practicable or feasible.
- The EIS should evaluate dry year alternatives where biological flows for fish/OSF are met, regardless of what is proposed by the Applicants in their draft Deschutes Basin Habitat Conservation Plan.
- Any and all alternatives analyses should include an analysis of the alternative under climate change scenarios. The Deschutes Basin Habitat Conservation Plan should be required to identify potential climate-related changes and develop specific management responses.
- The Draft EIS should select a range of alternatives that allows for evaluation of all major actions available to offset DBBC and City of Prineville impacts and not reduce the likelihood of recovery of Covered Species.
- Other specific alternatives should be considered, and the EIS analysis of each alternative should clearly articulate whether and to what degree they achieve the goals and objectives outlined in the purpose and need statement.
- The EIS should consider a Modified Flows Alternative with a range of enhanced upper Deschutes winter flows to help meet the needs of covered species. Flows could include 300 cfs, 450 cfs, and 600 cfs.
- The EIS should consider Middle Deschutes summer flows to improve conditions for fish species and improve water quality. Such a range should include 250 cfs (ODFW instream water right amount) but also lower flows such as 175 cfs (to understand how resources and water quality may be impacted especially if the lower Middle Deschutes flows occur in conjunction with additional cold water inflows from Tumalo Creek).

- In Whychus Creek, the alternative should consider flow ranges in the 45 cfs to 65 cfs range during irrigation season. In the Crooked River, the Draft EIS should analyze minimum flows below Bowman Dam of 80 cfs, 120 cfs, and 140 cfs. The ODFW has determined that a minimum of 80 cfs is necessary in the storage season to protect the resources in the tailwater fishery.
- The EIS should consider a Recovery Alternative which offers a vision for species recovery in the Deschutes watershed from which to assess how well implementation of the HCP Conservation Strategy will contribute to attaining the vision.
- The EIS should include a wide range of alternatives, included market-oriented solutions, piping of private laterals, storage, on-farm efficiencies, and some main canal piping.
- It is not possible for the public to identify and suggest proposed "reasonable alternatives" to the HCP because the public has not yet been permitted to read the HCP and does not know what is included in the document. The Draft HCP should be released to the public immediately and the scoping period should be extended to provide adequate time for the public to identify reasonable alternatives to the HCP for inclusion in the Draft EIS.
- EIS analysis should include those alternatives which provide for "certainty" in respect to necessary flows required as a basis for quality habitat condition in which each species is dependent. There is a need for binding minimum flows in the Crooked River system and Upper Deschutes River system that sustain and benefit all life history stages of those species for which the ITP is being proposed.

3.8 Action Area

Eight percent of commenters addressed the action area size and scope. Comments included the following suggestions and statements.

- The exact area that will be covered must be delineated in the Draft EIS.
- The Draft EIS should be clear about what area constitutes: 1) the "permit area" where the incidental take authorization applies; 2) the "plan area" that will be used for activities described in the HCP; and, 3) the area encompassed in the NEPA review.
- The NEPA scoping materials are unclear as to whether the Metolius River is included in the scope of the NEPA analysis. It is appropriate and necessary to include the Metolius River watershed.
- Given that the Proposed Action can directly and cumulatively affect species outside the designated HCP area, the NEPA scope should include the entire range of the species covered by the HCP. This is necessary to allow USFWS to make its required finding that the impact of take will not appreciably reduce the likelihood of survival and recovery of the species.

3.9 Current and Planned Activities

Three percent of commenters addressed examples of planned and current activities. Comments included the following suggestions and statements.

- The U.S. Bureau of Reclamation and Deschutes River Conservancy's Basin Study Work Group (BSWG) is actively forming policy ideas to conserve water and improve instream flows in the Basin. Some of their ideas might include new or re-imagined water storage options to better serve the DBBC districts while keeping more water in stream channels. If implemented, these ideas would drastically alter the baseline conditions the HCP is meant to address. The HCP should coordinate its conservation measures with the ideas and proposals of the BSWG.
- The practicability component of the HCP the cost estimates being generated by the BSWG process are concerning, and the cost estimates often discussed in BSWG are wildly expensive and astonishingly biased. The process has been directed and manipulated by the irrigators towards an outrageously over-engineered solution set that will likely fail the practicability test. The BSWG work products show that there are far cheaper and practical solutions.

3.10 Covered Activities, Avoidance, Minimization, and Mitigation

Three percent of commenters addressed covered activities that include avoidance, minimization, and mitigation measures. Comments included the following suggestions and statements.

- Conservation measures must avoid, minimize, and/or mitigate impacts to the maximum extent practicable, in that order.
- Measures should describe the specific actions that the permittee will implement to achieve the biological objectives in support of the HCP goals.
- Measures must be based on the biological needs of the species.
- As to the maximum extent practicable standard, the EIS should evaluate alternatives under a standard of technological and/or implementation practicability absent cost.

3.11 Covered Parties

Four percent of commenters addressed the HCP should require the DBBC districts to exercise authority over their users.

Chapter 4
Next Steps in Planning Process

The Service will consider all of the public scoping comments in its development of the EIS. Public scoping comments help identify issues for analysis and alternatives within the EIS. The Service will develop a reasonable range of alternatives to the proposed action, which will be carried forward for full analysis in the EIS. For each of the reasonable alternatives carried forward for full analysis, the EIS will identify potentially affected resources and assess potential impacts on each of those resources. If needed, measures to mitigate resource impacts will be included.

Following completion of the environmental review process, the Service will publish a Notice of Availability and a request for comments on the Draft EIS. The Draft Deschutes Basin HCP will be released for public review and comment concurrent with the Draft EIS. A comment period of no less than 60 days will follow the publication of the Draft EIS and may include meetings to accommodate public participation. The Service will consider all comments on the Draft EIS in the preparation of the Final EIS, which will include responses to all substantive comments received. Following the comment period, the Draft EIS may be modified based on the substantive comments received.

When complete, the Final EIS and responses to substantive comments will be made available to the public for a minimum 30-day review period. A Record of Decision will be issued by the Service following the review period of the Final EIS.

Appendix A

NEPA Notice of Intent

(3) Enhance the quality, utility, and clarity of the information to be collected; and

(4) Minimize the burden of the collection of information on those who are to respond, including using appropriate automated, electronic, mechanical, or other technological collection techniques or other forms of information technology.

Information Collection Requirement

Title: Security Appointment Center (SAC) Visitor Request Form and Foreign National Vetting Request.

Type of Request: New collection.

OMB Control Number: 1652–XXXX.

Form(s): TSA Form 2802.

Affected Public: Visitors to TSA facilities in the National Capital Region.

Abstract: The Secretary of the Department of Homeland Security (DHS) is authorized to protect property owned, occupied, or secured by the Federal Government. *See* 40 U.S.C. 1315. *See also* 41 CFR 102–81.15 (requires Federal agencies to be responsible for maintaining security at their own or leased facilities). DHS Instruction Manual 121–01–011–01 (Visitor Management for DHS Headquarters and DHS Component Headquarters Facilities (April 19, 2014)) requires all DHS components to vet visitors using the National Crime Information Center (NCIC) system before allowing them access to agency facilities. The Security Appointment Center (SAC) Visitor Request Form and Foreign National Vetting Request process manages risks posed by individuals entering the building who have not been subject to a criminal history records check. TSA will use the collected information (social security number, date of birth and, if a foreign visitor, passport information) to vet visitors via the NCIC system.

Number of Respondents: 24,702.

Estimated Annual Burden Hours: An estimated 412 hours annually.

Dated: July 19, 2017.

Christina A. Walsh,

TSA Paperwork Reduction Act Officer, Office of Information Technology.

[FR Doc. 2017–15490 Filed 7–21–17; 8:45 am]

BILLING CODE 9110–05–P

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

[FWS–R1–ES–2017–N064; FXES11140100000–178–FF01E00000]

Notice of Intent To Prepare a Draft Environmental Impact Statement for the Proposed Deschutes River Basin Habitat Conservation Plan in Oregon

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Notice of intent; notice of public scoping meetings; request for comments.

SUMMARY: We, the U.S. Fish and Wildlife Service (Service), intend to prepare a draft environmental impact statement (EIS) in accordance with the requirements of the National Environmental Policy Act (NEPA) to evaluate the potential impacts on the human environment caused by alternatives to the Deschutes River Basin Habitat Conservation Plan (Deschutes River Basin HCP). The Deschutes River Basin HCP is being prepared in support of a request for an Endangered Species Act (ESA) incidental take permit (ITP) or ITPs authorizing incidental take of listed species caused by covered activities. The potential applicants for the ITP(s) include the City of Prineville, the Arnold Irrigation District, Central Oregon Irrigation District, North Unit Irrigation District, Ochoco Irrigation District, Swalley Irrigation District, Three Sisters Irrigation District, Tumalo Irrigation District, and the Lone Pine Irrigation District in Oregon. These eight irrigation districts comprise the Deschutes Basin Board of Control (DBBC). We are also announcing the initiation of a public scoping period to engage Federal, Tribal, State, and local governments and the public in the identification of issues and concerns, potential impacts, and possible alternatives to the proposed action for consideration in the draft EIS. The National Marine Fisheries Service (NMFS) is a cooperating agency in the draft EIS process.

DATES: The public scoping period begins with the publication of this notice in the **Federal Register**.To ensure consideration, please send your written comments postmarked no later than September 22, 2017. The Service will consider all comments on the scope of the draft EIS analysis that are received or postmarked by this date. Comments received or postmarked after this date will be considered to the extent practicable.

Public meetings: The Service will conduct four public scoping meetings: Two in Madras, Oregon, and two in Bend, Oregon. The two Madras scoping meetings will be held on August 14, 2017, from 2 to 4 p.m. and 6 to 8 p.m., respectively, and the two Bend scoping meetings will be held on August 15, 2017, from 2 to 4 p.m. and 6 to 8 p.m., respectively.

ADDRESSES: To request further information or submit written comments, please use one of the following methods and note that your information request or comment is in reference to the development of the Deschutes Basin HCP and the preparation of the associated draft EIS:

- *U.S. mail:* U.S. Fish and Wildlife Service, Bend Field Office, Attn: Peter Lickwar, 63095 Deschutes Market Road, Bend, Oregon 97701–9857.
- *In-person Drop-off, Viewing, or Pickup:* Call (541) 383–7146 to make an appointment during regular business hours to drop off comments or view received comments at the above location. Written comments will also be accepted at the public meetings.
- *Email: peter_lickwar@fws.gov.* Include "Deschutes River Basin HCP–draft EIS" in the subject line of the message.
- *Fax:* U.S. Fish and Wildlife Service at 541–383–7638; Attn: Peter Lickwar.

We request that you send comments by only one of the methods described above. See the Public Availability of Comments section below for more information.

Public meetings: The addresses of the scoping meetings are as follows:

Madras, Oregon: Inn at Cross Keys Station, 66 NW Cedar St, Madras, OR 97741.

Bend, Oregon: U.S. Forest Service Building, 63095 Deschutes Market Road, Bend, OR 97701.

FOR FURTHER INFORMATION CONTACT: Peter Lickwar, U.S. Fish and Wildlife Service, (see **ADDRESSES** above); email at *peter_lickwar@fws.gov* or telephone 541–383–7146. If you use a telecommunications device for the deaf, please call the Federal Relay Service at 800–877–8339.

SUPPLEMENTARY INFORMATION: The Service intends to prepare a draft EIS in accordance with the requirements of NEPA to evaluate the potential impacts on the human environment caused by alternatives to the Deschutes River Basin HCP. The Deschutes River Basin HCP is being prepared in support of a request for an ESA ITP or ITPs authorizing incidental take of listed species caused by covered activities. The potential applicants for the ITP(s) include the City of Prineville, the Arnold Irrigation District, Central

Oregon Irrigation District, North Unit Irrigation District, Ochoco Irrigation District, Swalley Irrigation District, Three Sisters Irrigation District, Tumalo Irrigation District, and the Lone Pine Irrigation District in Oregon. These eight irrigation districts (Districts) comprise the DBBC.

We are also announcing the initiation of a public scoping period to engage Federal, Tribal, State, and local governments and the public in the identification of issues and concerns, potential impacts, and possible alternatives to the proposed action for consideration in the draft EIS. The conservation measures in the Deschutes River Basin HCP would be designed to minimize and mitigate impacts caused by the take of covered listed species that may result from the storage, release, diversion and return of irrigation water by the Districts and the City of Prineville.

This notice was prepared pursuant to pursuant to section 10(c) of the ESA (16 U.S.C. 1531 *et seq.*), and the requirements of NEPA (42 U.S.C. 4321 *et seq.*), and its implementing regulations in the Code of Federal Regulations at 40 CFR 1506.6. The primary purpose of the scoping process is for the public and other agencies to assist in developing the draft EIS by identifying important issues and identifying alternatives that should be considered.

The NMFS is a cooperating agency in the draft EIS process, and intends to adopt the draft EIS to address the impacts of issuing an ITP addressing listed species under its jurisdiction.

Background

Section 9 of the ESA prohibits "take" of fish and wildlife species listed as endangered under section 4 (16 U.S.C. 1538 and 16 U.S.C. 1533, respectively). The ESA implementing regulations extend, under certain circumstances, the prohibition of take to threatened species (50 CFR 17.31). Under section 3 of the ESA, the term "take" means to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct" (16 U.S.C. 1532(19)). The term "harm" is defined by regulation as "an act which actually kills or injures wildlife. Such acts may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering" (50 CFR 17.3). The term "harass" is defined in the regulations as "an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering" (50 CFR 17.3).

Under section 10(a) of the ESA, the Service may issue permits to authorize incidental take of listed fish and wildlife species. "Incidental take" is defined by the ESA as take that is incidental to, and not the purpose of, carrying out an otherwise lawful activity. Section 10(a)(1)(B) of the ESA contains provisions for issuing ITPs to non-Federal entities for the take of endangered and threatened species, provided the following criteria are met:

- The taking will be incidental;
- The applicant will, to the maximum extent practicable, minimize and mitigate the impact of such taking;
- The applicant will develop a proposed HCP and ensure that adequate funding for the plan will be provided;
- The taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; and
- The applicant will carry out any other measures that the Service may require as being necessary or appropriate for the purposes of the HCP.

Regulations governing permits for endangered and threatened species are at 50 CFR 17.22 and 17.32.

Plan Area

The Plan Area for the Deschutes River Basin HCP covers approximately 10,700 square miles of land in central Oregon. Bounded by the Cascades Mountains on the west, the Ochoco Mountains on the east, and the Columbia River to the north, the Deschutes River Basin includes six major tributaries above Lake Billy Chinook. Tributaries to the Deschutes River above the lake include the Crooked River, Metolius River, Little Deschutes River, Crescent Creek, Tumalo Creek, and Whychus Creek. Major tributaries of the lower Deschutes River include Shitike Creek, Trout Creek, Warm Springs River, and the White River. The first water diversions in the Deschutes River Basin started in the late 1860s, however, irrigation districts did not start to form until circa 1900.

The eight irrigation districts (Districts) are quasi-municipal corporations formed and operated under Oregon State law to distribute water to irrigators within designated district boundaries. The Districts span Crook, Deschutes, Jefferson, Klamath, and Wasco counties in Oregon. The Districts lie along and utilize the waters of the Deschutes River and its tributaries, including the Little Deschutes River, Crescent Creek, Crooked River, Ochoco Creek, Tumalo Creek, Whychus Creek, and a number of smaller tributaries within the greater Deschutes River Basin. The City of Prineville (City), located in Crook County, is a municipality of about 7,350 residents. The City lies at the confluence of the Crooked River and Ochoco Creek, and has an economy based on agriculture and light industry.

The goals of the proposed Deschutes River Basin HCP are to avoid and minimize incidental take of the covered species associated with the Districts' and the City's activities, and to mitigate the impacts of unavoidable take, primarily by modifying irrigation water storage, release, and diversion operations in the Deschutes River Basin, including the mainstem Deschutes River and its tributaries. The Deschutes River Basin HCP would provide a district-wide permitting approach for the Districts and the City. The proposed term for the Deschutes River Basin HCP and ITP(s) is from 20 to 40 years.

Covered Activities

The Districts and the City are seeking incidental take authorization under the ESA for activities that they conduct, permit, or otherwise authorize. The proposed covered activities may include, but are not limited to: Operation and maintenance of storage dams and reservoirs; operation and maintenance of diversions, pumps, and intakes; operation and maintenance of water conveyance and delivery systems; diversion of water; return flow; and conservation measures and associated construction activities.

Covered Species

Covered species under the proposed Deschutes River Basin HCP include threatened and endangered species listed under the ESA, and currently unlisted species that have the potential to become listed during the life of the HCP. The Districts and the City are proposing to seek incidental take coverage for three federally listed species, and two non-listed species. The Deschutes River Basin HCP would provide long-term conservation and management of these species, which are discussed in more detail in the following paragraphs.

The Oregon spotted frog (*Rana pretiosa*) is a native aquatic species endemic to the Pacific Northwest. It was federally listed as threatened under the ESA on September 29, 2014 (79 FR 51658).

The bull trout (*Salvelinus confluentus*) is a member of the genus *Char,* and is native to Oregon. The bull trout has specific habitat requirements that influence its abundance and distribution. The bull trout is seldom found in waters where temperatures exceed 59 to 64 degrees Fahrenheit. The final listing determination of threatened status for the bull trout in the coterminous United States was made on November 1, 1999 (64 FR 58910).

The steelhead (*Oncorhynchus mykiss*) in the Deschutes River Basin is part of the Middle Columbia River Distinct Population Segment that was listed by NMFS as threatened, effective on February 6, 2006 (71 FR 834). However, on January 15, 2013, NMFS issued a final rule that designated the steelhead upstream of the Pelton Round Butte Hydroelectric Project on the Deschutes River as a nonessential experimental population (78 FR 2893). This designation has an expiration date of 12 years from the effective date of the rule. Unlike other anadromous members of the family Salmonidae, steelhead do not necessarily die after spawning and sometimes spawn more than once.

The Districts and the City also propose to cover the following non-listed species under NMFS jurisdiction under the Deschutes River Basin HCP: The sockeye salmon (*Oncorhynchus nerka*), and the Middle Columbia River spring-run Chinook salmon (*Oncorhynchus tshawytscha*).

Draft Environmental Impact Statement

For purposes of NEPA compliance, preparation of an EIS is required for actions that are expected or have the potential to significantly impact the human environment (40 CFR 1500–1508).

To determine whether a proposed Federal action would require the preparation of an EIS, the Service must consider two distinct factors: Context and intensity (40 CFR 1508.27, Service and National Marine Fisheries Service HCP Handbook 2016). Context refers to the geographic scale (local, regional, or national) of significance of short and/or long-term effects/impacts of a proposed action. Intensity refers to the severity of the effects/impacts relative to the affected settings, including the degree to which the proposed action affects: an endangered or threatened species or designated critical habitat; public health or safety; scientific, historic or cultural resources; or other aspects of the human environment.

In determining whether the preparation of an EIS is warranted, we must also consider the ten components of intensity, as set forth under 40 CFR 1508.27(b):

1. Impacts that may be both beneficial and adverse. A significant impact may exist even if the Federal agency believes that on balance the effect will be beneficial.

2. The degree to which the proposed action affects public health or safety.

3. Unique characteristics of the geographic area such as proximity to historic or cultural resources, park lands, prime farmlands, wetlands, wild and scenic rivers, or ecologically critical areas.

4. The degree to which the effects on the quality of the human environment are likely to be highly controversial.

5. The degree to which the potential impacts are highly uncertain or involve unique or unknown risks.

6. The degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration.

7. Whether the action is related to other actions with individually insignificant but cumulatively significant impacts.

8. The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural, or historical resources.

9. The degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the ESA.

10. Whether the action threatens a violation of Federal, state, or local law or requirements imposed for the protection of the environment.

In this case, and after considering the above factors, the Service has determined that the Deschutes River Basin HCP–ITP action has the potential to significantly impact the human environment for the following reasons:

The Deschutes River Basin encompasses 10,500 square miles in Central Oregon and the Deschutes River is a major tributary to the Columbia River. On that basis, the covered area is of local, regional, and national significance.

The Applicants store, manage, and release water from the Deschutes River and its reservoirs for irrigation and municipal purposes. Hundreds of miles of irrigation conveyance systems are managed by the Applicants. Under the Deschutes River Basin HCP, modernization of these conveyance systems, which is already underway, is a covered activity that is likely to result in water conservation for farmers and listed species, and take decades to complete. Some portions of the conveyance systems have been listed on the National Historic Register, and will require additional analysis under NEPA. The covered activities may affect four ESA-listed species (the Oregon spotted frog, steelhead, spring chinook and the bull trout) and their critical habitat that by virtue of their listings and designations are of local, regional, and national significance. Given the geographic scale of the HCP and the nature and scope of the covered activities and species, the context and intensity of potential adverse and beneficial impacts of implementing the HCP on the human environment are likely to be of local, regional, and national significance.

The Service performed internal NEPA scoping for the Deschutes River Basin HCP–ITP action in close coordination with NMFS as a cooperating agency. During that internal scoping process, Service and NMFS staff reviewed the proposed ITP action and the purpose and need for taking the action, and identified the environmental issues requiring detailed analysis as well as identified connected, similar, and cumulative actions. The internal scoping analysis concluded that the proposed ITP action:

- Involves instream flow and habitat restoration decisions that significantly affect biodiversity and ecosystem functions across a large geographic area;
- Involves management decisions that are significantly controversial;
- Has highly uncertain effects or involve unique or unknown risks to biological, physical or other factors;
- Establishes precedents for future actions with significant effects;
- Will contribute to other individually insignificant but cumulatively significant impacts;
- Will have positive effects on wetlands, rivers, and ecologically critical areas but may have adverse effects on historic resources (canals) and farmlands;
- May affect some areas covered by the National Historic Preservation Act;
- Will adversely affect endangered or threatened species, their critical habitat, or other non-target species; and
- Will have social or economic impacts interrelated with significant natural or physical environmental effects.

The Service also determined with NMFS that the proposed Deschutes River Basin HCP–ITP action: Is of sufficient size and complexity to warrant an EIS; is similar to previous HCP's issued in the Pacific Northwest that likewise required the preparation of an EIS; and may have significant effects on the human environment. On that basis and in accordance with regulations at 40 CFR 1501.4, 1507.3, and 1508.27, the Service believes preparation of an EIS is warranted. As such, we do not intend to prepare an environmental assessment for this action.

Therefore, before deciding whether to issue an ITP(s) for the Deschutes River Basin HCP, we will prepare a draft EIS to analyze the environmental impacts associated with this action. As noted above, NMFS is a cooperating agency in the draft EIS process, and intends to adopt the draft EIS to address the impacts on the human environment of issuing an ITP(s) addressing listed species under its jurisdiction.

Under NEPA, a reasonable range of alternatives to a proposed project is developed and considered in the Service's environmental review document. In the draft EIS, the Service will consider the following alternatives: (1) No action (no ITP issuance); (2) the proposed action, which includes the issuance of take authorizations as described in the proposed Deschutes River Basin HCP; and (3) a range of additional reasonable alternatives. Alternatives considered for analysis in a draft EIS for an HCP may include: Variations in the permit term or permit structure; the level of take allowed; the level, location, or type of minimization, mitigation, or monitoring provided under the HCP; the scope of covered activities; the list of covered species; or a combination of these factors.

The draft EIS will identify and analyze the potential direct, indirect, and cumulative impacts of Service authorization of incidental take under permit issuance and of implementing the proposed Deschutes River Basin HCP on biological resources, land uses, utilities, air quality, water resources, cultural resources, socioeconomics and environmental justice, recreation, aesthetics, and other environmental issues that could occur with implementation of each alternative. The Service will also identify measures, consistent with NEPA and other relevant considerations of national policy, to avoid or minimize any significant impacts of the proposed action on the quality of the human environment. Following completion of the draft EIS, the Service will publish a notice of availability and a request for comment on the draft EIS and the applicants' permit application(s), which will include a draft of the proposed Deschutes River Basin HCP.

Public Scoping

The primary purpose of the scoping process is for the public to assist the Service, Districts, and the City in developing a draft EIS by identifying important issues and alternatives related to the applicants' proposed action. The scoping meetings will include presentations by the Service, Districts, and the City followed by informal questions and discussions. The Service welcomes written comments from all interested parties in order to ensure we identify a full range of issues and alternatives related to the proposed permit request. The Service requests that comments be specific. In particular, we seek comments on the following:

1. Management issues and goals to be considered in the development of the HCP;
2. Existing environmental conditions in the Districts and the City;
3. Other plans or projects that might be relevant to this proposed project;
4. Permit duration;
5. Areas and specific landforms that should or should not be covered;
6. Biological information concerning species in the proposed plan area;
7. Relevant data concerning these species;
8. Additional information concerning the range, distribution, population size, and population trends of the covered species;
9. Current or planned activities in the Plan Area and their possible impacts on the covered species;
10. Species that should or should not be covered;
11. Covered activities including potential avoidance, minimization, and mitigation measures;
12. Monitoring and adaptive management provisions;
13. Funding suggestions; and
14. Alternatives for analysis.

We will accept written comments at the public meetings. You may also submit written comments to the Service at our U.S. mail address, by email, or by fax (see **ADDRESSES** above). Once the draft EIS and draft HCP are prepared, there will be further opportunity for public comment on the content of these documents through an additional 90-day public comment period.

Public Availability of Comments

Comments and materials we receive, as well as supporting documentation we use in preparing the draft EIS, will become part of the public record and will be available for public inspection by appointment, during regular business hours, at the Service's Bend Field Office (see **FOR FURTHER INFORMATION CONTACT** section). Before including your address, phone number, email address, or other personal identifying information in your comment(s), you should be aware that your entire comment(s)—including your personal identifying information—may be made publicly available at any time. While you can ask us in your comment(s) to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

Reasonable Accommodation

Persons needing reasonable accommodations to attend and participate in the public meeting should contact Peter Lickwar (see **FOR FURTHER INFORMATION CONTACT**). To allow sufficient time to process requests, please call no later than August 1, 2017. Information regarding the applicants' proposed action is available in alternative formats upon request.

Authority

The environmental review of this project will be conducted in accordance with the requirements of the NEPA of 1969 as amended (42 U.S.C. 4321 *et seq.*), Council on Environmental Quality Regulations (40 CFR parts 1500–1508), other applicable Federal laws and regulations, and applicable policies and procedures of the Service. This notice is furnished in accordance with 40 CFR 1501.7 of the NEPA regulations to obtain suggestions and information from other agencies and the public on the scope of issues and alternatives to be addressed in the draft EIS.

Theresa E. Rabot,

Deputy Regional Director, Pacific Region, U.S. Fish and Wildlife Service, Portland, Oregon.

[FR Doc. 2017–15479 Filed 7–21–17; 8:45 am]

BILLING CODE 4333–15–P

DEPARTMENT OF THE INTERIOR

National Park Service

[NPS–WASO–NAGPRA–23496; PPWOCRADN0–PCU00RP14.R50000]

Notice of Intent To Repatriate Cultural Items: Cincinnati Art Museum, Cincinnati, OH

AGENCY: National Park Service, Interior.

ACTION: Notice.

SUMMARY: The Cincinnati Art Museum, in consultation with the appropriate Indian Tribes or Native Hawaiian organizations, has determined that the cultural items listed in this notice meet the definition of sacred objects. Lineal descendants or representatives of any Indian Tribe or Native Hawaiian organization not identified in this notice that wish to claim these cultural items should submit a written request to the Cincinnati Art Museum. If no additional claimants come forward, transfer of

Appendix B

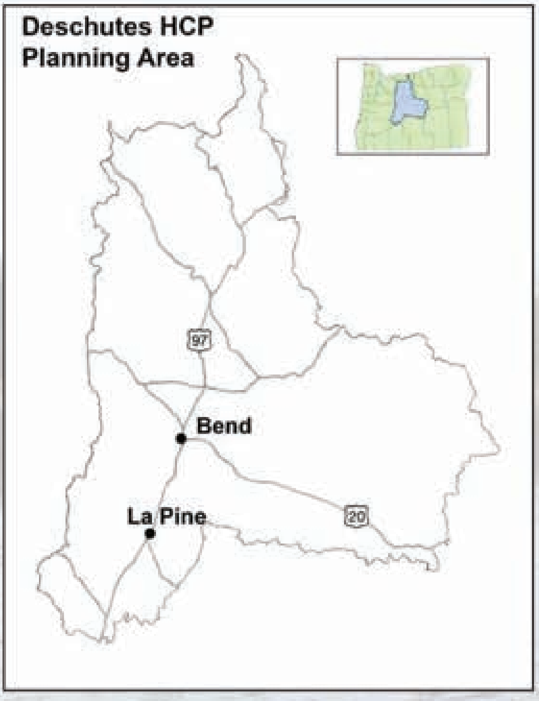
Scoping Display Advertisements and Informational Flyer

U.S. Fish & Wildlife Service

Deschutes River Basin

Habitat Conservation Plan (HCP)

Providing reliable water for farmers and residents in the Deschutes Basin while conserving fish, wildlife, and water resources for future generations.



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The HCP will cover ~10,700 mi^2 of land in the Deschutes River Basin of central Oregon. This Basin includes six major tributaries above Lake Billy Chinook. (Credit: USFWS).

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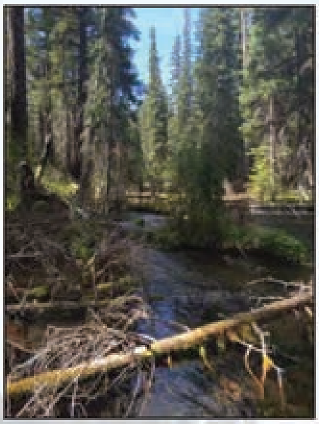

Bull trout habitat in the Deschutes River Basin (Credit: USFWS)

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HCPs are planning documents required as part of an application for an incidental take permit. They describe the anticipated effects of the proposed taking; how those impacts will be minimized, or mitigated; and how the HCP is to be funded.

HCPs can apply to both listed and non-listed species, including those that are candidates or have been proposed for listing. Conserving species before they are in danger of extinction or are likely to become so can also provide early benefits and prevent the need for listing.

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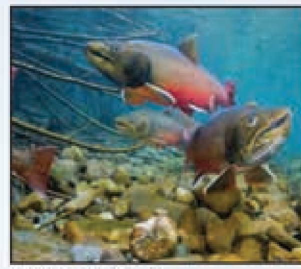

Bull trout (Credit: J.Sartore/National Geographic)

Oregon spotted frog (Credit: T.Waterstrat/USFWS)

Upper Deschute River (Credit: B.Moran/USFWS)

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Visit our Deschutes HCP Webpage: http://bit.ly/DeschutesHCP

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Appendix C

Scoping Meeting Presentations (DBBC and FWS)

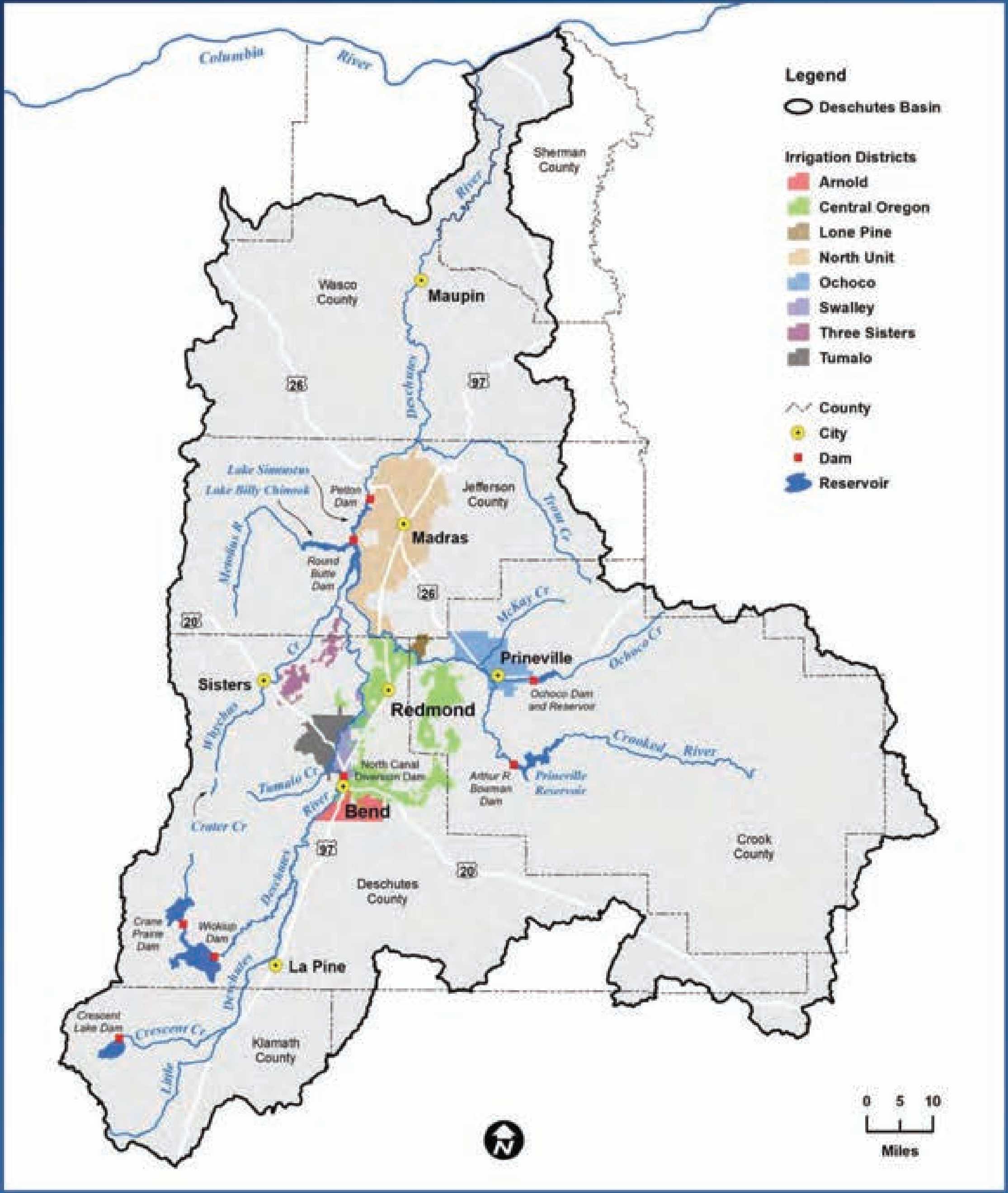

Deschutes Basin
Habitat Conservation Plan
NEPA Public Scoping
August 14, 2017 – Madras, OR
August 15, 2017 – Bend, OR

The Deschutes Basin Habitat Conservation Plan (DBHCP)

- An HCP is required for activities covered by an Incidental Take Permit issued under the Federal Endangered Species Act
- Deschutes Basin HCP will modify Irrigation District and City of Prineville activities to minimize and mitigate the impacts of those activities on the species covered by the Incidental Take Permits
- Has been in collaborative development since 2010

DBHCP Covered Parties

- Eight Irrigation Districts of the Deschutes Basin Board of Control (DBBC)
  - Arnold Irrigation District (AID)
  - Central Oregon Irrigation District (COID)
  - Lone Pine Irrigation District (LPID)
  - North Unit Irrigation District (NUID)
  - Ochoco Irrigation District (OID)
  - Swalley Irrigation District (SID)
  - Three Sisters Irrigation District (TSID)
  - Tumalo Irrigation District (TID)
- City of Prineville, Oregon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Lake Billy Chinook
Pelton Dam
Round Butte Dam
Metolius R
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Jefferson County
Trout Cr
McKay Cr
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Prineville
Ochoco Cr
Ochoco Dam and Reservoir
Sisters
Redmond
Whychus Cr
Tumalo Cr
North Canal Diversion Dam
Crooked River
Arthur R. Bowman Dam
Prineville Reservoir
Bend
Crater Cr
Crook County
Deschutes County
Crane Prairie Dam
Wickiup Dam
La Pine
Crescent Lake Dam
Crescent Cr
Little Deschutes
Klamath County
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DBHCP Covered Species

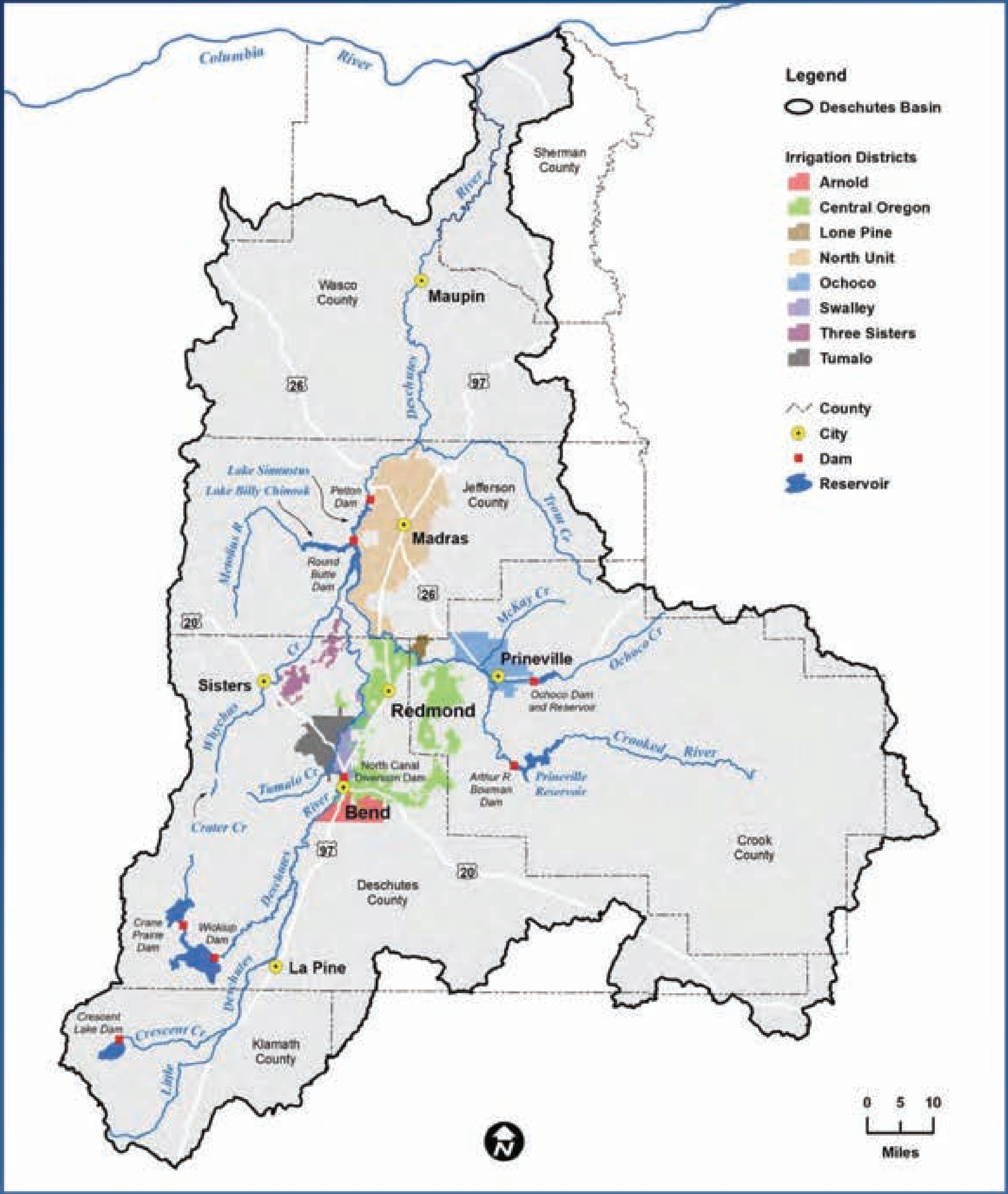
- Bull Trout
- Middle Columbia River Steelhead Trout
- Middle Columbia River Spring Chinook Salmon
- Deschutes River Summer/Fall Chinook Salmon
- Sockeye Salmon
- Oregon Spotted Frog

DBHCP Covered Activities

- Storage and Release of Irrigation Water
- Diversion of Irrigation Water
- Conveyance and Delivery of Irrigation Water
- Irrigation Return Flows
- Existing Hydropower
- City of Prineville Activities

Storage and Release of Water

- Five Main Storage Reservoirs
  - Crane Prairie Reservoir – Deschutes River; 4,900 acres
  - Wickiup Reservoir – Deschutes River; 11,200 acres
  - Crescent Lake Reservoir – Crescent Creek; 4,008 acres
  - Prineville Reservoir – Crooked River; 3,028 acres
  - Ochoco Reservoir – Ochoco Creek; 1,060 acres
- Reservoirs store water in fall, winter and early spring; and release water during irrigation season (Apr – Oct)



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Wickiup Reservoir

Ochoco Reservoir

Storage and Release of Water

- Four Reregulating Reservoirs
  - Haystack – North Unit Main Canal; 230 acres
  - Upper Tumalo – Tumalo Feed Canal; 165 acres
  - Watson – Whychus Creek Main Canal; 80 acres
  - McKenzie Canyon – Whychus Creek Main Canal; 12 acres
- Operated to buffer short-term fluctuations in demand

Diversion of Water

- 19 Primary Diversion Structures
  - Divert stored water and live (natural) flow
  - Screened to prevent entrainment where fish are present
  - Passage for upstream and downstream movement where fish are present

North Canal Dam (Deschutes River)

North Canal Dam (Deschutes River)

Tumalo Creek Diversion

Tumalo Creek Diversion

Red Granary Diversion (Ochoco Creek)

Red Granary Diversion (Ochoco Creek)

Whychus Creek Diversion

Whychus Creek Diversion

Diversion of Water

- 112 Pumps and Small Diversions
  - Most are owned and operated by patrons
  - Very small diversion rates
  - Most are currently unscreened

Crooked River Patron Pump

Crooked River Patron Pump

Conveyance and Delivery of Water

- Collectively over 1,170 miles of canals, ditches and pipelines
- Old canals are the focus of on-going water conservation projects
- District authority/responsibility ends at point of delivery to patron

Pilot Butte Canal

Pilot Butte Canal Piping Project

Lone Pine Pipe at Crooked River

Return Flows

- 46 identified points where irrigation water is returned to natural water body
  - Operational spills from canals
  - Surface runoff at downstream ends of Districts

Lone Pine Return to Crooked River

Juniper Canyon Return to Crooked River

Existing Hydropower

- Eight hydropower generators on existing canals
  - Siphon – Central Oregon Canal
  - Juniper Ridge – Pilot Butte Canal
  - Ponderosa – Swalley Main Canal
  - Mile 45 – North Unit Main Canal
  - Monroe Drop – North Unit Main Canal
  - Watson – Whychus Creek Main Canal
  - Watson Net Meter Micro – Whychus Creek Main Canal
  - McKenzie – Whychus Creek Main Canal

Example of Hydraulic Head on the Pilot Butte Canal

Juniper Ridge Hydroelectric Project

City of Prineville Activities

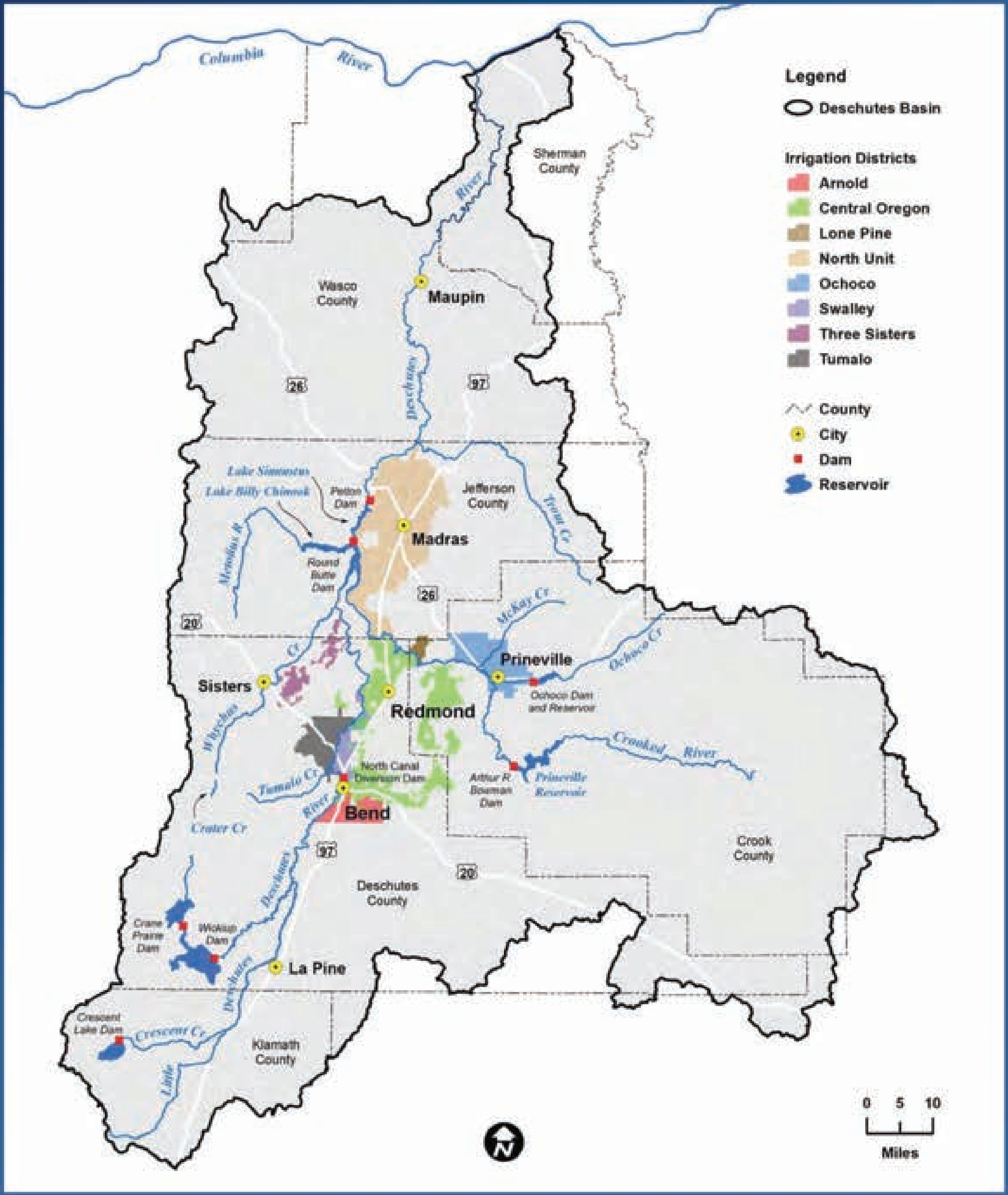
- Small diversions from Crooked River and Ochoco Creek (as OID patron)
- Groundwater pumping for municipal use
- Discharge of treated effluent to Crooked River

DBHCP Covered Lands

- Beds, banks and waters of the following:
  - Deschutes River (Crane Prairie Reservoir to mouth)
  - Crescent Creek (Crescent Lake Reservoir to mouth)
  - Little Deschutes River (Crescent Creek to mouth)
  - Tumalo Creek (lower 21.7 miles)
  - Whychus Creek (TSID Diversion to mouth)

DBHCP Covered Lands

- Crooked River (Prineville Reservoir to mouth)
- Ochoco Creek (Ochoco Reservoir to mouth)
- McKay Creek (Jones Dam to mouth)
- Lytle Creek (lower 5.7 miles)
- Trout Creek (Mud Springs Creek to mouth)
- Mud Springs Creek (lower 8 miles)



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20

Term of the DBHCP

- To be determined (20 – 50 years)

Need for the DBHCP

Effects of the Covered Activities on the Covered Species

Oregon Spotted Frog

- **Distribution on the Covered Lands**
  - Crane Prairie Reservoir
  - Wickiup Reservoir
  - Deschutes River (Wickiup to Bend)
  - Crescent Creek (downstream of Crescent Dam)
  - Little Deschutes River

Oregon Spotted Frog

- **Affected by:**
  - Fluctuation of reservoir levels
  - Seasonal high and low stream flows
  - Rapid changes in stream flow
  - All related to storage and release of irrigation water

Bull Trout

- **Distribution on the Covered Lands**
  - Deschutes River (upstream to Big Falls)
  - Whychus Creek (upstream to RM 2.4)
  - Crooked River (upstream to Opal Springs)

Bull Trout

- **Affected by:**
  - Flow reductions during summer (irrigation diversions) and winter (irrigation storage)

Steelhead Trout

- **Distribution on the Covered Lands (current and potential)**
  - Deschutes River (upstream to Big Falls)
  - Trout Creek and lower Mud Springs Creek
  - Whychus Creek (upstream to RM 37)
  - Crooked River (upstream to Bowman Dam)
  - Ochoco Creek (upstream to Ochoco Dam)
  - McKay Creek (upstream to RM 19)

Steelhead Trout

- **Affected by:**
  - Flow reductions during summer (irrigation diversions) and winter (irrigation storage)
  - Return flows

Chinook Salmon

- **Distribution on the Covered Lands (current and potential)**
  - Deschutes River (upstream to Big Falls)
  - Whychus Creek (upstream to RM 37)
  - Crooked River (upstream to Bowman Dam)

Chinook Salmon

- **Affected by:**
  - Flow reductions during summer (irrigation diversions) and winter (irrigation storage)
  - Return flows

Sockeye Salmon

- **Distribution on the Covered Lands (current and potential)**
  - Deschutes River (upstream to Big Falls)
  - Whychus Creek (upstream to RM 2.4)
  - Crooked River (upstream to Opal Springs)

Sockeye Salmon

- **Affected by:**
  - Flow reductions during summer (irrigation diversions) and winter (irrigation storage)

U.S. FISH & WILDLIFE SERVICE

DEPARTMENT OF THE INTERIOR

National Environmental Policy Act, the Endangered Species Act, and Habitat Conservation Plans

National Environmental Policy Act, the Endangered Species Act, and Habitat Conservation Plans

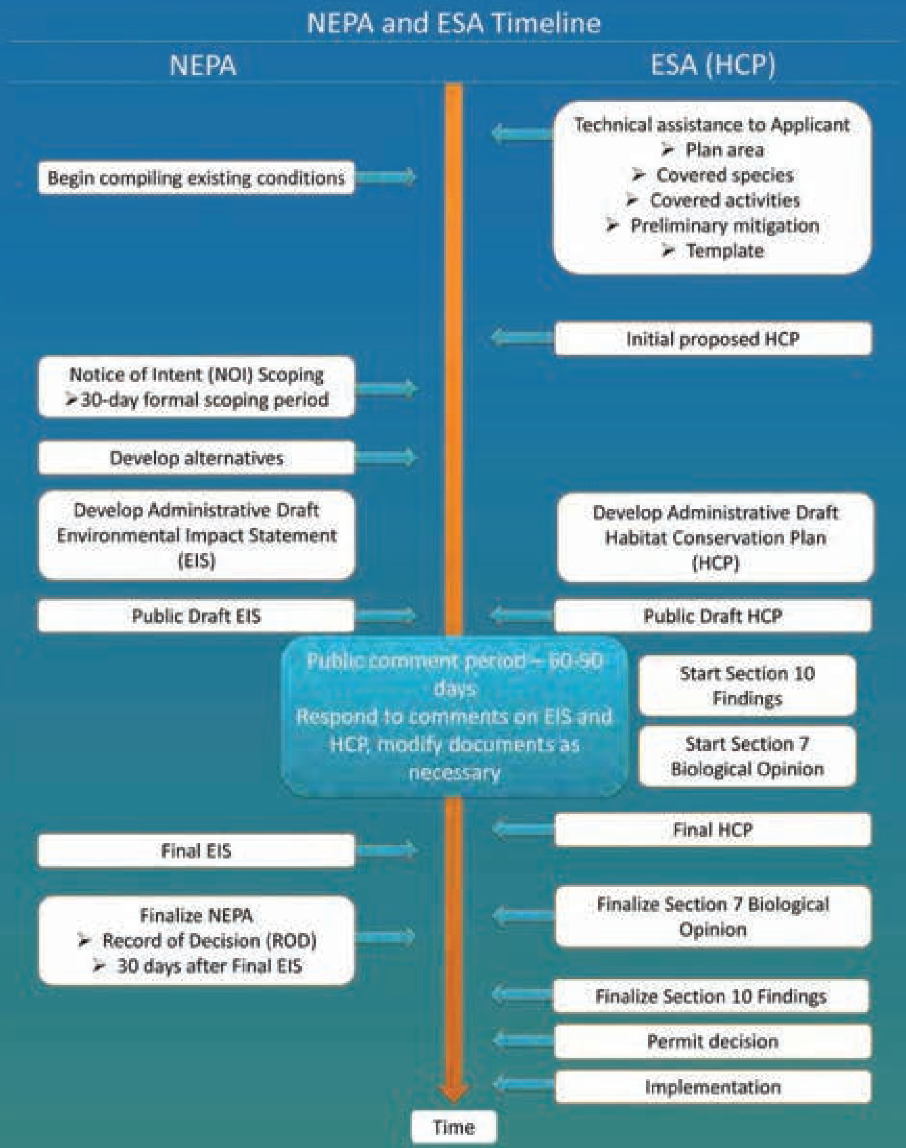
Why are we here?

- The DBBC and the City of Prineville are preparing a Habitat Conservation Plan (HCP) for several Deschutes River-dependent species.

- In response, USFWS will prepare an Environmental Impact Statement (EIS) under the National Environmental Policy Act (NEPA) for the HCP.

- Preparation of an EIS, triggers scoping.

ESA/NEPA Processes



Scoping

Why do Scoping?

- Scoping engages the public and asks for input
- The process identifies significant environmental issues for further analysis
- Other, less significant environmental issues, are identified but further analysis may not be necessary.

Scoping

- Get involved to help us identify important issues

- Give us your comments

  the public comment period goes through September 22, 2017

NEPA Options

	Categorical Exemption	Environmental Assessment	Environmental Impact Statement
Notice of Intent (NOI)	--	--	✓
Scoping	--	--	✓
Notice of Availability (NOA) of Draft HCP and Draft NEPA document	✓	✓	✓
Draft review period	30 days	30-60 days	60-90 days
Final document	--	Optional	✓
Responses to comments	--	Optional	✓
Final NOA	--	--	30 days
Decision document	Categorical Exclusion Questionaire	Finding of No Significant Impact (FONSI)	Record of Decision (ROD)

Scoping

We want comments on:

- Alternatives to the proposed action
- Measures to avoid, mitigate, or minimize effects
- Existing environmental conditions in the basin
- Permit duration
- Covered species and activities
- Biological goals and objectives of the HCP
- Any other significant issues

National Environmental Policy Act

The NEPA process:

- Is required for the Service to approve an Applicants' HCP.
- Helps the Service make decisions based on our understanding of the environmental consequences of approving the HCP.
- Is used to identify and take actions that protect, restore, and enhance the environment.
- Analyzes the effects of all the alternatives considered.

National Environmental Policy Act

NEPA considers the impacts of a federal action on elements of the human environment such as:

- water quality
- wetlands
- air quality
- socio-economic and cultural resources
- fish and wildlife species including ESA-listed

Environmental Impact Statement and Habitat Conservation Plans

The Service will prepare an EIS because the HCP is likely to:

- Cover a significant portion of the basin
- Cover multiple species and multiple activities
- Cover water management activities in the basin
- Affect the human environment and listed species

Environmental Impact Statement

What does an EIS include?

- Purpose and need for the action
- Alternatives (no action, proposed action, others)
- Affected environment
- Environmental effects of the alternatives
- Cumulative effects

Endangered Species Act

Endangered Species Act

Purpose

- To protect and recover imperiled species and the ecosystems upon which they depend.

Endangered Species Act

Species listed as endangered or threatened:

- '**Threatened**' means a species is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

- '**Endangered**' means a species is in danger of extinction throughout all or a significant portion of its range.

Endangered Species Act (ESA)

ESA protects endangered and threatened species and their habitats by prohibiting "take"

- **Take** means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or to attempt to engage in any such conduct."

Endangered Species Act (ESA)

- **Section 9 of the ESA** states it is unlawful for anyone to take endangered or threatened species.

However....

- **Section 10 of the ESA** allows incidental take of threatened and endangered species, if take occurs under an approved habitat conservation plan.

Habitat Conservation Plans

- Incidental Take refers to take that results from carrying out an otherwise lawful activity (for example, residential and commercial development, or road construction)

- A Habitat Conservation Plan is a voluntary plan developed by a non-Federal applicant
in order to receive an incidental take permit.

Habitat Conservation Plans

The Applicant's HCP must describe and include:

- Impacts likely to result from the taking of the species
- Measures the applicants will take to minimize and mitigate impacts
- Adequate funding to perform those measures
- Alternative actions that would not result in take and reasons those alternatives are not being used
- Additional measures as required by the Service

Habitat Conservation Plans

To approve the Applicant's HCP and issue an incidental take permit, the Service must determine:

- Taking is incidental
- The Applicants will, to the maximum extent practicable, minimize and mitigate the impacts of the taking
- The Applicants ensure adequate funding for the plan
- The taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild
- Any measures required by the Service will be met

Next Steps/Timeline

- NEPA Scoping
  -Public comment period ends 9/22/2017
- Draft EIS and draft HCP
  – Public comment period (2018)
- Final EIS and final HCP
  – Public comment period (2019)
- HCP Implementation

Contact Us

Send comments to:

Peter Lickwar peter_lickwar@fws.gov

More information:
http://bit.ly/DeschutesHCP

August 14-15, 2017

Appendix D
Scoping Meeting Materials

U.S. Fish & Wildlife Service

Deschutes River Basin

Habitat Conservation Plan (HCP)

Providing reliable water for farmers and residents in the Deschutes Basin while conserving fish, wildlife, and water resources for future generations.

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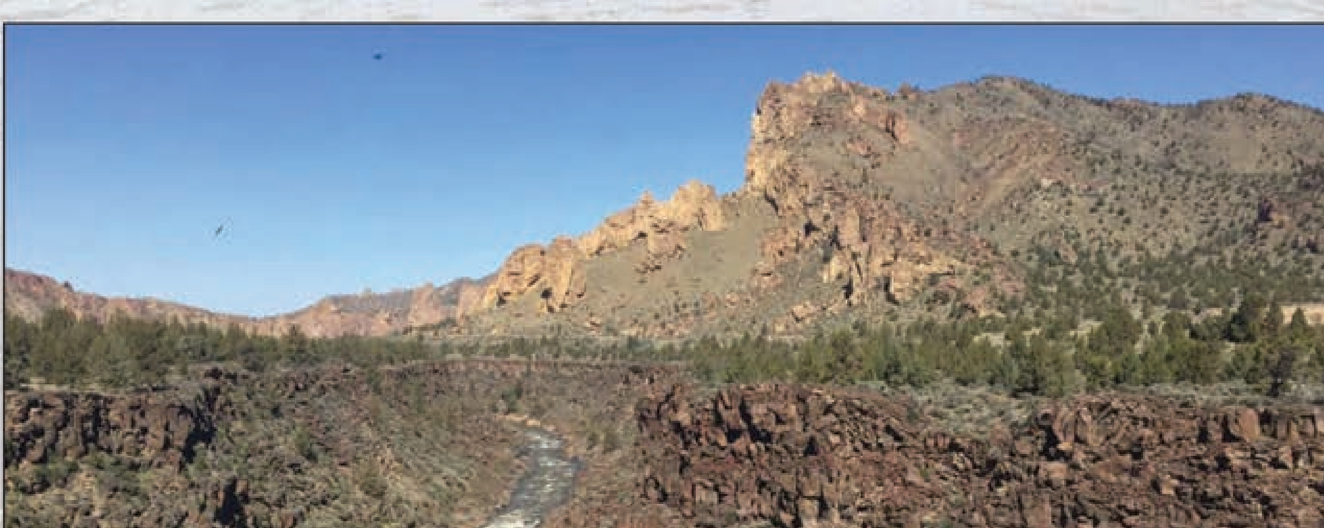

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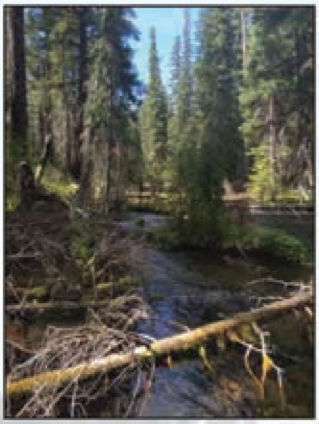

Bull trout habitat in the Deschutes River Basin (Credit: USFWS)

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HCPs can apply to both listed and non-listed species, including those that are candidates or have been proposed for listing. Conserving species before they are in danger of extinction or are likely to become so can also provide early benefits and prevent the need for listing.

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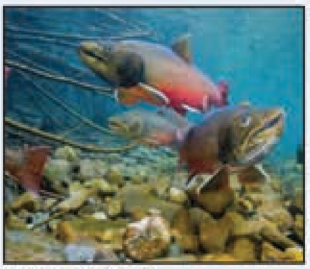

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Oregon spotted frog (Credit: T.Waterstrat/USFWS)

Upper Deschute River (Credit: B.Moran/USFWS)

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U.S. Fish & Wildlife Service

Habitat Conservation Plans Under the Endangered Species Act

John Cleckler/USFWS

The endangered California tiger salamander is among the listed species included in the East Contra Costa County Habitat Conservation Plan.

Introduction

Why should we save endangered species? Congress answered this question in the introduction to the Endangered Species Act of 1973 (Act), recognizing that endangered and threatened species of wildlife and plants "are of esthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its people."

After this finding, Congress said that the purposes of the Act are ". . . to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved [and] to provide a program for the conservation of such . . . species. . . ." Habitat Conservation Plans (HCPs) under section 10(a)(1)(B) of the Act provide for partnerships with non-Federal parties to conserve the ecosystems upon which listed species depend, ultimately contributing to their recovery.

What are HCPs?

HCPs are planning documents required as part of an application for an incidental take permit. They describe the anticipated effects of the proposed taking; how those impacts will be minimized, or mitigated; and how the HCP is to be funded.

HCPs can apply to both listed and nonlisted species, including those that are candidates or have been proposed for listing. Conserving species before they are in danger of extinction or are likely to become so can also provide early benefits and prevent the need for listing.

Who needs an incidental take permit?

Anyone whose otherwise-lawful activities will result in the "incidental take" of a listed wildlife species needs a permit. The U.S. Fish and Wildlife Service (FWS) can help determine whether a proposed project or action is likely to result in "take" and whether an HCP is needed. FWS staff can also provide technical assistance to help design a project to avoid take. For example, the project could be designed with seasonal restrictions on construction to minimize disturbance to a species.

What is the benefit of an incidental take permit and habitat conservation plan to a private landowner?

The permit allows the permit-holder to legally proceed with an activity that would otherwise result in the unlawful take of a listed species. The permit-holder also has assurances from the FWS through the "No Surprises" regulation.

What is "take"?

The Act defines "take" as ". . . to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." "Harm" includes significant habitat modification that actually kills or injures a listed species through impairing essential behavior such as breeding, feeding, or sheltering.

Section 9 of the Act prohibits the take of endangered and threatened species. The purpose of the incidental take permit is to exempt non-Federal permit-holders—such as States and private landowners— from the prohibitions of section 9, not to authorize the activities that result in take.

What do habitat conservation plans do?

In developing habitat conservation plans, people applying for incidental take permits describe measures designed to minimize and mitigate the effects of their actions— to ensure that species will be conserved and to contribute to their recovery.

Habitat conservation plans are required to meet the permit issuance criteria of section 10(a)(2)(B) of the Act:

- (i) taking will be incidental;
- (ii) the applicant will, to the maximum extent practicable, minimize and mitigate the impacts of the taking;

- (iii) the applicant will ensure that adequate funding for the plan will be provided;
- (iv) taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; and
- (v) other measures, as required by the Secretary, will be met.

What needs to be in HCPs?

Section 10 of the Act and its implementing regulations define the contents of HCPs. They include:

- an assessment of impacts likely to result from the proposed taking of one or more federally listed species.
- measures that the permit applicant will undertake to monitor, minimize, and mitigate for such impacts, the funding available to implement such measures, and the procedures to deal with unforeseen or extraordinary circumstances.
- alternative actions to the taking that the applicant analyzed, and the reasons why the applicant did not adopt such alternatives.
- additional measures that the Fish and Wildlife Service may require.

HCPs are also required to comply with the Five Points Policy by including:

1. biological goals and objectives, which define the expected biological outcome for each species covered by the HCP;
2. adaptive management, which includes methods for addressing uncertainty and also monitoring and feedback to biological goals and objectives;
3. monitoring for compliance, effectiveness, and effects;
4. permit duration which is determined by the time-span of the project and designed to provide the time needed to achieve biological goals and address biological uncertainty; and
5. public participation according to the National Environmental Policy Act.

What are "No Surprises" assurances?

The FWS provides "No Surprises" assurances to non-Federal landowners through the section 10(a)(1)(B) process. Essentially, State and private landowners are assured that if "unforeseen circumstances" arise, the FWS will not require the commitment of additional land, water, or financial compensation or additional restrictions on the use of land, water, or other natural resources beyond the level otherwise agreed to in the HCP without the consent of the permit-holder. The government will honor these assurances as long as permit-holders are implementing the terms and conditions of the HCPs, permits, and other associated documents in good faith. In effect, the government and permit-holders pledge to honor their conservation commitments.

Are incidental take permits needed for listed plants?

There are no Federal prohibitions under the Act for the take of listed plants on non-Federal lands, unless taking those plants is in violation of State law. However, the FWS analyzes the effects of the permit on listed plant species because section 7 of the Act requires that issuing an incidental take permit may not jeopardize any listed species, including plants. In general, it is a good idea to include conservation measures for listed plant species in developing an HCP.

What is the process for getting an incidental take permit?

The applicant decides whether to seek an incidental take permit. While FWS staff members provide detailed guidance and technical assistance throughout the process, the applicant develops an HCP and applies for a permit. The components of a completed permit application are a standard application form, an HCP, an Implementation Agreement (if applicable), the application fee, and a draft National Environmental Policy Act (NEPA) analysis. A NEPA analysis may result in a categorical exclusion, an environmental assessment, or an environmental impact statement.

While processing the permit application, the FWS prepares the incidental take permit and a biological opinion under section 7 of the Act and finalizes the NEPA analysis documents. Consequently, incidental take permits have a number of associated documents.

How do we know if we have listed species on our project site?

For assistance, check with the appropriate State fish and wildlife agency, the nearest FWS field office, or the National Marine Fisheries Service (NMFS), for anadromous fish such as salmon.

What kinds of actions are considered mitigation?

Mitigation measures are actions that reduce or address potential adverse effects of a proposed activity on species included in an HCP. They should address specific conservation needs of the species and be manageable and enforceable. Mitigation measures may take many forms, including, but not limited to, payment into an established conservation fund or bank; preservation (via acquisition or conservation easement) of existing habitat; enhancement or restoration of degraded or a former habitat; establishment of buffer areas around existing habitats; modifications of land use practices, and restrictions on access. Which type of mitigation measure used for a specific HCP is determined on a case by case basis, and is based upon the needs of the species and type of impacts anticipated.

What is the legal commitment of a HCP?

Incidental take permits make binding the elements of HCPs. While incidental take permits have expiration dates, the identified mitigation may be in perpetuity. Violating the terms of an incidental take permit may constitute unlawful take under section 9 of the Act.

Who approves an HCP?

The FWS Regional Director decides whether to issue an incidental take permit, based on whether the HCP meets the criteria mentioned above. If the HCP addresses all of the requirements listed above, as well as those of other applicable laws, the FWS issues the permit.

What other laws besides the Endangered Species Act are involved?

In issuing incidental take permits, the FWS complies with the requirements of NEPA and all other statutes and regulations, including State and local environmental/planning laws.

Who is responsible for NEPA compliance during the HCP process?

The FWS is responsible for ensuring NEPA compliance during the HCP process. However, if the Service does not have sufficient staff resources, an applicant may, within certain limitations, prepare the draft NEPA analysis. Doing so can benefit the applicant and the government by expediting the application process and permit issuance. In cases like this, the FWS provides guidance, reviews the document, and takes responsibility for its scope, adequacy, and content.

Does the public get to comment on our HCP? How do public comments affect our HCP?

The Act requires a 30-day period for public comments on applications for incidental take permits. In addition, because NEPA requires public comment on certain documents, the FWS operates the two comment periods concurrently. Generally, the comment period is 30 days for a Low Effect HCP, 60 days for an HCP that requires an environmental assessment, and 90 days for an HCP that requires an environmental impact statement. The FWS considers public comments in permit decisions.

What kind of monitoring is required for a HCP, and who performs it?

Three types of monitoring may be required: compliance, effectiveness, and effects. In general, the permit-holder is responsible for ensuring that all the required monitoring occurs. The FWS reviews the monitoring reports and coordinates with the permit-holder if any action is needed.

Does the Fish and Wildlife Service try to accommodate the needs of HCP participants who are not professionally involved in the issues?

Because applicants develop HCPs, the actions are considered private and, therefore, not subject to public participation or review until the FWS receives an official application. The FWS is committed to working with people applying for permits and providing technical assistance throughout the process to accommodate their needs.

However, the FWS does encourage applicants to involve a range of parties, a practice that is especially valuable for complex and controversial projects. Applicants for most large-scale, regional HCPs choose to provide extensive opportunities for public involvement during the planning process. Issuing permits is, however, a Federal action that is subject to public review and comment. There is time for such review during the period when the FWS reviews the information. In addition, the FWS solicits public involvement and review, as well as requests for additional information during the scoping process when an EIS is required.

Are independent scientists involved in developing an HCP?

The views of independent scientists are important in developing mitigation and minimization measures in nearly all HCPs. In many cases, applicants contact experts who are directly involved in discussions on the adequacy of possible mitigation and minimization measures. In other cases, the FWS incorporates the views of independent scientists indirectly through their participation in listing documents, recovery plans, and conservation agreements that applicants reference in developing their HCPs.

How does the FWS ensure that species are adequately protected in HCPs?

The FWS has strengthened the HCP process by incorporating adaptive management when there are species for which additional scientific information may be useful during the implementation of the HCP. These provisions allow FWS and NMFS to work with landowners to reach agreement on changes in mitigation strategies within the HCP area, if new information about the species indicates this is needed. During the development of HCPs, the FWS and NMFS discuss any changes in strategy with landowners, so that they are aware of any uncertainty in management strategies and have concurred with the adaptive approaches outlined.

What will the FWS do in the event of unforeseen circumstances that may jeopardize the species?

The FWS will use its authority to manage any unforeseen circumstances that may arise to ensure that species are not jeopardized as a result of approved HCPs. In the rare event that jeopardy to the species cannot be avoided, the FWS may be required to revoke the permit.

How can I obtain information on numbers and types of HCPs?

Our national HCP database displaying basic statistics on HCPs is available online from our Habitat Conservation Planning page at http://ecos.fws.gov/conserv_plans/servlet/gov.doi.hcp.servlets.PlanReportSelect?region=9&type=HCP.

U. S. Fish and Wildlife Service
Endangered Species Program
4401 N. Fairfax Drive, Room 420
Arlington, VA 22203
703-358-2171
http://www.fws.gov/endangered/what-we-do/hcp-overview.html

April 2011

Appendix E

Agency and Tribal Cooperating Agency Letters

Weidner , Emily <emily_weidner@fws.gov>

Fwd: Scoping comments

1 message

Lickwar , Peter <peter_lickwar@fws.gov> Mon, Sep 25, 2017 at 9:27 AM
To: Emily Weidner <emily_weidner@fws.gov>

---------- Forwarded message ----------
From: LAMB Bonnie <bonnie.lamb@state.or.us>
Date: Fri, Sep 22, 2017 at 2:11 PM
Subject: Scoping comments
To: "Lickwar, Peter" <peter_lickwar@fws.gov>

Hi Peter – Here are DEQ's comments on the Deschutes HCP scoping process. Thanks for the opportunity to provide comments.

Bonnie

Bonnie Lamb

DEQ Basin Coordinator

475 NE Bellevue Dr., Suite 110

Bend, OR 97701

(541) 633-2027

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Peter Lickwar
USFWS Bend, Oregon
Phone 541-383-7146

DEQ EIS Scoping Comments 092217.pdf
1607K

Oregon

Kate Brown, Governor

Department of Environmental Quality
Eastern Region Bend Office
475 NE Bellevue Drive, Suite 110
Bend, OR 97701
(541) 388-6146
FAX (541) 388-8283
TTY 711

Date: September 22, 2917

To: Peter Lickwar

From: Bonnie Lamb

Re: Deschutes River Basin HCP Scoping

DEQ would like to offer the following comments for your consideration as the EIS and draft HCP are further developed. I provided extensive comments during the period 2012-2014 when I was involved in stakeholder and technical working groups. I trust that these earlier comments will be reviewed as well. I provided specific comment letters on Tasks 3-6 (June 28, 2012) and on Chapter 5 (November 20, 2014). In addition, I submitted "track changes" and/or email comments on many of the different Tasks and Chapters, including: Table A-2, Study 15 (Phases 1 and 2), Study 2 (Phases 1- 3), and Studies 3-6 (Phase 2). I have attempted to summarize some of these comments here, but not with the level of detail that I provided earlier. I can provide you with copies of my earlier comments if you do not have them in your files.

1. Most of the water bodies identified as part of the Plan Area are included on Oregon's 303(d) list of impaired water bodies for one or more of the following parameters: temperature, dissolved oxygen, pH, chlorophyll-*a*, turbidity, sedimentation, aquatic weeds/algae, *E. coli*, total dissolved gas, biological criteria, flow modification, habitat modification. Resident fish and aquatic life are identified as beneficial uses impacted by all of these parameters, with the exception of *E. coli* and aquatic weeds/algae.

   We have not completed Total Maximum Daily Loads, which would identify causes of the impairments, for any of these listings. However, based on preliminary modeling done in the Deschutes Basin as well as in other parts of the state, it is very likely that some of the covered activities could contribute to the impairments. The EIS and HCP should address the effects of the covered activities on known water quality impairments and indicate how proposed conservation measures will contribute to attainment of water quality standards. While not exhaustive, the following list describes some of the potential impacts of covered activities:

   - Irrigation return flows can contribute pollutants, including heat, nutrients, pathogens (including fish pathogens such as *C. shasta)*, sediments/turbidity, and pesticides, to water bodies which support listed species. These pollutants can in turn affect in-stream temperature, pH, dissolved oxygen, growth of aquatic plants or algae, and fish health.
   - Diversion of water and reduced flows below the point(s) of diversion can contribute to a number of water quality impairments, including temperature, dissolved oxygen, pH, chlorophyll-a, growth of aquatic weeds or algae, and biological criteria.
   - The storage of water in reservoirs can affect the quality of the water. By impounding water, conditions can be created which lead to the growth of aquatic weeds and algae and/or contribute to water quality impairments for dissolved oxygen, pH or temperature. Algal blooms have been documented in most of the reservoirs covered by the Plan. In addition, storage of water during the non-irrigation season results in reduced flows below the reservoir, which can expose stream banks to freeze-thaw processes.

- The timing and release of water from reservoirs can contribute to water quality impairments downstream in a number of ways: (1) impairments in the reservoirs (or constituents that contribute to impairment, such as nutrients) can be passed downstream; (2) increased flows below reservoirs early in the irrigation season can transport sediment downstream from stream banks which were exposed to freeze-thaw processes during the winter; (3) below Wickiup and Prineville Reservoirs, studies have demonstrated elevated total dissolved gas levels (exceeding state standards) at high flow release levels and ODFW has documented the presence of bubble-gas disease in fish in the Crooked River below Prineville Reservoir.
- The activities of the City of Prineville have the potential to affect water quality in Ochoco Creek and Crooked River through possible reductions in stream flow (diversions and groundwater pumping) and discharge of treated wastewater to the Crooked River.

2. During the earlier development of the HCP, the Bureau of Reclamation was contracted to do a review of existing water quality data in the Deschutes Basin (Phase 1 for Studies 3-6, dated March 2013). I reviewed that document and provided a number of comments. I would encourage you to look at these comments, as I am not going to repeat them all here. While the report provided a good start at compiling existing data, it missed quite a bit of data that I knew about. And there has been a quite a bit more data collected since that time, including some TMDL studies in the Upper and Little Deschutes Subbasins and toxics monitoring throughout the basin. In addition, DEQ's Pesticide Stewardship Program began a pilot monitoring program in the Agency Plains area in 2014. Data from this effort could inform the discussion of water quality associated with return flows. Let me know if you would like assistance accessing any of DEQ's data.
3. While I recognize the importance of developing conservation measures to protect the Oregon spotted frog, I would encourage the USFWS to pay equal attention to the habitat and water quality needs of the listed and non-listed fish species that will be covered by this HCP in the middle Deschutes reach above Lake Billy Chinook. While these fish cannot pass up the Deschutes River beyond Big Falls, the flow and water quality impacts of water management activities in and upstream of Bend can be seen in the Deschutes River downstream of Big Falls. Restoring flows in the middle Deschutes is also important for protecting non-listed resident aquatic species.
4. Groundwater discharge through springs along lower Whychus Creek, lower Crooked River and the lower portion of the middle Deschutes River provides a significant source of water to these reaches. In most cases this water provides important cold water habitat for aquatic species. Given the relationship between leaking canals and groundwater discharge above Lake Billy Chinook, it is likely that conservation measures (such as piping canals) will reduce spring flow. The EIS and HCP should model these impacts and develop appropriate mitigation measures, recognizing that leaving an additional 5 cfs of water instream at the point of diversion does not have the same water quality benefits as 5 cfs of spring water.
5. In September, 2014, Conservation Measures were presented to the HCP Working Group in a draft Chapter 5. In this draft, it was unclear what the biological or ecological goals of the proposed measures were. As Conservation Measures are developed through this current EIS/HCP effort, they should be developed to ensure that the biological needs of the covered species are met. This could include quantifying the amount of habitat provided and/or improvements in water quality.
6. Given the complexity of water management in the Deschutes Basin and the limitations of models, it will be very important to have an adequate monitoring program in place to evaluate the impacts of the covered activities and proposed conservation measures over time. For water quality, DEQ maintains a network of long-term ambient monitoring stations in the Deschutes Basin. While this information will be helpful, there are not enough of these stations and they are not monitored frequently enough to be used in understanding the effects of activities covered under the HCP. As part of their monitoring responsibilities under the HCP, the applicants should commit to contributing to the development of a more comprehensive water quality monitoring program in the Plan Area. A number of entities have expressed interest in having

such a monitoring program in place and DEQ will be glad to assist with development of a monitoring strategy.

7. While likely outside of the scope of the HCP, DEQ staff wanted to identify two other potentially related water quality issues.
   - Water quality standards and beneficial uses apply to the canals. Irrigation canals are subject to NPDES permits.
   - The covered activities have the potential to affect local drinking water sources. For reference, the only public water system using surface water within the Plan Area is the City of Bend which has an intake on Bridge Creek. (City of Sisters has an intake on Pole Creek in the Whychus Creek Watershed, however the source is currently listed as inactive/emergency.) There are ~250 federally recognized public water systems using groundwater in the Plan Area. At least 12 community water systems, including the Cities of Bend and Prineville as well as Deschutes Valley Water District, have wells within 500 feet of the covered lands. Wells within 500 feet of surface water are typically flagged by the Oregon Health Authority for potential hydraulic connection to the surface water body. Additional information on public water supply locations can be provided if needed.

As you are well aware, many of the water management changes that will be considered in the EIS/HCP process are also being evaluated as part of the on-going Deschutes Basin Study. I would encourage you to utilize the results of the Basin Study to help inform the Deschutes River Basin HCP.

Please feel free to contact me if you have any questions about these comments. I can be reached at lamb.bonnie@deq.state.or.us or (541) 633-2027. Thank you for the opportunity to provide comments.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue, Suite 900
Seattle, WA 98101-3140

OFFICE OF
ENVIRONMENTAL REVIEW
AND ASSESSMENT

September 21, 2017

Peter Lickwar
U.S. Fish and Wildlife Service
Bend Field Office
63095 Deschutes Market Road
Bend, OR 97701-9857

Dear Mr. Lickwar:

The EPA has reviewed the July 24, 2017 Federal Register Notice of Intent from the US Fish and Wildlife Service to prepare a Draft Environmental Impact Statement for the Proposed Deschutes River Basin Habitat Conservation Plan in Oregon (EPA Project Number 17-0034-FWS). Our comments are in accordance with EPA responsibilities under the National Environmental Policy Act and Section 309 of the Clean Air Act. Section 309 specifically directs the EPA to review and comment in writing on the environmental impacts associated with all major federal actions.

The Deschutes River Basin HCP is being prepared in response to a request for incidental take permits under the Endangered Species Act. ITPs under the ESA would authorize the incidental take of federally-listed species caused by permitted activities (i.e., the storage, release, diversion and return of irrigation water). Species proposed for inclusion in the HCP include three federally-listed species (Oregon spotted frog, bull trout, and steelhead) and two currently unlisted species that have the potential to become listed during the life of the HCP (sockeye salmon and spring Chinook salmon). The potential applicants for the ITPs include the Irrigation Districts that comprise the Deschutes Basin Board of Control: the Arnold Irrigation District, Central Oregon Irrigation District, North Unit Irrigation District, Ochoco Irrigation District, Swalley Irrigation District, Three Sisters Irrigation District, Tumalo Irrigation District, the Lone Pine Irrigation District, and the City of Prineville.

According to the NOI, the EIS will evaluate a no action alternative; the proposed action, which would include the issuance of take authorizations as described in the proposed HCP; and a range of additional reasonable alternatives. As the EIS is developed, we encourage the Service to develop materials (especially web-based materials) to help the public and decision-makers understand and engage in dialogue about these alternatives. We also stress the importance of structuring the alternatives analysis so that components of individual alternatives can be extracted or incorporated as appropriate in the Final EIS. It should be possible for a hybrid alternative to emerge through the planning process, so long as it is within the spectrum of the alternatives analyzed in the Draft EIS.

We commend the parties to the HCP for their recognition of the value and importance of aquatic habitats in the Deschutes Basin and for their proactive efforts to conserve them. We also appreciate the DBBC's support, along with that of the Bureau of Reclamation, of the Deschutes Basin Study Work Group. This work will be foundational to a robust analysis of HCP alternatives through the NEPA process.

Because the available scoping materials do not lay out specific alternative directions, it is difficult to offer detailed comments or suggestions on how alternatives might be modified. Our attached comments do, however, make suggestions related to providing an adequate range of alternatives and highlight key issues that we recommend be addressed as the EIS is developed. We appreciate the opportunity to participate early in the planning process. If you would like to discuss these comments, please contact me at (503) 326-2859 or by electronic mail at kubo.teresa@epa.gov.

Sincerely,

Teresa Kubo
Office of Environmental Review and Assessment

Enclosure:

1. EPA Region 10 Scoping Comments on the NOI to Prepare a Draft Environmental Impact Statement for the Deschutes River Basin Habitat Conservation Plan

EPA Region 10 Scoping Comments on the NOI to Prepare a Draft Environmental Impact Statement for the Deschutes River Basin Habitat Conservation Plan (HCP)
September 21, 2017

Range of Alternatives
EISs should include a range of alternatives, which meet the stated purpose and need, goals and objectives, and responds to issues identified during the scoping process. The alternatives analysis should compare alternatives with respect to how well they respond to the stated purpose and need, goals and objectives, and scoping issues.

The Council on Environmental Quality recommends that all reasonable alternatives be considered, even if some of them could be outside the capability of the applicant or the jurisdiction of the agency preparing the EIS.[1]

In the interest of providing an adequate range of alternatives, we recommend the inclusion of a conservation alternative, as well as an alternative that would emphasize meeting municipal and agricultural needs. We recommend the conservation alternative broadly seek to maximize habitat protection and restoration and include the following considerations:

- Stream flows in the Upper Deschutes that mimic the natural hydrograph of the river. In the Upper Deschutes that would mean higher winter flows and lower summer flows. This would require flow modification at Wickiup, Crane Prairie and Crescent reservoirs, as well as conservation actions by the relevant irrigation districts;
- Increasing Deschutes River flows in the Middle Deschutes from the current protected flow of 134 cfs to the instream flow target of 250 cfs and increasing stream flow in Tumalo Creek from the current protected flow of 17.2 cfs to 54 cfs. Multiple lines of evidence show reduced stream temperatures at higher stream flows would be achieved through stream flow restoration in the middle Deschutes River and Tumalo Creek;[2]
- Required minimum flows in the Crooked River (as determined by the relevant regulatory agencies) during periods of drought;
- The inclusion of shaping flows during reservoir storage season (March 1 – April 15) to improve Oregon Spotted Frog (OSF) breeding conditions and limit the potential for egg desiccation; and,
- Opportunities for habitat restoration (consider opportunities on Forest Service land such as Ryan Ranch; areas around Wickiup Reservoir that could be physically modified to improve or create habitat; opportunities on private land; opportunities on BLM land, such as the Casey Tract on the Little Deschutes),

Water Quality
Water quality degradation is one of EPA's primary concerns. We recommend that the EIS disclose which waters may be impacted by the proposed HCP, the nature of the potential impacts, and the specific pollutants likely to impact those waters. It should also report those waterbodies potentially affected by the project that are listed on the State's most current EPA-approved 303(d) list of impaired waters. The EIS should describe any existing restoration and enhancement efforts for those waters, and

[1] http://ceq.hss.doe.gov/NEPA/regs/40/1-10.HTM#2
[2] http://www.upperdeschuteswatershedcouncil.org/wp-content/uploads/2016/12/2015-Middle-Deschutes-River-Instream-Flow-Restoration-and-Temperature-Response_FINAL.pdf

how the project will coordinate with Oregon DEQ as they develop TMDLs for the rivers and streams in the Upper Deschutes and Little Deschutes sub-basins. The EIS should also describe on-going protection efforts, and any mitigation measures that will be implemented to avoid further degradation of water quality within impaired waters. The state designates, and EPA approves, the applicable beneficial uses and associated criteria for protecting surface waters. These, combined with anti-degradation provisions, are considered the state water quality standards. The anti-degradation provision of the CWA and State of Oregon WQS apply to those waterbodies where WQS are currently being met. This provision prohibits degrading the water quality unless a robust analysis shows that important economic and social development necessitates some degradation. The EIS evaluation should determine and discuss how the antidegradation provisions of the CWA and Oregon WQS would be met. See 40 CFR 131, as well as the State of Oregon WQS, for more information regarding beneficial uses, water quality criteria, and antidegradation policies and procedures.

Align Conservation Efforts with Current Landscape-Level Strategies
We support and encourage partnerships among federal, state, local, and non-governmental entities to strategically and collaboratively conserve, restore, and maintain aquatic and wetland habitat. We recommend that strategic efforts include the following:

- Identify and prioritize the largest, most intact habitat patches;
- Identify and establish corridors/connections between and among habitat patches;
- Provide redundancy of habitats in the landscape;
- Identify and protect important refugia and biodiversity hotspots for wetland dependent plant and animal species;
- Restore degraded habitats, particularly those with the greatest potential for restoration and for meeting landscape-level conservation strategies;
- Seek to complement, augment, and connect with the important conservation work occurring within the planning area (such as at Ryan Ranch);
- Seek management agreements with landowners of working lands that contain remnant and/or high quality habitat; and,
- Provide incentives to landowners to retain and maintain wetland habitats and to have compatible land uses.

Active Management to Restore and Maintain Aquatic Habitats in the Deschutes Basin.
Management activities, such as aquatic habitat and wetland restoration, the construction of cattle exclosure fencing, and the removal and control of invasive species will be an important component of species protection and recovery. These actions need to be legal, feasible with respect to cost/funding and logistics, and reasonably acceptable to jurisdictions, landowners, and neighbors. We support the inclusion of active management, as proposed above, among the covered activities.

Climate Considerations
The EIS should disclose the extent to which the HCP and potential issuance of an ITP would incorporate consideration of future climate. It is projected that the Pacific Northwest could see rising stream temperatures, which are expected to reduce cold-water fisheries habitat; changes in the timing and length of seasons, which would influence changes in the ranges, phenology, community composition, biotic interactions and behavior of plants, insects, and animals (including predatory species); and increased winter rainfall, which will be accompanied by a reduction in snow pack, earlier snowmelts,

and increased runoff. This will affect hydrology and reservoir operation, as well as the potential timing and intensity of wildfire. The EIS should discuss the relevant potential effects of predicted future climate scenarios on the proposed actions, and how the HCP and ITP(s) would incorporate mitigation, adaptation, and education measures.

Monitoring and Adaptive Management

Monitoring and adaptive management will be critical to the success of the HCP. We recommend that adaptive management plans include:

- A timeline for periodic reviews and adjustments, as well as a mechanism to consider and implement additional mitigation measures, as necessary;
- Specific thresholds that would trigger changes in management actions, monitoring or mitigation;
- Criteria for determining whether additional mitigation measures are needed; and,
- A commitment to implementation of the proposed monitoring plan.

Ecosystem Services

The HCP's effects on ecosystem services, both positive and negative, should be analyzed and disclosed in the EIS. Of key importance in this context is the role of salmon as a provisioning species. Salmon produce highly valued food products harvested in various commercial, subsistence, and personal-use fisheries across the North Pacific. Salmon are also a principal focus of the spiritual and cultural lives of diverse native communities in the Pacific Northwest.

Salmon and steelhead also provide many ecosystem supporting services. Salmon are the principal food item of many terrestrial wildlife species[3,4] and a source of marine-derived nutrients to coastal lakes and streams[5,6,7]. They also act as watershed engineers that structure streambed habitats and alter sediment composition during spawning[8]. We recommend that these services be acknowledged, accounted for using quantitative (where feasible) or qualitative means, and fully considered in decision making.

This analysis should include the following elements,[9] which are basic tenets of the NEPA process:

- Describe the Federal action;
- Identify and classify key ecosystem services in the location of interest, i.e., the affected environment;
- Assess the impact of the Federal action on ecosystem services relative to the baseline;
- Assess the effect of the changes in ecosystem services associated with the Federal action; and
- Integrate ecosystem services analyses into decision making.

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[3] Willson, M. F., and K. C. Halupka. 1995. Anadromous fish as keystone species in vertebrate communities. *Conservation Biology* 9(3):489–497.

[4] Merz, J. E., and P. B. Moyle. 2006. Salmon, wildlife, and wine: marine-derived nutrients in human-dominated ecosystems of central California. *Ecological Applications* 16(3):999–1009.

[5] Bilby, R. E., Fransen, B. R., and P. B. Bisson. 1996. Incorporation of nitrogen and carbon from spawning coho salmon into the trophic system of streams: evidence from stable isotopes. *Canadian Journal of Fisheries and Aquatic Sciences* 53:164–173

[6] Cederholm, C. J., M. D. Kunz, T. Murota, and A. Sibatani. 1999. Pacific salmon carcasses: essential contributions of nutrients and energy for aquatic and terrestrial ecosystems. *Fisheries* 24:6–15.

[7] Finney, B. P., I. Gregory-Eaves, J. Sweetman, M. S. V. Douglas, and J. P. Smol. 2000. Impacts of climate change on Pacific salmon abundance over the past 300 years. *Science* 290:795–799.

[8] Schindler, D. E., M. D. Scheuerell, J. W. Moore, S. M. Gende, T. B. Francis, and W. J. Palen. 2003. Pacific salmon and the ecology of coastal ecosystems. *Frontiers in Ecology and the Environment* 1(1):31–37.

[9] http://www2.epa.gov/eco-research/ecosystems-services

Cumulative Impacts
Cumulative impacts result when the effects of an action are added to other effects on a resource in a particular place and within a particular time. It is the combination of these effects, and any resulting environmental degradation, that should be the focus of cumulative impact analysis.

In analyzing the HCP alternatives, we recommend the EIS characterize resources, ecosystems and communities in terms of their response to change and capacity to withstand stresses. The EIS should focus on resources which are "at risk" or have the potential to be significantly impacted under the various alternatives.

The EPA has issued guidance on how we are to provide comments to lead federal agencies on the assessment of cumulative impacts in Draft EISs, Consideration of Cumulative Impacts in EPA Review of NEPA Documents, which can be found on the EPA's web site at: https://www.epa.gov/nepa/cumulative-impacts-guidance-national-environmental-policy-act-reviews. The guidance states that in order to assess the adequacy of the cumulative impacts assessment, five key areas should be considered. The EPA tries to assess whether the cumulative effects analysis:

(1) Identifies resources, if any, that are being cumulatively impacted;
(2) Determines the appropriate geographic area (within natural ecological boundaries) and the time period over which the effects have occurred and would occur;
(3) Describes a benchmark or baseline;
(4) Looks at all past, present, and reasonably foreseeable future actions that have affected, are affecting, or would affect resources of concern; and,
(5) Includes scientifically defensible threshold levels.

Coordination with Tribal Governments
Development of the EIS should be conducted in consultation with all affected tribal governments, consistent with Executive Order 13175 (Consultation and Coordination with Indian Tribal Governments). The EIS should discuss whether or not the proposed project would affect tribal natural and/or cultural resources and address any concerns of the tribes in accordance with federal tribal trust responsibilities.

NPS Comments on Deschutes River Basin HCP

Lee Kreutzer: LKreutzer@nps.gov 8/4/2017

Thank you for this opportunity to participate in scoping for the Deschutes River Basin Habitat Conservation Plan. This office of the National Park Service, National Trails Intermountain Region, administers the Oregon National Historic Trail (NHT). We ask the Fish and Wildlife Service to determine whether the NHT falls within the area of potential effect for this undertaking, and if so, if the undertaking has potential to affect the NHT. Please add this office to the contact list for the planning process. Our point of contact will be Lee Kreutzer, Cultural Resources Specialist, who can be reached via email at Lee_Kreutzer@nps.gov and by phone at 801-741-1012 ext 118.

Weidner , Emily <emily_weidner@fws.gov>

Fwd: ODFW Deschutes River Basin HCP - draft EIS Comments

1 message

Lickwar , Peter <peter_lickwar@fws.gov> Mon, Sep 25, 2017 at 9:29 AM
To: Emily Weidner <emily_weidner@fws.gov>

---------- Forwarded message ----------
From: Ted Wise <ted.g.wise@state.or.us>
Date: Fri, Sep 22, 2017 at 7:50 PM
Subject: ODFW Deschutes River Basin HCP - draft EIS Comments
To: "Lickwar, Peter" <peter_lickwar@fws.gov>
Cc: Brett Hodgson <brett.l.hodgson@state.or.us>

Dear Mr. Lickwar:

Attached is the September 22, 2017 Oregon Department of Fish and Wildlife Deschutes River Basin HCP - draft EIS Comment Letter.

Should you have any questions on our comments please don't hesitate to call or email.

Thank-you.

- Ted W.

****

Ted Wise

Oregon Department of Fish & Wildlife

East Region Hydropower Coordinator

61374 Parrell Road

Bend, Oregon 97702

Email: ted.g.wise@state.or.us

Office Phone: 541-633-1115

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Peter Lickwar

USFWS Bend, Oregon
Phone 541-383-7146

ODFW Comments _ DBHCP EIS Scoping 9-22-17.pdf
185K

Oregon
Kate Brown, Governor

Department of Fish and Wildlife
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September 22, 2017

Peter Lickwar
United States Fish and Wildlife Service
U.S. Fish and Wildlife Service, Bend Field Office
63095 Deschutes Market Road,
Bend, OR 97701

Subject: ODFW Comments for the 2017 Deschutes River Basin Habitat Conservation Plan - draft EIS Scoping Process

Dear Peter:

Please accept the Oregon Department of Fish & Wildlife (ODFW) comments for the Deschutes River Basin Habitat Conservation Plan (DBHCP) - draft Environmental Impact Statement (EIS).

These comments serve as part of ODFW's continued DBHCP involvement including previously submitted remarks pertinent to the draft Chapter 5 DBHCP document detailing proposed mitigation measures released in August of 2014 by the "potential applicants for the ITP(s) including the City of Prineville and members of the Deschutes Basin Board of Control (i.e., Arnold, Central Oregon, North Unit, Ochoco, Swalley, Three Sisters, Tumalo, and Lone Pine Irrigation Districts in Oregon), collectively hereafter referred to as the Applicant. Our comments detail information and analysis that ODFW feels is important to be included as part of the 2017 DBHCP draft EIS scoping process. The lack of detailed species biological information and the generalized description of the Applicant's operations makes it challenging to provide more than cursory comments at this time. ODFW's comments contained herein at this initial stage, therefore are general in scope and are presented based on the understanding that as more information, including alternatives, are developed further, additional input from our agency will be provided. A comprehensive and thorough description and analysis of the impacts and the effects and any proposed mitigation actions for, and through, the DBHCP EIS is profoundly important to the aquatic habitats and listed species for which the Applicants are requesting Incidental Take Coverage.

ODFW appreciates the opportunity to provide input on the proposed HCP EIS and is hopeful that through continued effort, a sustainable habitat conservation plan beneficial to fish and wildlife species and the Applicant will emerge. ODFW is committed to providing input and working with the United States Fish and Wildlife Service, National Marine Fisheries Service and the Applicant in the effort to craft a DBHCP that appropriately provides for the habitat considerations of those species for which Incidental Take Coverage is being sought. Should you have any questions pertaining to these comments please do not hesitate to contact me.

Sincerely,

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COMMENTS OF OREGON DEPARTMENT OF FISH AND WILDLIFE ON DESCHUTES BASIN MULTI-SPECIES HABITAT CONSERVATION PLAN – DRAFT ENVIRONMENTAL IMPACT STATEMENT

The stated action for this particular draft Environmental Impact Statement (EIS) scoping is the issuance of an Incidental Take Permit(s) (ITP) for a proposed Deschutes Basin Multi-species Habitat Conservation Plan (DBHCP). The ITP is to provide coverage from incidental take for four salmonid fishes and one amphibian. The Mid-Columbia Summer Steelhead Trout (*Oncorhynchus mykiss*) and Bull Trout (*Salvelinus confluentus*) are currently federally listed threatened and endangered species. The other two salmonids which are proposed for coverage are Chinook Salmon (*Oncorhynchus tshawytscha*) and one population of Sockeye Salmon/Kokanee (*Oncorhynchus nerka)*. One federally listed threatened and endangered amphibian is to be covered – the Oregon spotted frog (*Rana pretiosa*).

Oregon Department of Fish & Wildlife Summary Comments

- Detailed information should be included in the DBHCP/EIS document pertaining to a thorough understanding of the habitats and life histories of all the species for which Incidental Take Coverage is being sought.

- The Applicant and United States Fish and Wildlife Service (USFWS) should provide the information necessary to allow a comprehensive review of the Oregon Spotted Frog (OSF) needs in conjunction with the biological/habitat needs of the other species in the upper Deschutes River reaches. This includes the need for a better understanding of the stream flow needs as related to the aquatic, riparian and wetland habitats.

- In respect to the duration of the proposed ITP, it is important that advantages and disadvantages of a range of timeframes be thoroughly analyzed. This should include timeframes of 5,10,15, 20 and 25 years.

- The length of the issued ITP is important to consider in respect to the limitations of models used to analyze such considerations such as climate change and in respect to limitations presented by the available information for each species as affected by the Applicant's operations.

- The analysis of the appropriate length of the ITP should include ability of Applicant's ability to fund the necessary mitigation measures.

- The analysis of the term of the ITP should be based on the flexibility of using an adaptive management model that allows timely and appropriate adjustments to management actions, during the life of the permit. The more difficult it is to make effective and timely adjustments to the issued DBHCP ITP, the shorter the duration of the ITP should be.

- The DBHCP EIS should include an analysis of the instream flow necessary in the Deschutes River, Whychus Creek and Crooked River to support quality habitat conditions for all life stages of the species for which "incidental take coverage" is being requested. Analyzed instream flow scenarios for those areas affected by the Applicants' activities and infra-structure should be built on a sound biological basis.

- The draft EIS Plan should thoroughly detail/analyze how any proposed mitigation measures and will contribute to objectives of the ESA-recovery plan for Mid-Columbia steelhead.

- The DBHCP EIS analysis should include those alternatives which provide for "certainty" in respect to necessary flows required as a basis for quality habitat condition in which each species is dependent. There is a need for binding minimum flows in the Crooked River system and Upper Deschutes River system that sustain and benefit all life history stages of those species for which the ITP is being proposed. This includes in particular, mid-Columbia Summer Steelhead Trout, Chinook Salmon, Bull Trout and the Oregon Spotted Frog.

- The draft DBHCP/EIS should address cumulative effects of the Applicant's activities in concert with other anthropologic impacts. A cumulative effects analysis should be in provided to adequately address effects of the Applicant's past and future activities.

- The DBHCP/EIS should thoroughly describe and address the City of Prineville's potential effects of future development and land uses on the covered species.

- An analysis is needed of the potential effects of climate change in relation to the proposed DBHCP.

- Compliance, effectiveness and effects monitoring should be thoroughly addressed in the EIS analysis.

- The effects/impacts of a no-action alternative to those species for which ITP coverage is being sought should be thoroughly examined. This should include limitations resulting from aspects of the current flow regimes for each of the stream systems on each of the species habitats and life history stages.

- The Summer Steelhead Trout population located in Deschutes River and tributaries downstream of the Pelton Round Butte Hydroelectric Project, Pelton Dam (RM 100) (Trout Creek, Sagebrush Creek, Mud Springs Creek), while federally listed under the Endangered Species Act (ESA) as a Threaten Species; are not part of the ESA 10(j) experimental designation given to Summer Steel Trout population that is above the Pelton Round Butte Project.

- The EIS should provide that alternatives analyzed are consistent with applicable Oregon Revised Statutes (ORS) and Oregon Administrative Rules (OAR).

Comments

ODFW recommends that in respect to enabling a sound analysis of the effects, impacts and potential mitigation measures commensurate with the impacts to the species, an adequate and thorough presentation of background information is necessary. ODFW recommends that the following information be included for each species proposed for ITP coverage:

I. Existing Information

A. Historical and Current Information Concerning Presence/Absence and Spatial and Temporal Distribution of Each Species on the Covered Lands
B. Life History
C. Biological Status
D. Species Habitat Condition Pre Covered Project Impacts.
E. Condition of Each Species' Existing Habitats
F. Habitat Capacity Estimates

II. Data Gaps
A. Presence/Absence and Spatial and Temporal Distribution Data Needs
B. Biological Status Data Needs
C. Habitat Data Needs

III. Effects of Covered Activities on the Species, Including Changes in Habitat Distribution, Abundance and Quality resulting from Covered Activities.

IV. Sensitivity of Each Species to Habitat Modifications Anticipated with Conservation Measures.

Information on historic and current habitats should be included for all species for which the Applicants are seeking coverage. A similar exercise was undertaken by the DBBC and City of Prineville in 2010 for assessing the implications of including redband trout as a covered species in the DBHCP (Biota Pacific Environmental Services 2010). For purposes of the redband trout assessment, "*covered lands included all surface waters, wetlands and riparian lands from the shoreline of all irrigation water reservoirs, including the irrigation supply network, downstream to elevation 1,945 feet above mean sea level, which is the maximum pool of Lake Billy Chinook.*" In this vein the EIS analysis should provide context on historical fish production in areas above all the storage dams for which the applicants are requesting coverage. An example of this information is to be found in Study 14-2: Evaluation of Fish Passage Options for Ochoco Dam (R2 Resource Consultants, Inc. 2014). This study was completed in March of 2104, by R2 Resource Consultant, Inc. and Biota Pacific Environmental Sciences, Inc. for the Deschutes Basin Board of Control (DBBC) and the City of Prineville. This study in concert with other available resources should be utilized as a part of the basis for informing the effects analysis. Additional sources have discussed historic anadromous habitats above Bowman Dam. The effects of restricted access to areas of more favorable spawning and rearing habitats is certainly a consideration in respect to effects analysis of the Applicant's operations.

Fish screens and their operation are required by Oregon statutes. The DBHCP ITP EIS should include a detailed accounting of irrigation diversions and associated dams or obstructions for which the Applicants are requesting ITP coverage. ODFW recommends that the EIS include information detailing the presence or absence of screens or passage facilities. If a diversion or passage barrier is equipped with a screen and or fish passage facility, information on date of installation (age) and condition of the screen or passage facility should be included.

Stream flow alteration by the Applicant's water storage and diversion facilities affect fish habitat in many ways including: the amount and distribution of spawning and rearing habitat; the risk of damaging incubating eggs or larval fish by scour or desiccation; risk of stranding fish in low flows; conditions for upstream and downstream migration; the biophysical factors that form and maintain stream channels and the lack of access to historically productive upper basin spawning and rearing habitats. Alteration of rivers and streams is also known to result in habitat fragmentation, as wetlands are drained or hydrologically altered.

The EIS should include a full ecological flow analysis which considers the frequency, magnitude, timing, rate of change, and duration of flow events necessary to support stream structure and function. The analysis of effects related to covered activities should account for those changes in river morphology, riparian habitats and wetlands, changes to water quality including water temperatures, changes in large woody debris inputs and blockages to historic habitats. These changes in habitats include effects to those riverine, riparian and wetland habitats inundated by the reservoirs proposed for ITP coverage. Changes in flow as a result of the Applicants' operations are significant in almost every month and reach. The DBHCP EIS should analysis the effects of significantly altered annual flow regimes resulting from the Applicant's infrastructure and operational activities on the riparian, wetlands, floodplains and general river geomorphology.

This statement should be expanded to include effects of altered flow regimes to riparian habitats, wetlands, river bank stability. Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands is recognized as a major factor contributing to loss of biological diversity and ecological function in aquatic ecosystems, including floodplains. Alteration of natural flow regimes in rivers and streams and their floodplains and wetlands has a variety of impacts which include: Reduction of habitat due to change in area, frequency and duration of activating floodplains and terminal wetlands. Riparian zones and the organisms inhabiting them can be dramatically altered as a result of change in flow patterns along the length of the stream course. As noted by (Poff et al. 1997), six components of flow regimes: amplitude, magnitude, frequency, duration, timing, and rate of change of hydrologic conditions, strongly influence the structure and function of riparian ecosystems. With respect to magnitude, for example, the width of riparian vegetation communities and their biomass increase with mean and median annual flow volume and drainage size in alluvial river channels (Stromberg 1993).

The EIS should detail and analyze the effects down ramping and up ramping rates of flow releases at all the Applicant's storage reservoir dams and diversion dams on the river environment and those species proposed for ITP coverage.

Deschutes River, Little Deschutes River and Crescent Creek

There are a number of the Applicant's patrons that individually divert small amounts of water at 33 locations on the Deschutes River. There should be a clear accounting of whether or not a diversion or passage barrier is equipped with a screen and or fish passage facility. Information on date of installation (age) and condition of the screen or passage facility should be included. A map with the location of each diversion, regardless of size, should accompany the diversion descriptions. This informational need applies to all stream reaches within the Applicant's operational framework, including the Crooked River and its tributaries and Whychus Creek.

The diversion of between 1200 cfs and 1700 cfs of instream flow during the spring; summer and early fall should be analyzed for its effect on fish and OSF habitat and OSF life stages.

The Central Oregon Irrigation District (COID), Siphon Power Project (FERC License 3571), located at approximately rivermile (RM) 169.5, about two miles above Bend. The EIS should analyze the environmental effects on OSF of the project. Please include information on the specifics of COID's Siphon Power, including operations, aspects of diverted flow, the bypass reach flows and other information that is pertinent to the proposed DBHCP and the ITP.

Return flows

In previous documents it has been identified that there are eight return flows directly to the Deschutes River, five of these enter the river at one of the reservoirs associated with the Pelton Round Butte Hydroelectric Project, and the other three enter the river downstream of Pelton Reregulating Dam. The rivermile (RM) location should be included in a table format for each point where irrigation flows return to the river. In addition the origin of the water that is being returned to the river should also be included.

The potential for irrigation return flows originating in the Deschutes River to contribute infectious Ceratonova shasta (C. Shasta) actinospores into the Crooked River and Trout Creek needs to be examined. This situation may result in a higher potential for infection of susceptible fish, including Summer Steelhead Trout and Chinook Salmon. Preliminary work done by ODFW (Stocking 2008) and others (Zielinski et al. 2010.) indicate a concern that warrants further investigation and that this issue needs be addressed as part of the EIS analysis.

Storage, Release and Diversion of Irrigation Water

Crane Prairie Reservoir and Wickiup Reservoir serve as thermal heat sinks. Data collected by the Upper Deschutes Watershed Council (UDWC) in 2004, (UDWC 2004) indicates that warming occurs in Crane Prairie and Wickiup to the extent that the baseline temperature is so high that any downstream cooling influences, i.e. Fall River and Spring River, are insufficient to bring temperatures back down into a range that meets criteria and is favorable for fish. Thus the negative thermal influence of the storage and release of the water for irrigation begins at the reservoirs and continues downstream into Bend and into the middle Deschutes River reach and subsequently into the reach below Big Falls. The warmer water in the middle Deschutes river reach is, at least in part, potentially attributable to the upstream reservoirs. Additionally, the North Canal Dam impoundment is a point of potential heat uptake for any water that continues downstream into the middle Deschutes River reach. This information should be included as part of the EIS analysis including a thorough description of the ecological changes as a result of the impoundment of large quantities of water for irrigation.

Water Quality

Information on water quality in Crescent Lake, Crane Prairie Reservoir or Wickiup Reservoir should be included in the EIS. Is the water quality in any of these reservoirs degraded during the summer months, and do they experience algae blooms as temperatures warm, including large blooms of the blue-green algae *Aphanizomenon* or the cyanobacteria *Microcystis?*

Entrainment of Covered Species

The DBHCP EIS should detail the status of fish screens, along with upstream and downstream passage facilities at each diversion. This should include the status of the Crescent Lake dam, Crane Prairie Reservoir dam and Wickiup Reservoir dam fish screens and fish passage facilities. The EIS should include information that substantiates that those facilities currently equipped with screens are sufficient to safely exclude juvenile and adult OSFs and the impacts associated those diversions and dams that are not screened or adequately screened including the North Unit Irrigation District North Canal Diversion screen.

Middle Deschutes River Instream Flow during the Irrigation Season

Should conversions of irrigation water rights for purposes of meeting flow targets be proposed, these conversions should be analyzed for potential effects on spring inputs into the middle Deschutes reach. Mitigation actions that may be proposed to provide groundwater mitigation credits in exchange for surface flows should be analyzed in respect to impacts of groundwater withdrawals that may reduce spring and seep inputs into any portion of the middle Deschutes between Bend Lake Billy Chinook. Reducing the amount of spring inflow by allowing groundwater withdraws in exchange for the upper Deschutes River flows warmed in Crane Prairie Reservoir and Wickiup Reservoir and the upper reaches of the Deschutes multiplies the warming effect on the middle Deschutes River reach. Mitigation practices that counter act efforts to reduce instream temperature are cause for concern.

The use of temporary leases to meet instream flow targets should analyzed as to the long term assurances of this type of flow mitigation. Temporary leases by their nature are temporary and do not amount to a permanent transfer of a water right to instream use. The need for having the foundation of any instream flow program/effort being based on certificated permanent instream water should be analyzed in the EIS.

Oregon Spotted Frog Comments and Recommendations

Length of the DBHCP:

Typically, HCP's identify specific actions designed to protect federally listed species and provide assurances to the Applicant that only those actions specified in the HCP will be required during the life of the permit. A long lived HCP may be appropriate when the needs of the listed species and their responses to management actions are well understood, but a shorter term HCP is appropriate in situations where significant biological and ecological knowledge gaps exist and timely adjustments to management actions may be needed to protect a species. The latter description exemplifies the current situation with respect to the Oregon spotted frog (OSF) in the Upper Deschutes River Basin. Our understanding of the frog's ecological needs and ability to function within the managed irrigation system has improved over the last few years, but most of that knowledge relates to the riverine environment and is far from complete. To date very little is known about OSF biology and ecology in a reservoir environment. Clearly, a more comprehensive understanding of the frog's needs within the Applicant's managed irrigation delivery system is needed.

Considering the above discussion, ODFW recommends that either: The term of the HCP is limited to a maximum of 5 to 10 years so that, if necessary, appropriate management modifications can be made following permit expiration, or a longer term (15 – 25 years) HCP is developed using an adaptive management model that allows timely and appropriate adjustments to management actions, during the life of the permit, as our understanding of the frog's biology and ecology within the managed system improve.

Biological and Ecological Information Gaps:

The purpose of an HCP is to protect federally listed species that exist where anthropogenic activities might otherwise cause their destruction. This is achieved by providing the Applicant with an incidental take permit that allows limited take of a listed species while requiring the Applicant to follow specific management actions designed to minimize or mitigate take by conserving the habitat upon which the species depend, thereby contributing to the recovery of the species as a whole.

Execution of a successful HCP requires that the needs of the listed species and their responses to management actions are well understood. However, as previously mentioned, our biological and ecological understanding of the OSF ability to function within the managed irrigation system is far from complete. Although important knowledge has been gained in the riverine system significant knowledge gaps exist and very little is known about OSF biology and ecology in a reservoir environment.

In order to meet the purpose of the HCP, ODFW believes that its development must address critical biological and ecological information gaps such as:
**Note: Efforts to address some of these questions are currently underway, but many are not.*

OSF Biology and Ecology:

What is the timing of oviposition, hatching, metamorphosis and overwintering habitat use in the mainstem Deschutes River, Crane Prairie Reservoir, Crescent Creek and the Little Deschutes River?

What is the survival rate of OSF life history stages and the effective population size in the mainstem Deschutes River, Crane Prairie Reservoir, Crescent Creek and the Little Deschutes River?

What is the relative contribution of OSF life history stages to population persistence, stability, and growth?

Which life history stages are the most sensitive to management actions and most likely to limit population stability or growth?

What is the range of OSF movements (distance and pathway) between breeding, rearing and overwintering habitats?

Is OSF survival effected by the selection of low quality vs. high quality overwintering sites?

OSF Habitat:

What are the locations and relative quality of OSF overwintering habitat on the mainstem Deschutes River, Crane Prairie Reservoir, Crescent Creek and the Little Deschutes River?

What are the flow contributions of Big Marsh Creek to Crescent Creek and the Little Deschutes River?

What mix of wetland vegetation is best suited for OSF egg and larval survival and how can water elevations be managed in the mainstem Deschutes River, Crane Prairie Reservoir, Crescent Creek and the Little Deschutes River to meet the desired conditions?

What are the potential long-term changes in wetlands along the mainstem Deschutes if future more stable flows are realized?

What is the potential for restoration projects, such as Ryan Ranch, to assist in recovery of OSF in the Upper Deschutes Basin?

Irrigation System Management Effects on Habitat and OSF:

What are the surface elevations that will inundate or expose key vegetation zones of sedges and rushes, important to oviposition and tadpole survival, in Crane Prairie Reservoir?

How does the timing and different ramp up and ramp down flow rates influence the timing and survival rates associated with oviposition, hatching, early tadpole development, and movement to overwintering sites in the mainstem Deschutes River, Little Deschutes River and Crescent Creek?

Does the fall drawdown on the Deschutes River below Wickiup Reservoir result in standing of juvenile or adult OSF in isolated pools or habitat and if so what drawdown rates preclude standing?

What is the relationship between year round in-stream flows and key OSF habitats on the mainstem Deschutes River, Little Deschutes River and Crescent Creek?

Invasive Species:

What are the conditions and mechanisms that may allow non-native flora and fauna to depress OSF populations?

What are the locations of established non-native flora and fauna populations, capable of depressing OSF populations, in the Upper Deschutes River Basin and what are the mechanisms that allowed their establishment?

How do changes in water elevation in Crane Prairie Reservoir limit or exacerbate predation on OSF by non-native species such as brown bullheads?

How do changes in water elevation in Crane Prairie Reservoir limit or exacerbate the spread and establishment of non-native flora such as reed canary grass?

Will flow rates designed to benefit various OSF life history stages also benefit non-native flora and fauna in the mainstem Deschutes River, Little Deschutes River and Crescent Creek?

Monitoring:

Beyond the need to address OSF biological and ecological knowledge gaps, the HCP should include a comprehensive and robust monitoring program that can identify the positive and negative effects of management actions on:

- All OSF life history stages
- OSF population stability and status in both the riverine and reservoir environs

- OSF habitat responses to management actions, and
- Invasive flora and fauna capable of depressing OSF populations.

Whychus Creek

Overview of Current Conditions

A good description of the current flow condition of Whychus Creek is in part found in the TSID Main Canal Piping Project (Phases 4-6) grant application dated May 17, 2012 as prepared by the Deschutes Resources Conservancy (DRC) in conjunction with TSID. The current condition of Whychus Creek is described as, "*Flow alterations due to irrigation diversions have occurred since the late 1800s in Whychus Creek. The stream is severely over allocated as rights have been issued authorizing diversion of more water than typically flows in the creek. Presently, the creek enjoys natural flows from its headwaters until it reaches river mile 23, where a series of major irrigation diversions remove close to 90% of the flow for a 5-mile stretch (Golden and Aylward, 2006). Below the City of Sisters, springs and return flow gradually rewater the creek around river mile 18, though flows remain insignificant as compared to the natural hydrograph. These conditions persist each year starting in April and ending in October. Insufficient instream flow has led to a decrease in water quality including elevated water temperatures throughout much of the watershed. As a result, Whychus Creek has been listed on Oregon's 303(d) list since 1998 for temperature (DEQ, 2002). In addition to poor water quality, fish habitat has suffered as a result of irrigation withdrawals. Impacts include increases in the channel width to depth ratio, reduced pool habitat, loss of oxbows and sloughs, loss of riparian habitat, and diminished channel/floodplain connectivity (NPCC, 2004). The decline of water quality and fish habitat in Whychus Creek and its correlation to low instream flow is well documented in a variety of watershed assessments published by a wide array of natural resource agencies.*" The above description of the current Whychus creek conditions should be included in the Overview of Current Conditions for the EIS.

The DBHCP EIS should include an analysis of the instream flow necessary in Whychus creek for providing quality habitat conditions supportive of each of the life stages of the species for which "incidental take" is being requested.

In previous documents there has been reference to "*one TSID patron that will divert water by pumping directly from Whychus Creek upstream of TSID's diversion and that this will be a covered activity.*" The EIS should detail this particular diversion and include information as to whether or not it is screened to prevent fish entrainment and as to whether or not the pump/diversion is gaged to ensure proper usage of water.

Whychus Creek Flow

Measures to address, contribute and or otherwise meet biological objectives/needs for all life history stages of steelhead trout and Chinook salmon in Whychus Creek should be analyzed.

As noted previously discussed the pros and cons of being dependent on instream leases should be analyzed. The EIS should explore the positive aspects of having the foundation of any instream flow program/effort based on explicitly dedicated certificated permanent instream water.

Whychus Creek Fish Screens and Fish Passage

Upstream and downstream passage is required at all artificial obstructions in those Oregon waters in which migratory native fish are currently or have historically been present. Correspondingly ODFW's fish screen statute requires the owner or operator of a diversion located in waters in which native and naturally spawning fish are currently present, to address fish screen requirements. NMFS also has fish screening and passage laws that apply to the waters of Whychus Creek. Additionally, TSID's Water Right Certificate No. 87798 certificate issued in October of 2012, by the Oregon Water Resources Department (OWRD) for use of water for hydroelectric purposes contains a condition declaring that the "water right holder shall construct, operate and maintain all fish screens, by-pass devices and fish passages as required by the Oregon Department of Fish & Wildlife.

ODFW asks that a paragraph be included that accurately describes the current state of covered species in the Whychus Creek system. This should be information pertaining to the Summer Steelhead, Chinook Salmon and Sockeye Salmon re-introduction efforts. It should discuss the extent and sites of releases of Summer Steelhead Trout and Chinook Salmon fry, downstream movement of juvenile smolts and any information on returning adult Summer Steelhead Trout or Chinook Salmon that may have entered or attempted to enter the Whychus creek system

Water Temperature

The draft EIS should include an analysis of the results of progressively increasing the instream flows beyond 30.19 cfs. For example what are the benefits of increasing the permanent instream flow to 35 cfs, 40 cfs, etc... ?

The draft EIS should address those instream flows necessary to maintain the stream temperature at ODEQ criteria for all the life stages of steelhead trout and Chinook salmon? How does ensuring 30 cfs of flow at the Sisters OWRD gage affect the flow and temperature in the downstream reaches of Whychus Creek?

In recent years through extensive monitoring conducted by the Upper Deschutes Watershed Council (UDWC) it has been demonstrated that 20 cfs and 30 cfs instream minimum flow does not provide adequate summer stream temperatures for salmonids. In the manner of the DBHCP draft EIS should consider/analyze information pertaining to instream flow which provides in instream temperatures that meet ODEQ criteria for all the life stages of anadromous and resident salmonids found in Whychus creek.

Where is cold water refugia located in the Whychus Creek system?

The EIS should analyze flows needed to provide for more suitable bull trout habitat, including stream temperatures upstream of Alder Springs? Bull trout have recently been documented at approximately RM 6 in Whychus Creek (ODFW 2014) several miles above Alder Springs perhaps indicating they might move further up Whychus Creek if more suitable conditions are achieved.

Crooked River, Ochoco Creek, McKay Creek and Lytle Creek

The EIS should include discussion as to how dams and altered flow regimes impact the river ecosystem. Alteration to natural flow regimes can occur through reducing or increasing flows, altering seasonality of flows, changing the frequency, duration, magnitude, timing, predictability and variability of flow events, altering surface and subsurface water levels and changing the rate of rise or fall of water levels. (Walker 1985; Gehrke *et al.* 1995; Kingsford 1995; Maheshwari *et al.* 1995; Poff *et al.* 1997; Boulton and Brock 1999; Robertson *et al.* 1999, 2001.

As mentioned in preceding comments, the effects of altering a river's natural flow regime can result in negative impacts to stream channel morphology, riparian habitats, water quality and many other aspects of the riverine environment. The Applicant's covered activities have altered flow regimes on the Crooked River. This can affect fish habitat in many ways, including: the amount and distribution of spawning and rearing habitat; the risk of damaging incubating eggs or larval fish by scour or desiccation; risk of stranding fish in low flows, conditions for up and downstream migration; the biophysical factors that form and maintain stream channels and the lack of access to historically productive upper basin spawning and rearing habitats. Alteration of rivers and streams is known to result in habitat fragmentation, as wetlands are drained or hydrologically altered. This can lead to changes in species composition as wetlands species are replaced by upland species; loss of genetic integrity when isolated habitats are too small to support viable populations; and increased numbers of competitor, predator, and parasite species tolerant of disturbed environments. Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands is recognized as a major factor contributing to loss of biological diversity and ecological function in aquatic ecosystems, including floodplains.

A significant water quality issue is dissolved gas (particularly nitrogen) super saturation during periods of releases of high volume of water from Bowman Dam. Due to the configuration of the outlet structure of Bowman Dam, atmospheric nitrogen is entrained in the Crooked River at levels that exceed the standards set by the Oregon Department of Environmental Quality when discharge exceeds approximately 600 cubic feet per second. At high enough levels of entrained nitrogen, deleterious effects are manifested in aquatic organisms through a condition known as gas bubble disease (Porter, T, and B. Hodgson. 2016).

The EIS should analyze water quality in Prineville Reservoir or Ochoco Reservoir. Is the water quality in any of these reservoirs degraded during the summer months, and do they experience algae blooms as temperatures warm, including blooms of the blue-green algae *Aphanizomenon or* the cyanobacteria *Microcystis?*

Under current conditions access to numerous miles of historic mainstem and headwater tributary spawning and rearing habitat is blocked by Ochoco Dam and Bowman Dam. The EIS should analysis the extent of the upstream historic habitats and benefits of having the access to historic habitats.

The EIS overview of current conditions for the OID and Crooked River Basin should include the status of fish screens and fish passage at all dams, diversions, infiltration galleries, pumps and locations where water is diverted on Johnson Creek, Dry Creek, McKay Creek and Lytle Creek. This applies to the passage and screening status of Bowman Dam and Ochoco Dam. A table should be included in the draft EIS which allows a reader to easily discern the status of each diversion, pump etc..

In respect to existing screens: It is important that if an existing screen does not meet current NMFS criteria that it be replaced with a screen that does meet current NMFS criteria including approach velocities, screen mesh etc... This should apply to older screens that at one time may have met standards, but are no longer compliant. Please include an analysis of the screens and or downstream and upstream fish passage facilities at Bowman Dam and Ochoco Dam.

ODFW asks that a paragraph be included that accurately describes the current state of covered species in the Crooked River system. This should be information pertaining to the Summer Steelhead and Chinook Salmon re-introduction efforts. It should discuss the extent and sites of releases of Summer Steelhead Trout and Chinook Salmon fry, downstream movement of juvenile smolts and any information on returning adult steelhead trout or Chinook salmon that may have entered or attempted to enter the Crooked River system.

How do flows at or near 3000 cfs affect the Crooked River channel morphology?

What is the historic recurrence timeframe for large flow events approaching 3000 cfs below Bowman Dam?

What studies have been to done to assess the benefits to fish habitat of higher flows as might have been experienced during natural conditions?

Ecological Flows or Seasonally Varying Flow are should be addressed. Flow variability with storage irrigation is much less than unregulated. Moderately high flows in March, April, May and other times can potentially provide many ecologically important benefits. At a minimum the DBHCP EIS should include Indicators of Hydrologic Alteration (IHA) model runs on existing, proposed and unregulated flows.

Previous efforts that modeled flow alternatives and assessed Crooked River environmental flows (Hardin 1993, Hardin 2011, Hardin, T. 2001, WPN 2010) should be incorporated into the EIS analysis in terms of flow scenarios that might provide more certainty of year round suitable habitat for summer steelhead and Chinook salmon.

Water Temperature

What are the net indirect effects on stream flow temperature of the reservoir releases and return flows?

What is the effect of the colder tail-water flows below Bowman Dam on Summer Steelhead Trout and Chinook Salmon habitat?

How does the current condition of riparian vegetation, channel morphology and habitat along the Crooked River and tributary streams affected by the irrigation diversions interrelate to current water temperature?

Oregon Department of Environmental Quality (ODEQ) has conducted modeling efforts demonstrating that increased flows past OID had significant temperature benefits. It is logical that these temperatures be examined in the DBHCP EIS analysis?

What are the temperatures of the tributaries flowing into the Crooked River above Prineville reservoir?

What are the temperatures immediately below the OID Crooked River diversion compared to temperatures immediately above the diversion during the irrigation season?

How would increasing flow affect the temperatures downstream of the OID Crooked River diversion?

What are the temperatures of the tributaries flowing into Ochoco reservoir?

Water Quality

How does water quality in Prineville and Ochoco Reservoirs affect the water quality (pH, turbidity) downstream of the dams throughout the year?

The DBHCP EIS should include a complete description of the effects and impacts of its infrastructure and operations. This acknowledgement of the full potential impacts of impoundment and alteration of flow regimes on the ecology of the affected streams is essential to proposing conservation measures that satisfactorily compensate for those effects.

Adequate flows necessary to recover and sustain healthy fish populations (specifically summer steelhead and Chinook salmon) need to be dependably available regardless of irrigation season timing. A flow regime that provides quality habitat conditions (not minimal) for all the stages of Summer Steelhead Trout, Chinook Salmon and other covered species in the Crooked River and its tributaries should be to the objective of "Conservation Measures" provided during the irrigation season.

What are the current ramping rate standards utilized by the Irrigation Districts or BOR downstream of their reservoir storage facilities? Rapid flow reductions can adversely affect fish populations by dewatering spawning, rearing, or foraging habitat and may strand fish. Smaller juvenile fish (less than about 50 mm long) are most vulnerable to potential stranding due to weak swimming ability and preference for shallower, near-shore habitats. River channel configuration, channel substrate type, time of day, and flow level before down-ramping (antecedent flow) are also key factors that determine stranding incidence.

Flows identified/analyzed in the DBHCP EIS should be based on scientific assessment that provides effective habitat for all life history stage requirements.

Please explain BOR's role in managing the flow releases out of Ochoco Reservoir?

What are the current flow conditions on Ochoco Creek during the irrigation season?

Please analyze the flows necessary to provide for adult migration, spawning, incubation, rearing and outmigration of Summer Steelhead and Chinook Salmon on Ochoco Creek?

How much habitat and what are the habitat conditions for anadromous fish above Jones Dam?

How much flow is diverted out of stream at Jones Dam during the irrigation season?

Please analyze what year round flow regime in McKay Creek would provide quality habitat for all life history stages of Summer Steelhead and Chinook Salmon?

The Crooked River Flow Assessment Report (Watershed Professionals Network 2011) conducted for the Deschutes River Conservancy and The Nature Conservancy should be incorporated into the discussion of environmental flows for the Crooked River. This report included IHA analyses for all the major Crooked River reaches. The IHA results quantify the hydrological differences between flow scenarios. Also, the input files for IHA are ~20 year daily flow series, which can easily be used to generate flow exceedance curves by reach and scenario.

An example of the how differing flows can affect fish habitat is found in a study conducted for the Ochoco Irrigation District by Vaughn etc. al. 2010. Significant changes were observed in the wetted area of the Crooked River and associated fish habitats. An excerpt from this 2010 report reads, "*Stream segments were categorized into three different types of habitat: pools, glides, and riffles. In May, the 1.6 km study reach was comprised of 16 different habitat units of which 49% were pools, 23% glides, and 28% riffles. During the October sampling effort there were 23 habitat units within the same study reach. The proportion of habitat types changed as well and was now dominated by glide habitat, 76%, with the remaining area made up of 16% pools and only 9% riffles. The increase in habitat units identified during the survey in the fall and the corresponding shift in dominant habitat type is expected due to the large decrease in flow observed during the second sampling effort. The flow in October was only 35% of the flow we observed during our May surveys (90 cfs vs. 245 cfs), which reduced water velocity through the study reach and altered the length of area classified as riffle habitat. The lower flows decreased the average wetted channel width from 31 m to 28 m and decreased the average depth in glides, 0.8 m vs. 0.4 m, but did not affect maximum pool depth which held steady at 1.3 m during both seasons.*"

Bull Trout Seasonal Foraging

Bull Trout are currently present immediately downstream of Deschutes Valley Water District's hydropower facility. Once upstream fish passage is constructed at this facility Bull Trout will once again have access to the lower reaches of the Crooked River above this point. Please analyze flow scenario(s) at which temperatures would be suitable during the various seasons of the year for Bull Trout foraging.

Trout Creek and Mud Springs Creek

Drain inputs should not be responsible for contributing to elevated temperatures or volumetric inputs of warmer water than in the Mud Springs Creek or Trout Creek system. Please include an analysis in the EIS on this point.

Sedimentation in Mud Springs is an acute issue. ODFW biologists who have operated a fish trap on lower Trout Creek since 1998 have observed turbidly issues emanating from Mud Springs Creek on an annual basis. Beginning in the mid-2000's high turbidity levels have been observed in Trout Creek throughout the irrigation season. The extreme turbidity inputs stop 3-4 days after the irrigation season ends around Oct 15th. This pattern was continuing still be observed into December 2014. The amount of sediment deposited over the spring and summer is quite significant and silt depths in pools can reach 2 - 3 feet deep directly below the confluence of Mud Springs. (T. Nelson per com 2014). This information should be included as part of the analysis for the ITP EIS.

ODFW recommends that conservation measures are needed to eliminate the temperature issues resulting from the 58 -11 and 61 -11 drain inputs into Mud Springs Creek.

ODFW recommends that conservation measures are needed to address the acute turbidity situation occurring annually in Mud Springs Creek during the irrigation period. The sediment levels observed in Mud Springs and Trout Creek at the confluence of Mud Springs Creek have the potential to effect incubating Summer Steelhead Trout eggs and fry emergence.

Climate Change

Climate Change should be accounted for in the draft EIS analysis. If climate change threatens the species by impacting the quality or quantity of its habitat in the future, or increasing its vulnerability to pathogens or exotic species, that increased vulnerability should be taken into account by the EIS analysis. The duration of the ITP should not exceed the limits of the climate change models used in the EIS analysis for assessing predicted effects.

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Appendix 2-A

EIS Alternatives Screening Process

Appendix 2-A
EIS Alternatives Screening Process

Introduction

This appendix presents the approach used to define and screen alternatives to the Deschutes Basin Habitat Conservation Plan (HCP) that may be included for detailed evaluation in the Deschutes Basin HCP Draft Environmental Impact Statement (EIS). The goal of the screening process is to identify a reasonable range of alternatives and alternative components that may be evaluated in the EIS, consistent with Council on Environmental Quality (CEQ) National Environmental Policy Act (NEPA) Regulations and guidance from the 2016 HCP Handbook.

This appendix consists of a brief overview of NEPA guidance for alternatives, a general description of the screening process and criteria, the selected purpose and need statement, a summary of the no-action alternative and Draft HCP (proposed action), ideas for action alternative components, and a three-phase screening process. The screening process is used to identify alternatives to carry forward for detailed analysis in the EIS and documents alternatives that were evaluated but eliminated from further consideration in the EIS.

NEPA Guidance for Alternatives

Alternatives have long been considered the heart of the EIS. Evaluating alternatives is guided by the "rule of reason" that requires a lead agency to consider a reasonable range of alternatives that could meet a defined purpose and need. According to the CEQ NEPA regulations (40 Code of Federal Regulations [CFR] 1502.14) the alternatives discussion disclosed in an EIS must meet the following requirements:

- Rigorously explore and objectively evaluate all reasonable alternatives.
- Include reasonable alternatives not within the lead agencies jurisdiction, if applicable.
- Include a no-action alternative.
- Evaluate the comparative merits of alternatives.
- Identify the lead agency's preferred alternative.
- Present alternatives that were eliminated from detailed study and describe the reasons for elimination.

The NEPA alternatives for an HCP should meet the purpose and need of the action, which generally is to authorize take incidental to otherwise lawful covered activities while minimizing and mitigating the impacts on take to the maximum extent practicable. The range of alternatives included in an EIS typically includes the proposed action, no action, and one or more variations of the proposed action.

The U.S. Fish and Wildlife Service (FWS) may confer with the applicant to ensure that the NEPA alternatives are reasonable but determining which alternatives to analyze in an EIS is ultimately FWS's decision.

The following are considerations to determine a reasonable range of alternatives to an HCP:

- Alternatives that include covered activities and impacts different from those in the proposed HCP. For example, different amounts or types of covered activities that could reduce effects on the human environment, including those to covered species.
- Alternatives that include an HCP conservation strategy that achieves higher or lower conservation than what is proposed (e.g., more or less protective of the covered species).
- An alternative that includes the same conservation strategy but with a different permit duration, either substantially more or less.
- Other reasonable courses of action necessary or appropriate for purposes of the HCP, and that meet Endangered Species Act (ESA) requirements. FWS could modify or develop other alternative components of the applicant's HCP, such as alternative covered lands, alternative covered species, or alternative permittees. Varying these components of the HCP may be difficult to justify because the HCP has already defined what FWS believes is the best approach.
- Other reasonable courses of action necessary or appropriate for purposes of the HCP that cause the least damage to the environment and best protects, preserves, and enhances the human environment. This environmentally preferable alternative (43 CFR 46.30) would also include any potential mitigation measures not already included in the proposed action or other alternatives.

For the Deschutes Basin HCP EIS it is logical to start alternatives development by considering variations to the conservation measures and the alternatives to take currently presented in the Draft HCP document. However, because NEPA's directive to reduce effects on the human environment is broader than that of ESA, an EIS should also consider alternatives that could reduce other effects of HCP implementation while reasonably meeting the purpose and need for the action. The following purpose and need statement was developed during the May 9, 2018, Alternatives Screening Workshop. The purpose and need statement was developed with input from FWS, National Marine Fisheries Service (NMFS), and Deschutes Basin Board of Control representatives, considering a number of options to include purpose statements that are defined more broadly and more narrowly for alternatives screening purposes.

Purpose and Need

FWS's purpose and need is distinct from the HCP applicants' purpose and need (43 CFR 46.420). The proposed federal action being evaluated in this EIS is the issuance of incidental take permits (ITPs) under Section 10(a)(1)(B) of ESA by FWS and NMFS (the Services) in response to the ITP applications from the DBBC and the City of Prineville. The ITPs would authorize incidental take of the covered species that could result from covered activities in the plan area over the 30-year term of the ITPs.

The purpose and need statement is important because it establishes the basis for determining whether viable alternatives to issuing ITPs for the proposed HCP may meet the intended purpose and reduce potential effects from implementing the proposed HCP. Therefore, the definition of the purpose for the federal action is important in determining the range of alternatives that are considered during development of an EIS. As stated in the HCP Handbook, the purposes of the Services' action include:

- Fulfilling the Services' authority and conservation obligations under ESA Section 10(a)(1)(B);
- Complying with related laws and regulations, Executive Orders, and agency directives and policies; and
- Ensuring that implementation of the HCP will help to achieve long-term species and ecosystem conservation objectives.

The Services' underlying need is to respond to the applicants' submittal of their proposed HCP and ITP applications. The Service's need is therefore based on:

- The directive to the Services by ESA to issue an ITP to a non-federal entity if that permit application and HCP satisfy all permit issuance criteria;
- Compliance by the applicant and Services with ESA, NEPA, and other applicable federal laws and regulations; and
- The ITP application received and what the ITP would authorize, if approved.

Based on the guidance above and input during the May 9, 2018, Alternatives Screening Workshop, the following purpose and need statement is presented in Chapter 1, *Purpose and Need*, of this EIS and used in this alternatives screening process.

The purpose of the federal action considered in this EIS is to fulfill the Services' Section 10(a)(1)(B) conservation authorities and obligations and to render decisions on the ITP applications requesting authorization of take of three species listed as threatened under ESA—Oregon spotted frog, Middle Columbia River steelhead, and bull trout—and two nonlisted species—spring Middle Columbia River Chinook salmon and sockeye salmon.

The need for the federal action is to respond to the applicant's request for ITPs for the covered species and covered activities as described in the HCP. The Services will review the ITP applications to determine if they meet permit issuance criteria. The Services will also ensure that issuance of the ITPs and implementation of the Deschutes Basin HCP comply with other applicable federal laws, regulations, treaties and applicable Executive Orders, as appropriate.

Summary of Alternatives Options

Identification of potential alternatives to evaluate in the EIS has its foundations in the HCP development process and the alternatives to take presented in the Deschutes Basin HCP. These alternatives include:

- The proposed HCP (i.e., the EIS proposed action)
- Alternatives for the Upper Deschutes River at Wickiup Reservoir (e.g., increased minimum flows)
- An alternative for the Middle Deschutes River (e.g., increased minimum flows)
- An alternative for Crescent Creek (e.g., increased minimum flows)

- An alternative for Whychus Creek (e.g., increased flows from conservation)
- Alternatives for the Crooked River, Ochoco Creek and McKay Creek

In addition, a number of other alternative components could be modified and incorporated into alternatives considered for the EIS. Table 1, *Summary of Alternatives Options for the Deschutes Basin EIS*, provides an overview of the alternative components that could be combined to create alternative options for consideration during the alternatives screening process. Table 1 is intended to confirm assumptions for the NEPA no-action alternative and proposed action and to develop a robust list of potential alternative components to be considered for alternatives screening. Suggestions in scoping comments and ideas identified during the project initiation meeting, alternatives screening workshop and coordination meetings are also considered. Based on the alternative components presented in Table 1, a total of 15 alternatives were formulated and considered for detailed analysis in the Draft EIS, including the following:

Alternative 1. Accelerated Increases in Upper Deschutes River Fall/Winter Minimum Flows

Alternative 1 would reduce the time to increase flow in the Upper Deschutes River compared to the proposed action by providing a minimum fall/winter (September 16–March 31) flow as follows:

- 0 to 2 years: 100 cubic feet per second (cfs)
- 3 to 5 years: 200 cfs
- 6 to 10 years: 300 cfs
- 11 to 30 years: 400 cfs

Alternative 2. Enhanced Increases in Upper Deschutes River Fall/Winter Minimum Flows and 50-Year Permit Term

Alternative 2 would increase the permit term to 50 years and provide a minimum fall/winter flow of 500 cfs from year 31 to year 40 and 600 cfs from year 41 to year 50. This alternative is the same as the “Wickiup Alternative to Take 2” provided in the HCP (see Chapter 11 of the Draft Deschutes Basin HCP).

Alternative 3. Enhanced Upper Deschutes River Winter Flows

Alternative 3 would enhance flows in the Upper Deschutes River sooner than under Proposed Action as follows:

- 0 to 5 years: 200 cfs
- 6 to 10 years: 300 cfs
- 11 to 15 years: 400 cfs
- 16 to 30 years: 500 cfs

Alternative 4. Accelerated and Enhanced Upper Deschutes River Winter Flows

Alternative 4 would accelerate the schedule of enhancement of minimum winter flows in the Upper Deschutes River compared to Alternative 1 and increase the enhancement at each time period compared to Alternative 1 as follows.

- 0 to 5 years: 300 cfs
- 6 to 10 years: 400 cfs
- 11 to 15 years: 500 cfs
- 16 to 20 years: 600 cfs

Alternative 5. Modified Upper Deschutes River Fall/Winter Minimum Flows

Alternative 5 would increase minimum winter flows in the Upper Deschutes River to 400 cfs for the entire permit term (0–30 years). This alternative immediately provides the greatest minimum winter flow enhancement proposed under the proposed action.

Alternative 6. Enhanced Variable Upper Deschutes River Fall/Winter Minimum Flows

Alternative 6 would base fall and winter flows on available annual surplus fall storage in Crane Prairie and Wickiup Reservoirs and precipitation forecasts, providing greater than minimum flows during above-normal and wet years and allowing less than minimum flow during below-normal and drought years.

Alternative 7. Variable Deschutes River Fall/Winter Minimum Flows with Reduced Permit Term

Alternative 7 would base Deschutes River fall/winter flows on available surplus fall storage and precipitation forecasts and reduce the permit term to 20 years to account for uncertainties about species response. This alternative is the same as Alternative 6 but with a shorter permit term.

Alternative 8. Reduced Covered Species

Alternative 8 would provide ITPs only for species currently listed, dropping sockeye and Chinook salmon. This alternative would consider reservoir and river flow enhancement for Oregon spotted frog, bull trout, and steelhead only.

Alternative 9. Limit Covered Activities to Deschutes River

Alternative 9 would limit covered activities to the Upper and Middle Deschutes River and exclude all covered activities on the Crooked River, Ochoco and McKay Creeks, and City of Prineville groundwater pumping.

Alternative 10. Continuation of 2017/2018 Fall/Winter Flows on the Upper Deschutes River

Alternative 10 would enhance minimum Deschutes River fall/winter flows to 200 cfs and eliminate flow enhancements offered for the proposed action. This alternative would essentially be a continuation of the recent Deschutes River flows that occurred in fall/winter 2017/18 but without other flow enhancements in the proposed action.

Alternative 11. Deschutes River Flow and Restoration/Enhancement

Alternative 11 would combine fall/winter flow enhancement at 400 cfs with targeted restoration/enhancement actions at Slough Camp, Ryan Ranch, and other Upper Deschutes River sites. This alternative would provide the same fall/winter flows in the Upper Deschutes River as proposed at year 21 for the proposed action and would implement targeted restoration actions for covered species. Restoration projects would be partially funded by a restoration fund for water leasing and habitat restoration actions in the Upper Deschutes River.

Alternative 12. Flow Enhancement through Conservation, Demand Management, and On-Farm Efficiencies

Alternative 12 would provide increased fall/winter and Oregon spotted frog breeding season minimum flows of 600 cfs through irrigation district water conservation, demand management, and water use efficiencies beyond current canal piping projects. This alternative would require on-farm water delivery and use efficiencies primarily for the Central Oregon Irrigation District and North Unit Irrigation District to improve water supply use efficiency in the Deschutes Basin.

Alternative 13. Reduced Permit Term

Alternative 13 would reduce the permit term to 20 years for the proposed action. This alternative would reduce the time ITPs are in place for covered species to address uncertainties about the feasibility and effectiveness of the conservation strategy.

Alternative 14. Preliminary Injunction Alternative

Alternative 14 would attempt to maintain stable water levels in Crane Prairie and Wickiup Reservoirs year round.[1] This alternative would provide Oregon spotted frog minimum breeding season/rearing flows of 770 cfs in the Upper Deschutes River by March 15 to September 15 and 600 cfs during over-wintering months. This alternative would increase flows for Oregon spotted frog breeding earlier and more than under the proposed action and would require greater fall/winter period flows than the proposed action.

Alternative 15. No Take Alternative

Alternative 15 would modify current operation and maintenance of covered activities to completely avoid take of covered species. Under this alternative form of no action, the Services would not issue ITPs because take would not occur.

[1] The plaintiffs preliminary injunction is addressed in injunction declaration filings for the Deschutes Basin HCP. This alternative is adapted from the alternative concepts in those documents (U.S. District Court, District of Oregon, Eugene Division 2016).

Table 1. Summary of Alternatives Options for Deschutes Basin HCP EIS

Alternative Component	Alternative 1: No Action	Alternative 2: Proposed HCP	Ideas for Action Alternatives	Scoping Comment or Other Inputs
Permit Mechanism	No programmatic or project HCPs and no incidental take permits. Separate and smaller HCPs are infeasible because of the inter-connectedness of the system and the inability of individual irrigation districts to adequately mitigate their activities on their own.	Two programmatic incidental take permits, one from FWS and one from NMFS, issued jointly to all permittees.	• Permits issued to all participating entities separately from FWS and NMFS, for a total of 18 incidental take permits.	Comments received indicating patron activities should be addressed.
Covered Species	N/A	Five proposed covered species: Oregon spotted frog, bull trout, steelhead trout, sockeye salmon, chinook salmon (spring run)	• Discussed Cascade frog as potential covered species in past but only occurs in small corner of Tumalo Creek upstream of TID diversion. • No alternatives available: Report prepared by HCP consultant clearly documents rationale for selection of proposed covered species	Comments received indicating that redband trout and native species should be addressed.
Covered Activities	Actions as currently required by the 2017 and 2019 Biological Opinion are assumed to continue and apply to the activities covered by that BiOp. Assume decreased future diversions due to reduced water demand from ongoing slow retirement of water rights to development and to increased water use efficiency	Operations and maintenance activities of nine private and federal dams in the Deschutes Basin that are operated by local irrigation districts; operation and maintenance of diversions, pumps, and intakes by the participating irrigation districts and the City of Prineville; operation and maintenance of water conveyance and delivery systems; water diversions and return flows by the participants; and HCP conservation measures.	• Limit covered activities to just Upper and Middle Deschutes Basin (no Crooked River). • Include operations and maintenance activities of Round Butte Dam/Lake Billy Chinook and Pelton Dam/Lake Simtustus (dams and reservoirs owned and operated by Reclamation). • If HCP limits water conveyance covered activity to the point of diversion, an alternative would be to add water conveyance to the point of delivery.	Comments were received that covered activities should include piping of water supply canals and patron laterals. Comments were received that the EIS should address the effects of on stream patron diversions.
Plan Area	N/A. BiOp actions would apply in same area as proposed HCP.	The Deschutes Basin watershed, in which all covered activities and conservation measures would occur	• Plan area excludes Crooked River system if covered activities exclude Crooked River.	Comments were received to make sure the distinction between the Plan Area and the Permit Area are clearly defined and to be clear what rivers and creeks are included.
Permit Area	N/A since no permits issued	Permits are limited to narrow corridors of covered river and stream segments, covered reservoirs, and covered diversion structures and canals.	• If covered activities are narrower than the proposed HCP, permit area would exclude the river segments and facilities no longer covered (e.g., Crooked River and facilities there). • Others?	Same as above.
Permit Term	N/A since no permits issued. BiOp is assumed to be renewed every 5–10 years.	30 years	• 20 year permit term • 40–50 year permit term	Comments were received that the permit term considered should range from 5–40 years and that shorter permit terms should be considered given uncertainties about species responses to the conservation strategy.

Alternative Component	Alternative 1: No Action	Alternative 2: Proposed HCP	Ideas for Action Alternatives	Scoping Comment or Other Inputs

Conservation Strategy	Includes actions in the 2017 and 2019 BiOp and 2005 Steelhead BiOp Incorporates effects of climate change.	Regulate water surface elevations and flow from Crane Prairie and Wickiup Reservoirs to minimize fluctuations during OSF breeding, rearing/foraging and overwintering
		
		Upper Deschutes minimum 600 cfs flow 4/1–9/15 subject to inflow and storage. 800 cfs flow limit 4/1–30.
		
		Upper Deschutes winter flow schedule to improve OSF habitat during winter up to 400 cfs by year 21
		
		Stock pond diversion coordination to prevent middle Deschutes from dropping below 250 cfs
		
		Crescent Creek minimum flow, 20 cfs and limit ramping rates
		
		Whychus Creek increased flows (31.18 cfs) after 5 years for salmonids
		
		Crooked River, Ochoco and McKay Creek flow increases, monitoring, conservation fund, and diversion structure requirements
			• No Crane Prairie Alternatives
			• Upper Deschutes flow increase to 500 cfs during winter by year 31
			• Upper Deschutes flow increase to 600 cfs during winter by year 41
			• Less flow in Upper Deschutes than proposed (550 or 600 cfs minimum)?
			• Variable flow in the Upper Deschutes depending on reservoir storage and forecasts (600 cfs)
			• More flow in Crescent Creek (30 cfs, 3/15 – 11/30)
			• Less flow in Crooked River than proposed
			• More flow in Crooked River than proposed
			• Greater summer flows in Upper Deschutes to benefit fish instead of OSF (see earlier public draft of HCP)
			• Flow regime in Upper Deschutes that benefits OSF over fish (what would this be?)
			• Combination Alternatives:
			  ○ Less flow in Upper Deschutes and Crooked River than proposed
			  ○ More flow in Upper Deschutes and Crooked River than proposed
			• Demand management, conservation and on-farm efficiencies
			• Market-based conservation incentives
			• Habitat restoration, enhancement and protection for OSF and salmonids
			• Piping patron canal laterals
			• Screen on- stream patron diversions
				Many comments were received about specific river and creek flows that should be required to improve covered species habitat conditions.
				
				Comments were received that the conservation strategy considered should fully account for potential effects on the local economy and reduce flow requirements to minimize social and economic effects.
				
				A comment was received that the EIS should evaluate a Recovery Alternative against which the proposed conservation strategy is compared.

Alternatives Screening

The goal of alternatives screening is to identify a reasonable range of alternatives to be considered in the EIS and to provide a structure for explaining and documenting the reasons why some alternatives were considered but not carried forward for detailed analysis in the EIS based on technical, economic and environmental considerations.

The screening process starts with a clear statement of purpose and need. If an alternative or alternative component can be clearly shown to not meet the purpose of the federal action it should be dismissed from further review. The lead agency should also develop a list of feasibility factors based on technology, environmental, economic, social, cost or legal factors. Alternatives that pass through the purpose and need screen are progressively narrowed at each level of the screening process.

For this EIS, a three phase screening process was used as described below and summarized in Tables 2, 3 and 4. Answers to screening questions are yes, maybe or no. Alternatives receiving yes or maybe responses were carried forward to the next screening level. Each progressive screening level from first to third applies increasingly stringent criteria to narrow the range of alternatives. In the first screening level, alternatives have been passed through the purpose and need screening criteria if most of the purpose and need is met. This approach is taken to ensure that a robust number of alternatives are considered for detailed review in the EIS and that the purpose and need statement does not unfairly eliminate alternatives from consideration in the EIS.

First Tier Screening Criteria

Is or does the potential alternative:

- Meet the purpose and need of the lead agency?
- Realistic and reasonable?
- Address a relevant issue identified or unresolved conflicts concerning project impacts, mitigation plans, or alternative uses of available resources?
- Provide for a streamlined endangered species permitting process?
- Provide a means to implement covered activities in a manner compliant with applicable state and federal fish and wildlife protection laws?
- Coordinate and standardize mitigation and compensation requirements in laws and regulations related to biological and natural resources in the plan area?

Second Tier Screening Criteria

- Does the alternative avoid or substantially lessen any of the significant environmental effects of, or potentially address one or more significant issues related to, the proposed action?
- Is the alternative different enough from other alternatives to allow for clear decision-making?

Third Tier Screening Criteria

- Are costs of the alternative marginal compared to those of the proposed action such that a reasonably prudent public agency would proceed with, or it would be practicable to proceed with, the potential alternative?
- Would implementation time compared with that of the proposed action result in the potential alternative meeting the project purpose within an acceptable time frame?
- Would technology or physical components required by the alternative be technically feasible?
- Would construction, operation, and/or maintenance of the potential alternative not violate any federal or state statutes or regulations?
- Would outcomes of the alternative be clearly desirable by the lead agency from a policy standpoint?

Alternatives Screening Conclusions

First Tier Screen

The first tier alternatives screening is summarized in Table 2. Of the 15 alternatives considered in the first tier screening, four alternatives were eliminated from consideration in the Draft EIS. Alternatives 8 and 9, which would restrict the covered species considered and covered activities on the Crooked River system, respectively, were eliminated because both alternatives would not meet the purpose and need to issue ITPs for the specified covered species requested by the applicants and Alternative 9 would likely not provide a means to implement covered actions outside the Deschutes River. Alternative 14, Preliminary Injunction Alternative, was eliminated from further review because the level of spring and winter flows suggested in this alternative has been shown to be unsustainable from a water storage/supply perspective and suggested flow levels could have unintended consequences for covered species (U.S. Fish and Wildlife Service 2017, 2019). Alternative 15, No Take Alternative, was eliminated from further consideration because although it has the potential to meet the purpose and need for issuing ITPs for covered species, implementing such an alternative would likely be infeasible and unrealistic because operation and maintenance of covered activities would need to be so severely restricted to achieve no take of covered species.

All of the other remaining 11 alternatives were passed through to the second tier alternatives screening.

Second Tier Screen

The second tier alternatives screening is summarized in Table 3. Of the 11 alternatives considered in the second tier screening, five alternatives were eliminated from further consideration in the Draft EIS. Alternatives 1, 5, and 12 were eliminated because flows under these alternatives were similar to those of Alternatives 2, 3, and 4 and could be captured within the range of those other alternatives. Alternatives 2, 3, and 4 were considered preferable based on the potential to achieve benefits for covered species. Alternative 5 was also considered to be marginally feasible given the rapid water operations changes considered under this alternative and the potential negative effects on water supply early in the permit term. Alternative 12 differed from other alternatives only in the mechanism for providing increased river flows for covered species, focusing on on-farm conservation and demand management, which are potential responses that could occur under many of the alternatives. Alternative 10 was eliminated from further consideration because the level of flows provided during the winter months is not thought to benefit Oregon spotted frog habitat areas on the Deschutes River and because the alternative is similar to the no-action alternative. Alternative 13 was eliminated because it is the same as the proposed action except that it has a shorter permit term—20 years versus 30 years. It was decided that the shorter permit term could be incorporated into another alternative.

The remaining 6 alternatives were passed through to the third tier alternatives screening.

Third Tier Screen

The third tier alternatives screening is summarized in Table 4. Of the 6 alternatives considered in the third tier screening, 2 alternatives were eliminated from further consideration in the Draft EIS and two alternatives were incorporated into the two remaining alternatives. Alternative 2, Enhanced Upper Deschutes River Flows and 50 Year Permit Term, was eliminated from further review because the length of the permit term was considered infeasible given some of the uncertainties about covered species' response to proposed conservation measures and practical considerations about issuing ITPs for an extended permit term. Scoping comments were also received requesting shorter permit terms to offset perceived uncertainty about species responses to the conservation strategy (see scoping comments). Alternative 11, Deschutes River Flow and Restoration/Enhancement, was eliminated from further consideration, because it could add substantial cost to the current conservation strategy and such habitat restoration and enhancement actions are already being implemented by the U.S. Forest Service, Upper Deschutes Watershed Council, and other local entities in the Deschutes River Basin. Incorporating habitat restoration and enhancement actions into an action alternative would also require changing an established basin approach. However, rejecting this alternative does not preclude including restoration funding for future projects that may improve conditions for covered species.

Alternative 6, Enhanced Variable Upper Deschutes River Flows, passed all of the screens and the concept of variable streamflow was incorporated into Alternative 3. Similarly, Alternative 7, Variable Deschutes River Flows with Reduce Permit Term, passed all of the screens and variable streamflow and a shortened 20-year permit term were incorporated into Alternative 4. Combining these alternatives is beneficial because it preserves a robust range of alternatives and incorporates important differences across the alternatives when compared to the no-action alternative.

Consideration of No-Action Alternative Options

Consideration has been given to options for no-action alternatives based on comments received from the applicants and guidance provided in the 2016 HCP Handbook. The HCP Handbook guidance provides:

> *If the project does not involve development, but rather some operation or maintenance regime, no action generally means the applicant will continue to operate in a way that avoids take. Examples of this version of "no action" include timber harvesting in a manner that avoids take, parkland operation and maintenance that avoids take, utility operation and maintenance that avoids take, operation of wind turbines in a way that avoids take, etc. (Section 13.3.2.1, page 13-7).*

This guidance contemplates operations and maintenance in the context of timber harvest plans, parks, utilities and wind turbine development, which would involve avoiding operating and maintaining facilities in portions of a plan area to avoid taking species. Although this no-take approach for the no-action alternative could be feasible for projects involving terrestrial species that occur in specific or localized habitats, it is less than practical for ongoing water supply facility operations and maintenance activities. This is because, in the case of the Deschutes Basin, a no-take scenario would likely involve severe restrictions to water supply operations that may preclude the Applicants from effectively delivering irrigation water. Further, historical operations have resulted in such significant modification of the physical structure of the river and the current location of listed species related to the covered activities that it is unclear what flow regime, if any, could be implemented that would result in no take. For example, no take for the Oregon spotted frog would likely require substantial reduction, or perhaps near elimination, of Deschutes Basin water supply operations.

Therefore, alternatives, including the no-action alternative, that require no take of the covered species were considered to be not realistic, reasonable, or feasible because implementing a no take alternative would not resolve covered species conflicts with water supply delivery; and would require severe restriction or substantial reduction of agricultural water supply in the basin. Because of the aquatic nature of the covered species addressed in this EIS, ensuring no take from current water management operations would likely be impossible without substantial water supply changes in the basin. For this project, this type of alternative would likely conflict with existing state and federal law, including basin water rights. Because of these conflicts, a no-take alternative for water management in the Upper Deschutes Basin, including for the no-action alternative, is considered infeasible and has been eliminated from further consideration in the Draft EIS.

Scoping comments were also received indicating that the no-action alternative should reflect the Services' recommendation for species protection actions in the absence of issuance of an ITP. In other words, what would the Services require or recommend of applicants in the absence of the proposed action and incidental take coverage? The Deschutes Project Biological Opinion (BiOp) provides guidance in the Conservation Recommendations section that identified several additional actions and recommendations for the draft HCP. For the reasons mentioned above, these measures alone would also not prevent take, however they would further reduce it. Elements from these recommendations were used in the development of alternatives, and currently are represented in Alternative 4. The purpose of a no-action alternative in an EIS is to establish a reasonable point of comparison for other action alternatives (46 Federal Register [FR] 18026 [March 23, 1981]) and to describe a predictable future without the proposed action. It provides information to a decision-maker about what could happen in the future if an action is not approved. It is not intended to dictate to applicants a particular course of action if an ITP is not approved.

Using this logic, the Services have chosen to describe the no-action alternative as continuation of existing operations as provided under the Deschutes Project BiOp (U.S. Fish and Wildlife Service 2017, 2019), and continuation of the NOAA 2005 BiOp requirements and other current programs and projects that would occur without implementation of the proposed project or alternatives.

Selected EIS Alternatives

Based on the three-tiered screening process, described above and summarized in Tables 2, 3 and 4, the following alternatives were identified as those to be analyzed in the Draft EIS.

- Alternative 1, No Action
- Alternative 2, Proposed Action (Deschutes Basin HCP)
- Alternative 3, Enhanced Variable Streamflow
- Alternative 4, Enhanced and Accelerated Variable Streamflow

Alternatives 3 and 4 evaluated in the Draft EIS were modified related to the timing and amount of winter streamflow based on an iterative RiverWare modeling exercise to optimize streamflow for Oregon spotted frog and fish.

Table 2. First Screen of Alternatives

Alternative Screening: First Screen Criteria	Alternative 1: Accelerated Upper Deschutes River Winter Flows	Alternative 2: Enhanced Upper Deschutes River Winter Flows and 50 year permit	Alternative 3: Enhanced Upper Deschutes River Winter Flows	Alternative 4: Accelerated and Enhanced Upper Deschutes River Winter Flows	Alternative 5: Modified Upper Deschutes River Winter Flows	Alternative 6: Enhanced Variable Upper Deschutes River Flows	Alternative 7: Variable Deschutes River Flows with Reduced Permit Term	Alternative 8: Reduced Covered Species	Alternative 9: Limit Covered Activities to Deschutes River	Alternative 10: Continuation of Current Voluntary Flows	Alternative 11: Deschutes River Flow and Restoration/Enhancement	Alternative 12: Flow Enhancement through Conservation	Alternative 13: Reduced Permit Term	Alternative 14: Preliminary Injunction Alternative	Alternative 15: No Take Alternative
Meet the purpose and need of FWS and the applicant?	Yes.	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Maybe	Yes	Yes	Yes	Maybe	Yes
Is the alternative realistic and reasonable?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Maybe	Maybe	Maybe	No	maybe	Yes	No	No
Address a relevant issue identified or unresolved conflicts concerning project impacts, mitigation plans, or alternative uses of available resources?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No
Provide for a streamlined endangered species permitting process?	Maybe	Maybe	Maybe	Maybe	Maybe	Maybe	Maybe	Maybe	Maybe	Maybe	No	Maybe	Maybe	Maybe	Yes
Provide a means to implement covered activities in a manner compliant with applicable state and federal fish and wildlife protection laws?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Maybe	Yes	Yes	Yes	Maybe	No
First Screen Summary	This alternative is carried forward to second tier screening	This alternative is carried forward to second tier screening	This alternative is carried forward to second tier screening	This alternative is carried forward to second tier screening	This alternative is carried forward to second tier screening	This alternative is carried forward to second tier screening	This alternative is carried forward to second tier screening	This alternative has been eliminated from detailed consideration in the EIS.	This alternative has been eliminated from detailed consideration in the EIS.	This alternative is carried forward to second tier screening	This alternative is carried forward to second tier screening	This alternative is carried forward to second tier screening	This alternative is carried forward to second tier screening	This alternative has been eliminated from detailed consideration in the EIS.	This alternative has been eliminated from detailed consideration in the EIS.

Table 3. Second Screen of Alternatives

Alternative Screening: Second Screen Criteria	Alternative 1: Accelerated Upper Deschutes River Winter Flows	Alternative 2: Enhanced Upper Deschutes River Winter Flows and 50 year permit	Alternative 3: Enhanced Upper Deschutes River Winter Flows	Alternative 4: Accelerated and Enhanced Upper Deschutes River Winter Flows	Alternative 5: Modified Upper Deschutes River Winter Flows	Alternative 6: Enhanced Variable Upper Deschutes River Flows	Alternative 7: Variable Deschutes River Flows with Reduced Permit Term	Alternative 10: Continuation of Current Voluntary Flows	Alternative 11: Deschutes River Flow and Restoration/Enhancement	Alternative 12: Flow Enhancement through Conservation	Alternative 13: Reduced Permit Term
Avoid or substantially lessen any of the significant environmental effects of, or potentially address one or more significant issues related to, the Proposed Action?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Different enough from another alternative to allow for clear decision-making?	No	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	No
Second Screen Summary	This alternative has been eliminated from detailed consideration in the EIS.	This alternative is carried forward to third tier screening	This alternative is carried forward to third tier screening	This alternative is carried forward to third tier screening	This alternative has been eliminated from detailed consideration in the EIS.	This alternative is carried forward to third tier screening	This alternative is carried forward to third tier screening	This alternative has been eliminated from detailed consideration in the EIS.	This alternative is carried forward to third tier screening	This alternative has been eliminated from detailed consideration in the EIS.	This alternative has been eliminated from detailed consideration in the EIS.

Table 4. Third Screen of Alternatives

Alternative Screening: Third Screen Criteria	**Alternative 2: Enhanced Upper Deschutes River Winter Flows and 50 year permit**	**Alternative 3: Enhanced Upper Deschutes River Winter Flows**	**Alternative 4: Accelerated and Enhanced Upper Deschutes River Winter Flows**	**Alternative 6: Enhanced Variable Upper Deschutes River Flows**	**Alternative 7: Variable Deschutes River Flows with Reduced Permit Term**	**Alternative 11: Deschutes River Flow and Restoration/Enhancement**
Costs are marginal compared to those of the proposed action such that a reasonably prudent public agency would proceed with, or it would be practicable to proceed with, the potential alternative?	Yes	Yes	Yes	Yes	Yes	No
Implementation time compared with that of the proposed action would result in the potential alternative meeting the project purpose within an acceptable time frame?	No	Yes	Yes	Yes	Yes	Maybe
Technology or physical components required would be clearly technically feasible?	Yes	Yes	Yes	Yes	Yes	Yes
Construction, operation, and/or maintenance of the potential alternative would not violate any federal or state statutes or regulations?	Maybe	Maybe	Maybe	Maybe	Maybe	Maybe
Outcomes could be clearly desirable from a policy standpoint?	Maybe	Yes	Yes	Yes	Yes	No
Third Screen Summary	This alternative has been eliminated from detailed consideration in the EIS.	This alternative is carried forward for analysis in the Draft EIS	This alternative is carried forward for analysis in the Draft EIS	This alternative concept has been incorporated into Alternative 3 carried forward to the Draft EIS.	This alternative concept has been incorporated into Alternative 4 carried forward to the Draft EIS.	This alternative has been eliminated from detailed consideration in the EIS.

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Appendix 2-B

No-Action and Cumulative Scenarios

Appendix 2-B
No-Action and Cumulative Scenarios

Tables 1 and 2 present information on the past, current, and future projects considered in the no-action and cumulative analyses. In some instances, projects or their outcomes were less certain and were therefore considered only in the cumulative scenario. These projects are denoted with an asterisk (*) in the tables.

Table 1. Past and Current Projects

Project	Description
Water Conservation Projects	
Tumalo Irrigation District	Allocation of Conserved Water projects implemented by Tumalo ID through 2013 resulted in instream water rights of 17.67 cfs in Tumalo Creek and 331.5 AF of water released from Crescent Lake Reservoir. Similar projects from 2014 through 2018 have resulted in instream water rights of about 2.45 cfs for Tumalo Creek and 51.6 acre-feet for Crescent Lake Reservoir. (Vaughn pers. comm.)
Three Sisters Irrigation District	Allocation of Conserved Water projects implemented by Three Sisters ID have resulted in instream water rights of about 28.18 cfs in Whychus Creek. With recent completion of canal modernization, an additional 3 cfs of conserved water is anticipated. (Vaughn pers. comm.)
Central Oregon Irrigation District	Allocation of Conserved Water projects and permanent instream water right transfers implemented by Central Oregon ID between 2006 and 2013 have resulted in instream water rights of about 25 cfs in the Deschutes River and 4 cfs in the Crooked River. (Vaughn pers. comm.)
Swalley Irrigation District	Allocation of Conserved Water projects implemented by Swalley ID between 2006 and 2013 resulted in instream water rights of about 35 cfs in the Deschutes River. (Vaughn pers. comm.)
North Unit Irrigation District	Allocation of Conserved Water projects implemented by North Unit ID between 2006 and 2013 have resulted in instream water rights of about 1 cfs in the Deschutes River and 23 cfs in the Crooked River. (Vaughn pers. comm.)
Resource Protection and Enhancement Projects	
City of Prineville Wastewater Treatment Wetlands	The City of Prineville's Crooked River Wetland Complex, which was completed in 2016, improved 2 miles of riparian corridor along the Crooked River and constructed over 120 acres of wetlands, benefitting many species of fish and wildlife, including lower river temperatures.
Crooked River Stream Habitat Restoration	This Crooked River Watershed Council project addressed passage and screening at 13 of 17 sites considered to be significant barriers to fish on the Crooked River.
Camp Polk Meadow Preserve	This Deschutes River Conservancy project protects 151 acres of the Camp Polk Meadow Preserve, which contains approximately 1.4 miles of Whychus Creek with wetlands, meadows, aspen groves and ponderosa pine stands.
Tumalo Creek Bridge to Bridge Restoration	This USFS project, completed in 2007, restored channel stability, fish and wildlife habitat, and riparian vegetation to 2.2 miles of Tumalo Creek damaged in the 1979 Bridge Creek Fire.

Project	Description
Whychus Creek Floodplain Restoration and Dam Removal Project	This USFS project addressed the loss of floodplain and flood channel connection to the creek that resulted from berm construction following the 1964 flood.
Whychus Creek Restoration	This project is led by the Deschutes Partnership, a consortium of the Deschutes Land Trust, Deschutes River Conservancy, and the Upper Deschutes Watershed Council, procured land along Whychus Creek for restoration, increased streamflow on Whychus Creek during the low flow summer months, and completed riparian habitat restoration and fish passage projects.
Three Sisters Irrigation Diversion Dam and Fish Passage Restoration	This Three Sisters Irrigation District project, completed in 2011, restored fish passage and habitat for resident and anadromous fish above the Three Sisters Irrigation diversion dam.
Vandervert Ranch Fish Habitat	This project, led by Upper Deschutes River Watershed Council and the Oregon Watershed Enhancement Board, would accelerate the process of creating undercut banks, providing improved environments for trout in the Little Deschutes River.
Deschutes River Spawning Enhancement	This USFS project restored approximately 100 cubic yards of spawning gravel to the Deschutes River immediately below Wickiup Dam.
Ryan Ranch Wetland Restoration	This USFS and Upper Deschutes River Watershed Council project restored 0.3 mile of riverbank along the Upper Deschutes River, including the natural hydrological function of a historic slough floodplain.

cfs = cubic feet per second; USFS = U.S. Forest Service.

Table 2. Reasonably Foreseeable Future Projects

Project	Description
Water Conservation Projects	
Tumalo Irrigation District Irrigation Modernization Project	This canal piping project, which began in October 2018 and has an anticipated 12-year timeline, would protect conserved water instream under Oregon's Allocation of Conserved Water process and thereby increase instream flow below irrigation diversions in the Middle Deschutes River and Tumalo Creek. Flows would increase incrementally over the first 10 years of the analysis period as projects are completed (Farmers Conservation Alliance 2018a).
Swalley Irrigation District Irrigation Modernization Project	This canal piping project, which is planned to begin in 2019 and has an 8- to 9-year timeline, would protect conserved water instream under Oregon's Allocation of Conserved Water process and thereby increase instream flow below irrigation diversions in the Middle Deschutes River and Tumalo Creek. Flows would increase incrementally over the first 10 years of the analysis period as projects are completed (Farmers Conservation Alliance 2018b).
Central Oregon Irrigation District*	According to Central Oregon ID's *Preliminary Investigative Report for the Central Oregon Irrigation District Irrigation Modernization Project* (Farmers Conservation Alliance 2017), Central Oregon ID would pipe up to 75 miles of canals and laterals delivering approximately 5 cfs or greater. The project would reduce canal seepage losses by up to 156 cfs (Farmers Conservation Alliance 2017:27).

Project	Description
Lone Pine Irrigation District*	According to Lone Pine ID's *Preliminary Investigative Report for the Lone Pine Irrigation District Irrigation Modernization Project* (Farmers Conservation Alliance 2018), Lone Pine ID would replace up to 15 miles of LPID's existing canal system with approximately 11.3 miles of pipe, reducing the length of pipe required through realignment of the existing conveyance system. The project would reduce canal seepage by up to 8.8 cfs. (Farmers Conservation Alliance 2018c:37).
Ochoco Irrigation District*	According to Ochoco ID's *Preliminary Investigative Report for the Ochoco Irrigation District Infrastructure Modernization Project* (Farmers Conservation Alliance 2019), Ochoco ID would pipe high priority canals and laterals in the district, install new pump stations and include activities to implement the McKay Creek Water Rights Switch (Farmers Conservation Alliance 2019:12).
Arnold Irrigation District*	According to Arnold ID's *Preliminary Investigative Report for the Arnold Irrigation District Infrastructure Modernization Project* (Farmers Conservation Alliance 2019), Arnold ID would pipe up to 31.5 miles of canals and laterals, 13 miles of aerial flume and open Arnold Canal and 18.5 miles of open laterals. The project would reduce canal seepage losses by up to 45.1 cfs (Farmers Conservation Alliance 2019:33)
McKay Creek Water Rights Switch	This Deschutes River Conservancy project would restore up to 11.2 cfs and eliminate all direct creek withdrawals from river miles 6 through 12 by exchanging McKay Creek water rights with Ochoco Irrigation District water rights from the larger Crooked River system and permanently transferring the McKay rights instream.
Resource Protection and Enhancement Projects	
Opal Springs Fish Passage	This Crooked River Watershed Council project will construct a fish ladder at Opal Springs Dam to restore access to approximately 130 miles of habitat in the Lower Crooked River, including McKay and Ochoco Creeks. The fish ladder is expected to be operational by winter 2019.
Deschutes River Trail Restoration	This USFS project would restore sections of the Deschutes River Trail between Benham and the forest boundary (Meadow trailhead to Sunriver) to the natural character and would also restore riparian zones.
Upper Deschutes Riparian Habitat Conservation Area Restoration	This USFS project would restore riparian areas along the Upper Deschutes River, downstream of the Wickiup Dam to Burgess Road that have been affected by heavy dispersed recreation to the natural character through subsoiling, seeding, and planting native species.
Upper Little Deschutes Restoration Project	This USFS project would restore two areas totaling 6,286 acres along the Little Deschutes River beginning in 2020 to increase shallow groundwater retention and improved hyporheic flow, in support of Oregon spotted frogs. (Wilcox pers. comm.)
Farewell Bend Park Riparian Restoration	This project, led by the Upper Deschutes River Watershed Council and Bend Park and Recreation District, completed an inventory and assessment of riverbank conditions on 10.5 miles of district-owned property, summarized conditions at 13 locations, and identified opportunities for restoration and improved river access. The first potential project is located between the Bill Healy Bridge and the Farewell Bend footbridge.
Crooked River Stream Habitat Restoration	The Crooked River Watershed Council expects to complete an additional 20 miles of stream restoration projects in the mainstem Crooked River, Ochoco Creek, and McKay Creek are anticipated within the next 10 years.
Whychus Canyon Restoration	Deschutes River Conservancy plans to restore 6 miles of Whychus Creek, 3.6 miles of which will consist of restored meadow habitat, and its associated

Project	Description
	floodplain to provide high quality spawning and rearing habitat as well as wetland and riparian habitat for resident and migratory wildlife. The project would restore the key functions and values of the historic wet meadows and associated in-stream and riparian habitats.
2018 Pre-Commercial Thin	This ongoing USFs project will continue implementing approximately 4,300 acres of pre-commercial thinning. Activities overlap with the study area in Little Deschutes River and Crescent Creek. Vegetation management will be oriented toward enhancement of scenic and wildlife values and is consistent with the management for these Wild and Scenic Rivers, which are designated as Recreation Rivers. (Wilcox pers. comm.)
North Unit Irrigation District Water and Energy Conservation Initiative	Deschutes River Conservancy supports water quality and fish habitat improvements in the Crooked River through a water banking agreement allocated from Central Oregon ID. The project would improve water management and increase hydropower generation at two existing facilities, generating 318,638 kilowatt hours of renewable energy annually in perpetuity. The project would enhance irrigation conveyance efficiencies, generate 1,300 acre-feet of new Deschutes River water supply for farmers in North Unit ID, 1,300 acre-feet of new instream water rights in the lower Crooked River, address limiting factors of low flow and temperature, and facilitate the reallocation of water from an agricultural water use to an environmental water use.
Deschutes River Water Leasing Program	Deschutes River Conservancy manages this program to lease water rights that are not currently being used with districts and landowners. Leases enhance flows in the Deschutes River, Whychus Creek, Tumalo Creek, Lower Crooked River, and Little Deschutes River.
Deschutes River Water Right Transfers	Deschutes River Conservancy manages this program to acquire and transfer water rights for dedication to permanent instream use. Instream transfers may be for restoration or mitigation purposes, serving to meet instream flow targets and the needs of farmers, cities, and other new groundwater uses.
Pelton Round Butte Fund	This Portland Gas and Electric fund would provide $21 million by 2020 for projects in the Deschutes Basin, such as removing fish passage barriers, stabilizing stream banks, restoring channels and floodplains, and conserving water.

* Denotes project is only considered under the cumulative scenario.
cfs = cubic feet per second; ID = Irrigation District.

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Appendix 2-C

Rationale for Oregon Spotted Frog Conservation Fund

September 2019

Rationale for Oregon Spotted Frog Conservation Fund

The Service is outlining a recovery strategy for Oregon spotted frog (OSF) in the Upper Deschutes River Basin and a draft Recovery Plan for the species is anticipated in 2021. In general, a conservation strategy for OSF in the Upper Deschutes River Basin will include the following biological goals:

- Expand the overall distribution of populations and increase population viability and abundance of OSF to contribute to the regional recovery of the species.
- Reduce threats to existing populations of OSF.
- Increase the number of individuals in all age classes at known sites.
- Increase connectivity between disjunct populations.

Oregon spotted frogs in all sub-basins across the range are subject to more than one stressor (i.e., threats). Many OSF breeding sites are small and isolated from each other. Because of OSF's fidelity to breeding locations, fluctuating water levels in the embryonic and tadpole life stages, combined with risk of predation and low overwinter survival, may result in the species being vulnerable to rapid population declines. Changing climate has the potential to exacerbate these stressors through changes in timing and availability of snow and rain events that sustain wetland habitat or creating temperature more favorable to non-native predators, competitors, or disease (Blaustein et al. 2010, p. 288 – 289).

The Upper Deschutes River and Little Deschutes River sub-basins are occupied by OSF and within the area affected by water management covered by the Deschutes Basin HCP (HCP). The HCP covers approximately 35 percent of the geographic area designated as OSF critical habitat deemed essential for the conservation of the species.

Threats to OSF within the geographic area covered by the HCP, identified in the 2014 ESA listing (79 FR 51658) and the Service's Deschutes Project Biological Opinion (USFWS 2017 and 2019), include not only hydrological changes due to water management but continued wetland habitat loss due to a lack of natural disturbance processes (e.g., floods, fire, beaver activity, etc.). Open water areas within wetlands are being encroached upon by lodgepole pine, cattails and shrubs. Reed canarygrass, an invasive species, is present within a number of OSF sites and render these habitats less suitable for OSF as it spreads. Introduced predators such as bullfrogs and nonnative fish also are present within a number of OSF sites and active management is necessary to reduce predation on spotted frogs.

Oregon spotted frog conservation measures outlined in the draft HCP have aimed to adjust the timing and volume of water stored and released to improve hydrological conditions within spotted frog habitat at key times during the species lifecycle. The proposed conservation measures in the draft HCP will occur over time as the HCP permit is expected to span 30 years. Therefore, the anticipated benefits to OSF habitat from hydrological changes will vary spatially and temporally within the Upper Deschutes River Basin. Currently, the draft HCP only addresses the threat to OSF from water management.

In the Deschutes River downstream of Wickiup Dam, the proposed HCP conservation measures that increase winter flow may not be sufficient to improve hydrological conditions that support spotted frog habitat for a number of years post implementation. Furthermore, passive and active habitat restoration of the river and OSF habitat is not feasible in some areas until hydrological improvements are achieved (e.g., winter flow increases in the Deschutes River). Habitat maintenance work at OSF sites will be necessary to reduce existing threats to OSF and maintain population viability currently and into the future as flows are restored to the Deschutes River. Funds are needed to implement site specific actions to improve habitat conditions for OSF.

Restoring Spotted Frog Habitat in the Upper Deschutes River Basin

This document outlines some of the OSF conservation actions that could be implemented spatially and temporally within the Upper Deschutes River Basin for OSF within the context of the Deschutes Basin HCP. Some of these conservation actions could be implemented in the short-term, prior to and concurrent with hydrological adjustments to storage and release from reservoirs as identified in the draft HCP. As the Service develops a Recovery Plan (anticipated draft in 2021) for Oregon spotted frog, actions that promote recovery will be further identified in an Implementation Plan for the Upper Deschutes River Basin.

Crane Prairie Reservoir

Invasive species are among the existing threats to OSF at Crane Prairie reservoir. The US Forest Service is working to control invasive aquatic weeds in Crane Prairie. However, reed canarygrass is not among the aquatic weeds currently being treated. Treatment of reed canarygrass at Crane Prairie reservoir will be necessary to prevent spread into OSF breeding sites. The Oregon Department of Fish and Wildlife is working to control nonnative brown bullheads within Crane Prairie. Funds to continue these invasive species control efforts will be necessary in the future.

Wickiup Reservoir

The feasibility of habitat enhancement for spotted frogs within Wickiup Reservoir will likely be dependent upon future management of the reservoir and the fluctuation of water storage volumes.

Deschutes River and Adjacent Wetlands Below Wickiup Reservoir

Restoration of the functioning condition of the Deschutes River is a key path to restoring spotted frog habitat and improving connectivity between OSF populations between Wickiup Dam and Bend, OR. Restoration in this segment of the Deschutes River is primarily dependent upon improvement of flows coupled with some site-specific physical river channel habitat improvements that convey water into oxbows and wetland habitats where spotted frogs occur.

Within the regulated water management regime, the physical configuration of the Deschutes River combined with the variation in the timing and duration of flow volumes within its channel (described in terms of cubic feet per second (cfs)) influence the ecological function of the river and wetlands inhabited by spotted frogs. In its current condition, the Deschutes River channel is wider by approximately 20 percent than it was historically as a result of storage and release operations from Wickiup Dam (USFS 1996). The widened river channel affects the way water is distributed spatially onto the floodplain and into wetlands. Essentially, higher than historical flows are needed to reach and support the ecological function of floodplain wetland habitats where spotted frogs occur.

Wetland habitats have shifted in distribution due to the high summer flows for irrigation and the hydroperiod (i.e., seasonal timing and duration of water) within wetlands has changed under the regulated water management regime. The vegetative characteristics of wetland and riparian areas are dependent on the volume, timing, and duration that water is present. High irrigation season flows result in deep inundation of riverine slough habitats, inhibiting the growth of emergent wetland vegetation in many areas. During the irrigation storage season when flows in the Deschutes River are lowest, large unvegetated areas within the wetlands are without water. Although wetland habitat may extend further onto the Deschutes River floodplain due to high summer flows, the existing condition of wetlands is degraded due to water storage and release operations such that spotted frog may not successfully complete its lifecycle (USFWS 2017; USFWS 2019).

The upper end of the Deschutes River hydrograph (i.e., high summer flows) results in similar damage to the riparian vegetation. Ongoing degradation of the river is evident. The widened channel in many areas is unvegetated, a result of the erosive processes that have occurred in the past and continue as water is stored and released. In this regulated system, hydrograph modification with the purpose of restoring physical and ecological function to the Deschutes River and wetlands should trend toward a more natural flow regime. In a hypothetically restored condition, flows from Wickiup Dam could range from approximately 500 cfs in winter to approximately 1,200 cfs during the summer season[1]. Improving the ecological function of the river and wetland habitat for OSF will require both passive and active restoration.

The draft HCP proposes to increase winter flows up to 400 cfs by year 21 of the permit. The effect of increases in winter flows results in lower summer flows, thus trending toward a less abrupt hydrograph on an annual basis. Prior to and concurrent with increases in winter flows anticipated via HCP implementation, there are OSF conservation actions needed to improve habitats and reduce threats to the species. Restoration and conservation opportunities will vary spatially and temporally within the Upper Deschutes River basin. Examples of potential conservation and restoration actions for OSF and its habitat are bulleted below. We anticipate

[1] This is a hypothetical flow scenario to illustrate a range in flows that could support physical and ecological function of the river while providing optimum passive and active restoration opportunities.

that continued monitoring of OSF sites will inform additional actions necessary to support OSF conservation and recovery.

Deschutes River winter flows between 100 and 300

Winter flows between 100 and 300 cfs will allow for localized and site specific restoration activities to mitigate risk to existing OSF populations. When these flows are being achieved, the types of restoration and conservation actions that provide benefits to OSF and its habitat include but are not limited to:

- Reed canary grass treatment at existing OSF sites.
- Bull frog removal in Sunriver.
- Treatment of encroaching vegetation (cattails, lodgepole, etc) in Sunriver, Slough Camp and LSA Marsh.
- Potential beaver dam analog at Dead Slough to mitigate headcut formation and maintain winter water at higher elevations.

Deschutes River winter flows at 400

Winter flows of 400 cfs will allow for localized and site specific restoration activities to mitigate risk to existing OSF populations. These flows may facilitate connectivity between overwintering and breeding habitat areas for OSF. Some passive restoration is likely to occur under this flow scenario but active management of OSF sites will be necessary. When these flows are being achieved, the types of restoration and conservation actions that provide benefits to OSF and its habitat include but are not limited to:

- Site specific riparian planting as passive restoration occurs.
- Reed canary grass treatment at existing OSF sites.
- Bull frog removal in Sunriver.
- Treatment of encroaching vegetation (cattails, lodgepole pine, etc.) in Sunriver, Slough Camp and LSA Marsh.
- Potential beaver dam analog at Dead Slough to mitigate headcut formation and maintain winter water at higher elevations.

Deschutes River winter flows at 500

Winter flows of 500 cfs are likely to support passive and active restoration opportunities while maximizing the potential to develop site specific restoration activities to mitigate risk to existing OSF populations. Physical habitat restoration of the Deschutes River channel is likely to support the ecological function of the river and adjacent wetlands for OSF. Improved base flow in winter increases the opportunity to intercept groundwater within floodplain wetlands. Higher winter flows facilitate connectivity between overwintering and breeding habitat areas for OSF.

Based on observations of flows and corresponding floodplain inundation in past studies (USFS 1996; USFWS 2017), winter flows of at least 500 cfs in the Deschutes River downstream of Wickiup Dam are necessary to support riparian vegetation. Inundation of the root systems of riparian plants through winter along the river corridor will facilitate bank stabilization and lessen the impact of erosion and sedimentation to the river as flow releases from the dam increase during spring and summer.

Winter flows of 500 cfs could support the following types of restoration and conservation actions that provide benefits to OSF and its habitat:

- Bank restoration and planting riparian vegetation.
- Wood placement within channel to improve depositional aggradation to reduce cross-sectional area of river channel thus improving floodplain/wetland connectivity to river channel.
- Beaver dam analogs in oxbows, side channels and wetlands to moderate the effects of flow fluctuations.
- Excavation of existing wetlands and river to improve hydrological connectivity.
- Reed canary grass treatment at existing OSF sites.
- Excavation of oxbows on floodplain to intercept groundwater.
- Physical habitat modifications at site scale to benefit specific life stages of OSF.

Little Deschutes River Basin (including Crescent) - Winter flows at ~20 to 30 cfs from Crescent

There are potential opportunities to conduct conservation actions for OSF on Federal and private lands under the current and future flow regime as only a portion of this sub-basin is affected by storage and release operations at Crescent Dam. Approximately 70 percent of the lands adjacent to the Little Deschutes River and Crescent Creek are in private ownership. Therefore, private lands are important to conservation and recovery of OSF.

Current plans are underway to implement bull frog control on private lands in the lower reaches of the Little Deschutes River. A team of volunteers and consultants, with help from Federal and State agencies, are developing a strategy to control bull frogs and reduce threats to OSF. Funding to support these efforts will be needed in the future.

The following types of conservation and restoration activities may be conducted within the Little Deschutes River sub-basin to support OSF conservation:

- Installation of beaver dam analogs and wood structures within channel to increase duration and spatial extent of water on the floodplain and within oxbow habitats to support spotted frog life cycles and habitat connectivity.
- Riverbank restoration.
- Reed canary grass treatment along the river and at OSF sites.
- Bull frog removal to reduce predation on spotted frogs.
- Excavation of oxbows on floodplain to intercept groundwater.

Restoration of spotted frog sites outside of lands affected by water management

There are several OSF sites (e.g., Upper Little Deschutes River Restoration Project area (Odell Pasture), Long Prairie, etc.) outside of the area affected by water management in the Upper and Little Deschutes River sub-basin where wetland function could be restored to promote OSF conservation. Some of these sites (e.g., Dilman) need maintenance to reduce existing threats to

OSF. Funds are needed to implement restoration and maintenance of existing OSF where threats to the species are present and ongoing.

Citations

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Appendix 3.1-A
Regulatory Environment

Appendix 3.1-A
Regulatory Environment

Following are the regulations that are applicable to the proposed action and alternatives, by resource.

Water Resources

Law, Regulation, or Program	Description
Federal	
Interior Department Appropriation Act, 1955 (68 Statute 361, Public Law 83-465)	Authorized the emergency rehabilitation of Crescent Lake Dam on July 1, 1954.
Emergency Relief Appropriation Act of 1935	Initiated the Deschutes Project and approved construction of Crane Prairie Dam to replace an existing dam.
Section 4 of the Act of June 25, 1910 (36 Stat. 836) and Subsection B of Section 4 of the Act of December 5, 1924 (43 Statute 702)	Found the North Unit of the Deschutes Project to be feasible by Secretary of the Interior on September 24, 1937, and subsequently approved by the President on November 1, 1937.
Act of August 6, 1956	Authorized the Crooked River Project.
Crooked River Collaborative Water Security and Jobs Act of 2014	• Authorizes the release of 5,100 acre-feet (af) of stored water from Prineville Reservoir to serve as mitigation for the City of Prineville groundwater pumping. • Authorizes the use of 2,740 af of uncontracted, stored water to replace some of the agricultural water supply that previously has been diverted out of McKay Creek. • Increases the amount of uncontracted, stored water that is authorized for release to benefit downstream fish and wildlife (previously limited to 10 cubic feet per second), while providing non-discretionary protection for the priority of certain water contracts. All such releases will be pursuant to an annual release schedule to be developed by Reclamation. • The first fill protection is subject to compliance with the U.S. Army Corps of Engineers' flood curve requirements and the original 10 cubic foot per second release to benefit fish and wildlife. The annual first fill protection extends to: ○ 68,273 af of water to fulfill 16 existing USBR water supply contracts; ○ 2,740 af of water to supply certain McKay Creek lands; ○ 10,000 af of water made available to North Unit Irrigation District (or certain other USBR contractors) under temporary water service contracts; and ○ 5,100 af of water made available to the City of Prineville
State	
Water Rights Act, ORS 537.010 et. seq.	Provides that all water within the state belongs to the public and establishes state regulation of appropriation of water for beneficial use consistent with the act.
Ground Water Act of 1955	Provides for state regulation of groundwater.

Law, Regulation, or Program	Description
Deschutes Basin Ground Water Mitigation Rules, OAR 690-505-0600–690-505-0630 (authorized by ORS 537.746)	Establishes the mitigation process for groundwater permit applications in the Deschutes Ground Water Study Area.
Water Distribution Rules, OAR Chapter 690, Division250	Guides the administration of Oregon water laws related to regulatory actions.

ORS = Oregon Revised Statute; OAR = Oregon Administrative Rule

Water Quality

Law, Regulation, or Program	Description
Federal	
Section 303, Clean Water Act	Applies to water quality standards to be met.
Section 10, Rivers and Harbors Act of 1899, 33 U.S.C. 403	Applies to activities that could affect navigable waters of the United States.
Section 404, Clean Water Act, 33 U.S.C. 1344	Discharge of dredged or fill-material into waters of the United States, including wetlands. Permits are issued following public interest review and analyses according to EPA's Section 404(b)(1) guidelines.
State	
ORS 196.795-990	Removal/fill permits.
ORS 568.900 to 568.933; ORS 561.191	Oregon Department of Agriculture authority for water quality.
ORS Chapter 527	Oregon Department of Forestry authority for water quality.
ORS 468B.030,468B.035	Oregon has primacy for implementing the National Pollutant Discharge Elimination Program under the Clean Water Act.

Biological Resources

Law, Regulation, or Program	Description
Federal	
Magnuson-Stevens Fishery Conservation and Management Act, 16 U.S.C. 1801 et seq.	Requires an *essential fish habitat* consultation between the National Marine Fisheries Service and the federal lead agency to document potential harm to essential habitats used by fish species that are managed under federal fisheries management plans, measures for avoiding and minimizing adverse effects, and any conservation measures used to offset these effects.
Bald and Golden Eagle Protection Act, 16 U.S.C. 668–668c	Provides protection for bald and golden eagles.
Migratory Bird Treaty Act, 16 U.S.C. 703–712	Makes it illegal to take any migratory bird.
Fish and Wildlife Coordination Act, 16 U.S.C. 661–666	Applies to water resource activities affecting general fish and wildlife resources.

Law, Regulation, or Program	Description
Endangered Species Act, 16 U.S.C. 1531 et seq.	Protects species listed as threatened or endangered. Section 7 requires federal agencies to avoid taking actions that jeopardize listed species or that destroy or adversely modify their critical habitat. Section 10 lays out the standards for obtaining incidental take permits in conjunction with habitat conservation plans for listed species.
Section 10, Rivers and Harbors Act of 1899, 33 U.S.C. 403	Regulates via a permitting program activities that could affect navigable waters of the United States.
Plant Protection Act of 2000, 7 U.S.C. 7701 et seq.	Addresses protection of native plants and sets forth quarantine requirements for foreign plant species in the United States, including noxious weeds.
Treaty with the Tribes of Middle Oregon (1855)	Set aside reservation land and reserve fishing, gathering and hunting for the Confederated Tribes of Warm Springs.
United States v. Winans, 198 U.S. 371 (1905)	U.S. Supreme Court held that the Treaty with the Yakama of 1855, and similar treaties, protects tribal access rights to fishing, hunting, and other privileges on off-reservation lands.
United States v. Oregon 302 F. Supp. 899 (D. Or. 1969)	Ongoing federal court case that protects and implements the reserved fishing rights of Columbia River treaty tribes. The federal court continues to oversee the management of the Columbia River through the United States v. Oregon proceedings. Fisheries in the Columbia River and its tributaries are co-managed by the states of Washington, Oregon, and Idaho as well as four treaty tribes and other tribe's traditional fishing areas.
Section 404, Clean Water Act, 33 U.S.C. 1344	Regulates the discharge of dredged or fill material into waters of the United States, including wetlands. Provides for the issuance of permits for such discharge under certain circumstances following a public interest review and analyses according to the U.S. Environmental Protection Agency's Clean Water Act Section 404(b)(1) guidelines.
Treaty with the Tribes of Middle Oregon (1855)	Treaty with Confederated Tribes of Warm Springs, establish the reservation and ceded lands. Reserve fishing, hunting, gathering roots and berries, and pasturing their stock in ceded lands and usual and accustomed stations on unclaimed lands.
Secretarial Order 3206 (1997)	Clarifies the responsibilities of the Department of the Interior and Department of Commerce to ensure that Indian tribes do not bear a disproportionate burden for the conservation of listed species.
State	
Oregon Endangered Species Act, O.R.S. 496.002–496.192	Triggers internal state consultations when activities taken by state agencies on state lands may affect state-listed threatened or endangered species. Such consultations are typically completed in conjunction with federal agency consultation under Section 7 of the federal Endangered Species Act, as appropriate.
Oregon Removal-Fill Permit, O.R.S. 196.795–900	Requires parties who plan to remove or fill material in wetlands or waterways to obtain a permit from the Department of State Lands.
Oregon Revised Statute Chapter 569–Weed Control	Gives the Oregon Department of Agriculture authority to regulate noxious weeds and to require any landowner to implement noxious weed control measures.

Law, Regulation, or Program	Description
Oregon Revised Statute Chapter 570–Plant Pest and Disease Control; Invasive Species	Allows agricultural inspectors to impose quarantines, establish control areas, and otherwise regulate management of plant pests, including noxious weeds.
O.A.R. 603–052–1200—Quarantine; Noxious Weeds	Designates plants that are noxious weeds and provides requirements for control measures.
O.A.R. 603–073, "Plants: wildflowers and endangered, threatened, and candidate species"	Defines and lists candidate, threatened, and endangered plants in Oregon and places prohibitions on harvest or collection of such plants.
Oregon Policy to Recovery and Sustain Native Stocks	Sets policy to achieve goals to achieve recovery and sustainability of native stocks of salmon and trout.

Land Use and Agricultural Resources

Law, Regulation, or Program	Description
Federal	
Farmland Protection Policy Act, 7 U.S.C. 4201	Preserves farmland; prohibits unnecessary conversion of farmland for non-agricultural use. Makes provisions for restoring, maintaining, and improving the quantity and quality of farmland. Farmland governed under the act includes prime farmland, unique farmland, and land of statewide or local importance; also includes forestland, pastureland, cropland, or other land, but not water or urban built-up land.
Upper Deschutes Resource Management Plan (Bureau of Land Management 2005)	Provides management direction and guides future actions on lands administered by the Bureau of Land Management.
Lower Deschutes River Management Plan, Record of Decision (Bureau of Land Management 1993)	Provides management direction and guides future actions on lands administered by the Bureau of Land Management.
Supplement to the Lower Deschutes River Management Plan, Lower Deschutes River Allocation System, Final Decision (Bureau of Land Management 1997)	Provides updated management direction and guides future actions on lands administered by the Bureau of Land Management.
Shoreline Management Plan, Pelton Round Butte Project, FERC Project Number 2030 (Portland General Electric Company and the Confederated Tribes of the Warm Springs Reservation of Oregon 2011)	Guides new development and resource protection on the shorelines of Lake Billy Chinook and Lake Simtustus to achieve a balance of the interests of the Licensees and private and commercial property owners and recreational users, while allowing the Licensees to efficiently manage the Project's power generating facilities and fulfill the Project purposes.
Prineville Reservoir Resource Management Plan (Bureau of Reclamation 2003)	Provides management direction and guides future actions for Prineville Reservoir.
Forest Plan: Deschutes National Forest (U.S. Forest Service 1990)	Provides national forest–wide and area-specific standards and guidelines for recreation and other uses of U.S. Forest Service lands.

Law, Regulation, or Program	Description
State	
Statewide Planning Goals and Guidelines, Goal 3: Agricultural Lands, OAR 660-015-0000(3)	Preserves and maintains agricultural lands for farm use, consistent with existing and future needs for agricultural products, forest, and open space.
State Agricultural Land Use Policy, ORS 215.243	Declares that open land used for agricultural use is an efficient means of conserving natural resources and should be preserved to maintain the state's agricultural economy.
Regional/Local	
Crook County Comprehensive Plan (Crook County 2003)	Preserves agricultural lands, protects agriculture as an economic enterprise, balances economic and environmental considerations, limits non-agricultural development, maintains a "low" population density, and maintains a high level of livability in Crook County.
Deschutes County Comprehensive Plan (Deschutes County 2011)	Preserves and maintains agricultural lands and the agricultural industry; retains agricultural lands through Exclusive Farm Use zoning.
Jefferson County Comprehensive Plan (Jefferson County 2013)	Preserves, protects, and maintains agricultural and rangeland that is presently under production, or has the potential to be productive. Recognizes the importance of irrigation for crop production.
Klamath County Comprehensive Plan (Klamath County 2010)	Economically stabilize the agricultural community in Klamath County, including the designation of agricultural lands as "Exclusive Farm Use" that are subject to the regulations of Exclusive Farm Use zones.
Wasco County Comprehensive Plan (Wasco County 2010)	Protect agriculture as an important part of the economy of Wasco County.

Aesthetics and Visual Resources

Law, Regulation, or Program	Description
Federal	
National Scenic Byways (Federal Highway Administration 1995)	Designates roadways as National Scenic Byways or All-American Roads based on six criteria of scenic, historic, recreational, cultural, archaeological, and/or natural intrinsic qualities.
National Wild and Scenic Rivers Act (16 U.S.C. §§ 1271–1287)	Establishes a National Wild and Scenic Rivers System for the protection of certain rivers as designated as wild, scenic, or recreational.
Deschutes National Forest Land and Resource Management Plan (Deschutes National Forest 1990) (pp. 36, 121, 130, 153, 155–158, 190, 200–202)	Identifies protections for Wild and Scenic Rivers (WS and M17) and scenic views (M9).
Cascade Lakes National Scenic Byway Corridor Management and Interpretive Plan 2011 (Deschutes National Forest 2011) (pp. 11–13)	Establishes strategies for management and protection of the scenic corridor.

Law, Regulation, or Program	Description
Newberry National Volcanic Monument Comprehensive Management Plan (Deschutes National Forest 1994) (pp. 22, 34, 39, 51–55, 65–66)	Establishes strategies for management and protection of the National Monument.
Metolius River Wild and Scenic River Management Plan (Deschutes National Forest 1997) (pp. 3, 7)	Establishes strategies for management and protection of the Wild and Scenic River.
Upper Deschutes River Wild and Scenic Rivers and State Scenic Waterway Comprehensive Management Plan (Deschutes National Forest 1996) (pp. 30, 32–34, 37–38)	Establishes strategies for management and protection of the Wild and Scenic River and State Scenic Waterway.
Whychus Creek Wild and Scenic River Management Plan (Deschutes National Forest 2010) (p. 35)	Establishes strategies for management and protection of the Wild and Scenic River.
Ochoco National Forest Land and Resource Management Plan (Ochoco National Forest 1989) (pp. 4-180, 4-182, 4-194, 4-241)	Identifies protections for Dispersed Recreation (Management Area 14 or MA-F14), Riparian (MA-F15), General Forest Winter Range (MA-F21), and General Forest (MA-F22), in addition to forest-wide protections for scenery management.
State	
Oregon Scenic Waterways Act (ORS §§ 390.805–390.940, State of Oregon 2018a, 2018b)	Designates state scenic rivers that are free-flowing, provide scenic quality as viewed from the river, and offer sustainable natural and recreational resources.
Oregon Scenic Byways and Bikeways (Oregon Tourism Commission and Oregon Department of Transportation 2018)	Designates scenic byways and bikeways that meet key criteria.
Regional/Local	
Comprehensive Plans for Crook, Deschutes, Jefferson, Klamath, Sherman, and Wasco Counties and for the Cities of Maupin, Madras, Sisters, Redmond, Bend, La Pine, Prineville	Provide goals and objectives for aesthetics and visual resources and other uses on unincorporated private lands within the planning area.

Recreation

Law, Regulation, or Program	Description
Federal	
National Wild and Scenic Rivers Act (16 U.S.C. §§ 1271–1287)	Established in 1968 to balance development with preservation of rivers possessing outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, in free-flowing condition, and to protect their immediate environments for the benefit and enjoyment of present and future generations.
Upper Deschutes Wild and Scenic River Management Plan, Record of Decision and Final Environmental Impact Statement (U.S. Forest Service 1996)	Defines standards and guidelines for recreation and other uses on U.S. Forest Service lands associated with the Upper Deschutes River Wild and Scenic River area.
Upper Deschutes Resource Management Plan (Bureau of Land Management 2005)	Provides management direction and guides future actions on lands administered by the Bureau of Land Management.
Lower Deschutes River Management Plan, Record of Decision (Bureau of Land Management 1993)	Provides management direction and guides future actions on lands administered by the Bureau of Land Management.
Supplement to the Lower Deschutes River Management Plan, Lower Deschutes River Allocation System, Final Decision (Bureau of Land Management 1997)	Provides updated management direction and guides future actions on lands administered by the Bureau of Land Management.
Lower Crooked River, Chimney Rock Segment, Middle Deschutes/Lower Crooked Wild and Scenic Rivers' Management Plan (Bureau of Land Management 1992)	Provides management direction and guides future actions on lands administered by the Bureau of Land Management.
Whychus Creek Wild and Scenic River Management Plan (U.S. Forest Service 2010)	Defines desired future conditions, consistent and inconsistent uses, and standards and guidelines for management of Whychus Creek Wild and Scenic River (formerly Squaw Creek).
Big Marsh Creek Little Deschutes River Wild and Scenic Rivers Management Plan (U.S. Forest Service 2001)	Defines standards and guidelines for recreation and other uses on U.S. Forest Service lands associated with the Big Marsh Creek Little Deschutes River area.
Shoreline Management Plan, Pelton Round Butte Project, FERC Project Number 2030. (Portland General Electric Company and the Confederated Tribes of the Warm Springs Reservation of Oregon 2011)	Guides new development and resource protection on the shorelines of Lake Billy Chinook and Lake Simtustus to achieve a balance of the interests of the Licensees and private and commercial property owners and recreational users, while allowing the Licensees to efficiently manage the Project's power generating facilities and fulfill the Project purposes.

Law, Regulation, or Program	Description
Prineville Reservoir Resource Management Plan (Bureau of Reclamation 2003)	Provides management direction and guides future actions for Prineville Reservoir.
Forest Plan: Deschutes National Forest (U.S. Forest Service 1990)	Provides national forest–wide and area-specific standards and guidelines for recreation and other uses of U.S. Forest Service lands.
State	
Oregon Scenic Waterways Act (ORS 390.805–390.925)	Established in 1970 and specifies that all fill and removal in a State Scenic Waterway requires an individual removal-fill permit from the Department of State Lands. Protects free-flowing character of designated rivers, protects and enhances scenic and natural values, and promotes expansion of the scenic waterways system.
Regional/Local	
Comprehensive Plans for Crook, Deschutes, Jefferson, Klamath, Sherman, and Wasco Counties.	Provide goals and objectives for recreation and other uses on unincorporated private lands within the planning area.

Tribal Resources

Law, Regulation, or Program	Description
Federal	
Treaty with the Tribes of Middle Oregon (1855)	Treaty with Confederated Tribes of Warm Springs, establish the reservation and ceded lands. Reserve fishing, hunting, gathering roots and berries, and pasturing their stock in ceded lands and usual and accustomed stations on unclaimed lands.
The Klamath Tribes Treaty of 1864	Set aside reservation land and reserve fishing, gathering and hunting for the Klamath Tribes on reservation lands.
United States v. Winans, 198 U.S. 371 (1905)	U.S. Supreme Court held that the Treaty with the Yakama of 1855, and similar treaties, protects tribal access rights to fishing, hunting, and other privileges on off-reservation lands.
United States v. Oregon 302 F. Supp. 899 (D. Or. 1969) "Sohappy v. Smith"	Ongoing federal court case that protects and implements the reserved fishing rights of Columbia River treaty tribes. The federal court continues to oversee the management of the Columbia River through the United States v. Oregon proceedings. Fisheries in the Columbia River and its tributaries are co-managed by the states of Washington, Oregon, and Idaho as well as four treaty tribes, Warm Springs, Yakama, Umatilla and Nez Perce tribes.
Endangered Species Act of 1973 (16 USC 1531 et seq.)	NMFS is responsible for managing, conserving, and protecting ESA-listed marine and anadromous species. All state fisheries are subject to review by NOAA Fisheries.
United States v. Washington, 384 F. Supp. 312 (W.D. Wash. 1974) "Boldt Decision"	Federal district court interpreted the rights of treaty tribes to take fish in their "usual and accustomed places in common with all citizens" to mean that treaty tribes have a treaty-reserved right to harvest 50% of the harvestable portion of fish.
Executive Order 12875; Enhancing the Intergovernmental Partnership (1993)	Establish regular and meaningful consultation and collaboration with state, local, and tribal governments.

Law, Regulation, or Program	Description
Secretarial Order 3206 (1997)	Clarifies the responsibilities of the Department of the Interior and Department of Commerce to ensure that Indian tribes do not bear a disproportionate burden for the conservation of listed species.
Confederated Tribes of The Warm Springs Reservation Water Rights Settlement Agreement (1997)	The Confederated Tribes of the Warm Springs Reservation entered into a water rights settlement agreement with the State of Oregon and U.S. government on November 17, 1997. Settles the tribes water rights boarding the reservation and on reservation.
Executive Order 13175; Consultation and Coordination with Indian Tribal Governments (2000)	Establishes regular and meaningful consultation and collaboration with tribal officials in the development of federal policies that have tribal implications.
Commerce Department Administrative Order (DAO 218-8) (2012)	Implements Executive Order 13175, Consultation and Coordination with Indian Tribal Governments, and describes the actions to be followed by the Department of Commerce concerning tribal self-government, trust resources, treaty, and other rights.
Secretarial Order 3317 (2011)	Update, expand, and clarify Department of Interior policies on consultation with tribes and provisions for conducting consultation in compliance with EO 13175.
Secretarial Order 3335 (2014)	Reaffirmation of the Federal Trust Responsibility to Federally Recognized Indian Tribes and Individual Indian Beneficiaries.
National Historic Preservation Act Section 106, 36 CFR Part 800	Requires federal agencies to take into account the effects of their undertakings on historic properties and to provide the Advisory Council on Historic Preservation (ACHP) with a reasonable opportunity to comment. Federal agencies are required to consult on the Section 106 process with State Historic Preservation Offices (SHPO), Tribal Historic Preservation Offices (THPO), Indian Tribes (to include Alaska Natives) [Tribes], and Native Hawaiian Organizations (NHO).
State	
Executive Order EO-96-30; State/Tribal Government to Government relations	Establish formal government-to-government relationships between Oregon's Indian tribes and Oregon State is to establish a process which can assist in resolving potential conflicts, maximize key intergovernmental relations and enhance an exchange of ideas and resources.
Relationship of state agencies with Indian Tribes ORS 182.162 to 182.168	Oregon state agencies to develop and implement policy on relationship with tribes; cooperation with tribes.
Regional/Local	
No local laws, regulations, or treaties apply to tribal resources.	

Socioeconomics and Environmental Justice

Law, Regulation, or Program	Description
Federal	
Executive Order 12898	Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, directs federal agencies to identify and address the disproportionately high and adverse environmental effects (including human health, economic, and social effects) of their actions on minority and low income populations. The order promotes access for minority and low-income communities to public information and public participation.
State	
Oregon Environmental Justice Task Force	The Environmental Justice Task Force (EJTF) was created by the Legislature in 2007 (Senate Bill 420) to help protect Oregonians from disproportionate environmental impacts on minority and low-income populations. The EJTF encourages state agencies to give all people knowledge and access to improve decisions that affect environment and the health of all Oregonians.

Cultural Resources

Law, Regulation, or Program	Description
Federal	
36 CFR 800	Implementing regulations of Section 106 of the National Historic Preservation Act.
National Historic Preservation Act	Legislation requiring consideration of cultural resources where projects include federal money, permitting, or land. The National Historic Preservation Act outlines a process for consideration that includes consultation, identification, evaluation, and mitigation of adverse effects of projects on significant cultural resources.
National Environmental Policy Act	Legislation requiring environmental review of projects with federal involvement. Environmental review includes consideration of cultural resources although no process for such consideration is outlined in NEPA.
State	
ORS 358.653	Oregon state legislation requiring consideration of project impacts on cultural resources including consultation with the state historic preservation office. This law is superseded by Section 106 if a project has a federal nexus.
Oregon's Goal 5: Natural Resources, Scenic and Historic Areas, and Open Spaces	To protect natural resources and conserve scenic and historic areas and open spaces.

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None

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None

Biological Resources

None

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Tribal Resources

None

Socioeconomics and Environmental Justice

None

Cultural Resources

None

Appendix 3.1-B
RiverWare Model Technical Memorandum

RECLAMATION
Managing Water in the West

Technical Memorandum

Hydrologic Evaluation of Alternatives for the Deschutes Basin Habitat Conservation Plan

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Regional Office

August 2019

Mission of the U.S. Department of the Interior

The Department of the Interior (DOI) conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

Mission of the Bureau of Reclamation

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Acronyms and Abbreviations

AF	Acre-feet
AID	Arnold Irrigation District
CENO	Central Oregon Canal (part of COID)
cfs	cubic feet per second
COID	Central Oregon Irrigation District
DRC	Deschutes River Conservancy
DBHCP	Deschutes Basin Habitat Conservation Plan
EIS	Environmental Impact Statement
LPID	Lone Pine Irrigation District
MWRV	Minimum Winter Release Volume
NCAO	North Canal (part of COID)
NUID	North Unit Irrigation District
OID	Ochoco Irrigation District
OSF	Oregon Spotted Frog
SID	Swalley Irrigation District
TID	Tumalo Irrigation District
TSID	Three Sisters Irrigation District
OWRD	Oregon Water Resources Department
Reclamation	Bureau of Reclamation

1. Introduction

The Bureau of Reclamation is cooperating with U.S. Fish and Wildlife service on the Environmental Impact Statement (EIS) for the Deschutes Basin Habitat Conservation Plan (DBHCP) on the Deschutes River in central Oregon. As part of that study, Reclamation used a RiverWare model of the river, distribution, and reservoir system to simulate the alternatives for the EIS. This technical memorandum documents the model representation of the alternatives and summarizes a selection of the results.

2. Reference RiverWare Model

The water resources modeling for the DBHCP EIS was conducted using a daily time-step RiverWare (Zagona et al. 2001) model of the Deschutes Basin above the Pelton Round Butte reservoir complex. A short summary of the model is presented here. The model development is described in-depth in Reclamation 2017a.

Unregulated hydrology is input to the model and represents river flows, stream gains (springs or small tributaries) and losses without reservoir operations or diversions. The model then applies rules to operate the system with different configurations of logic and in-stream and consumptive demands. The unregulated hydrology is mean daily flows from water years 1980 to 2009 (October 1980 through September 2009). Reclamation 2017c documents how these data were developed.

The RiverWare model represents the Upper Deschutes River, Crescent Creek, Little Deschutes River, Tumalo Creek, Whychus Creek, Crooked River, and Ochoco Creek. Figure 1 shows a map of the Deschutes River and Crooked River Basins and the included tributaries.

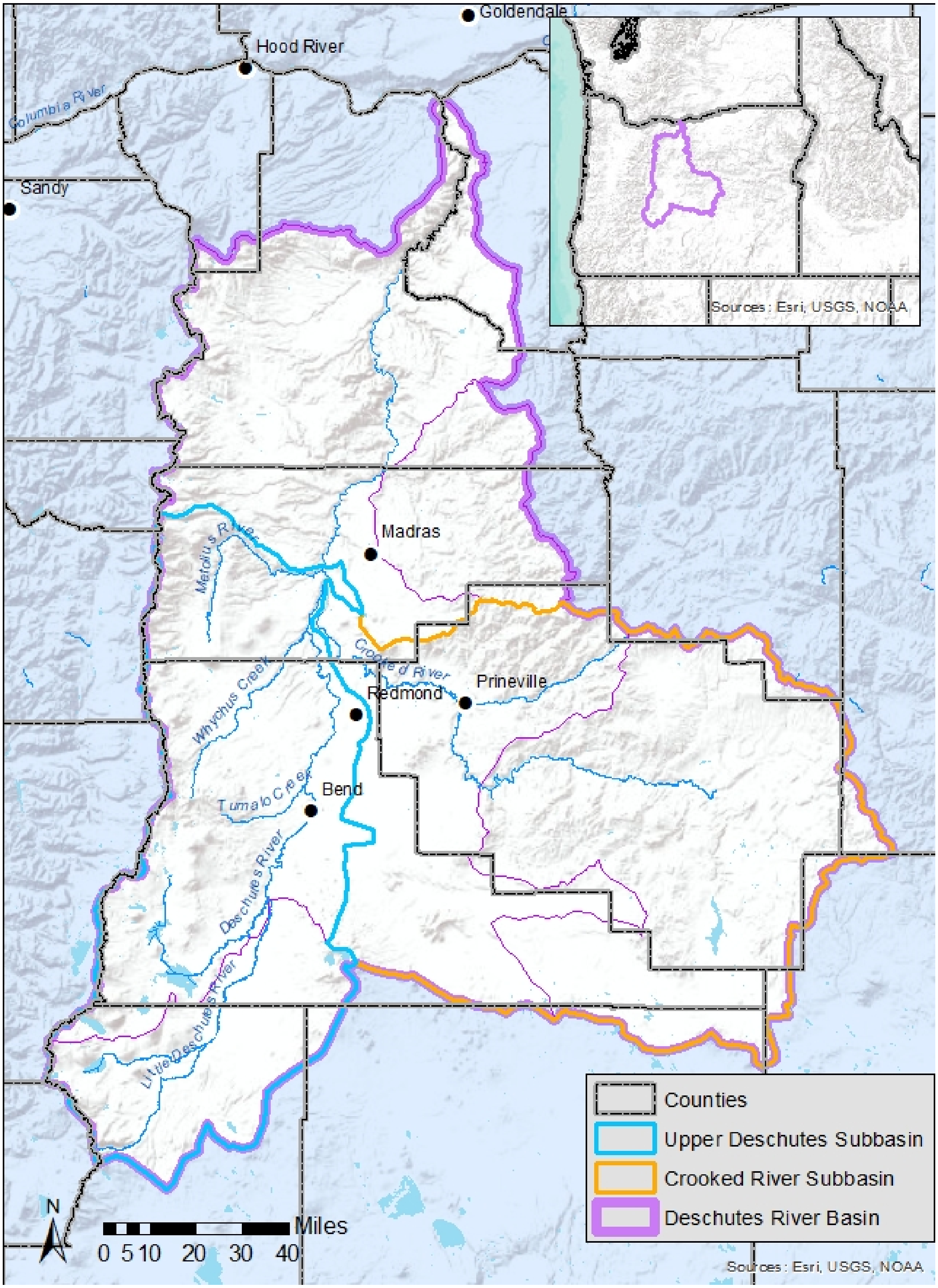


Figure 1. Deschutes River and Crooked River Basins.

RiverWare is a general rules-based modeling platform that requires full definition of the physical layout of a river system and logic to define operation of the system. The model is constructed using RiverWare objects that define reservoirs, diversions, river reaches, control points (which monitor in-stream flow locations), and river gages. Figure 2 and Figure 3 diagram the layout of the RiverWare model for the Upper Deschutes and the Crooked River subbasins, respectively. The red circles indicate water users (representing diversions) and are labeled with the irrigation district or other water user acronym that they serve. The yellow boxes indicate stream gages and are named with their four-letter acronym from the Hydromet program (https://www.usbr.gov/pn/hydromet/), with the exception of the Highway 126 gage on the Crooked River. The green triangles represent locations where gains and losses are input into the model. The blue diamonds represent control points. The model itself has more detail than these schematics, but they show the most relevant features of the model.

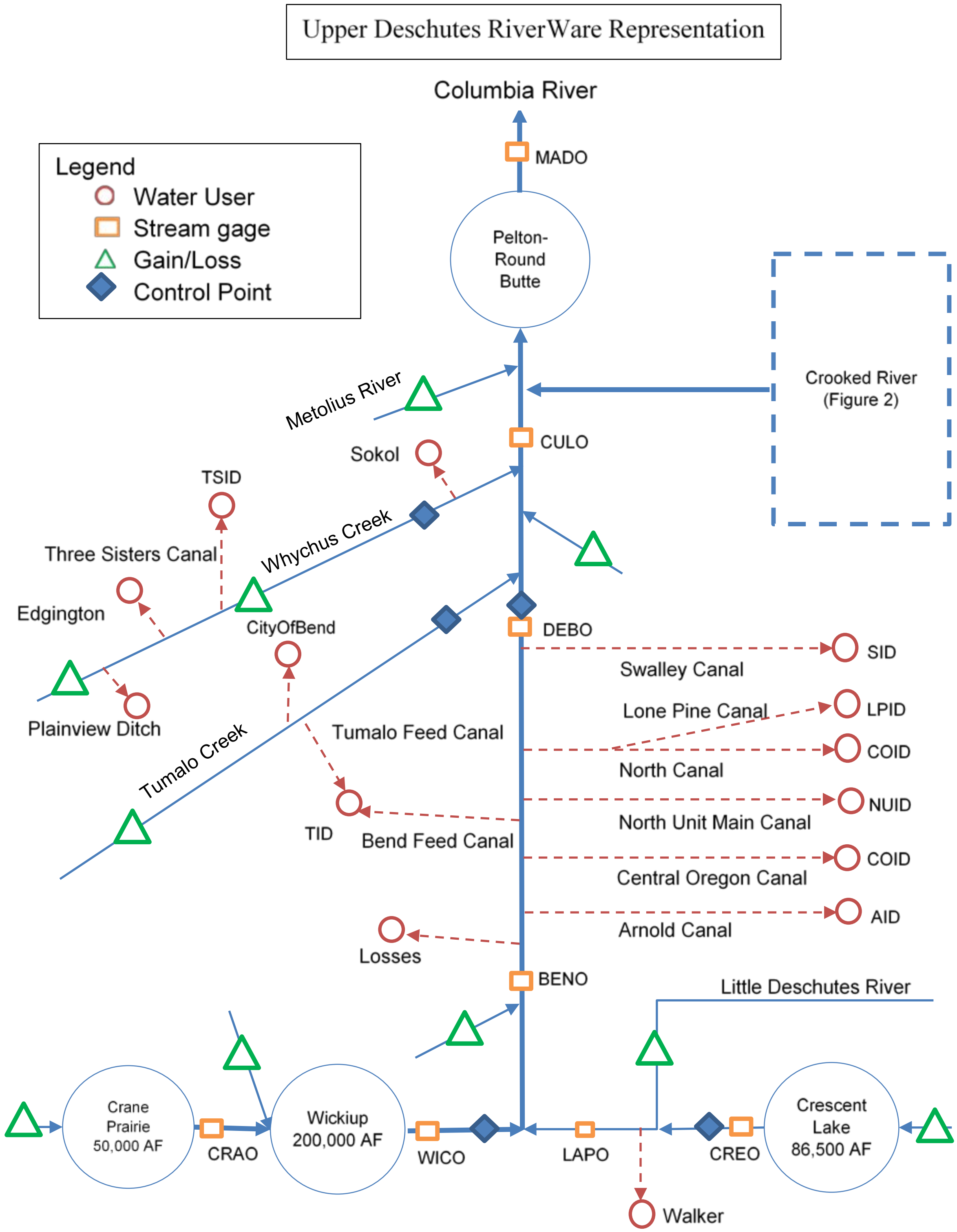


Figure 2. Schematic of RiverWare representation of Upper Deschutes River.

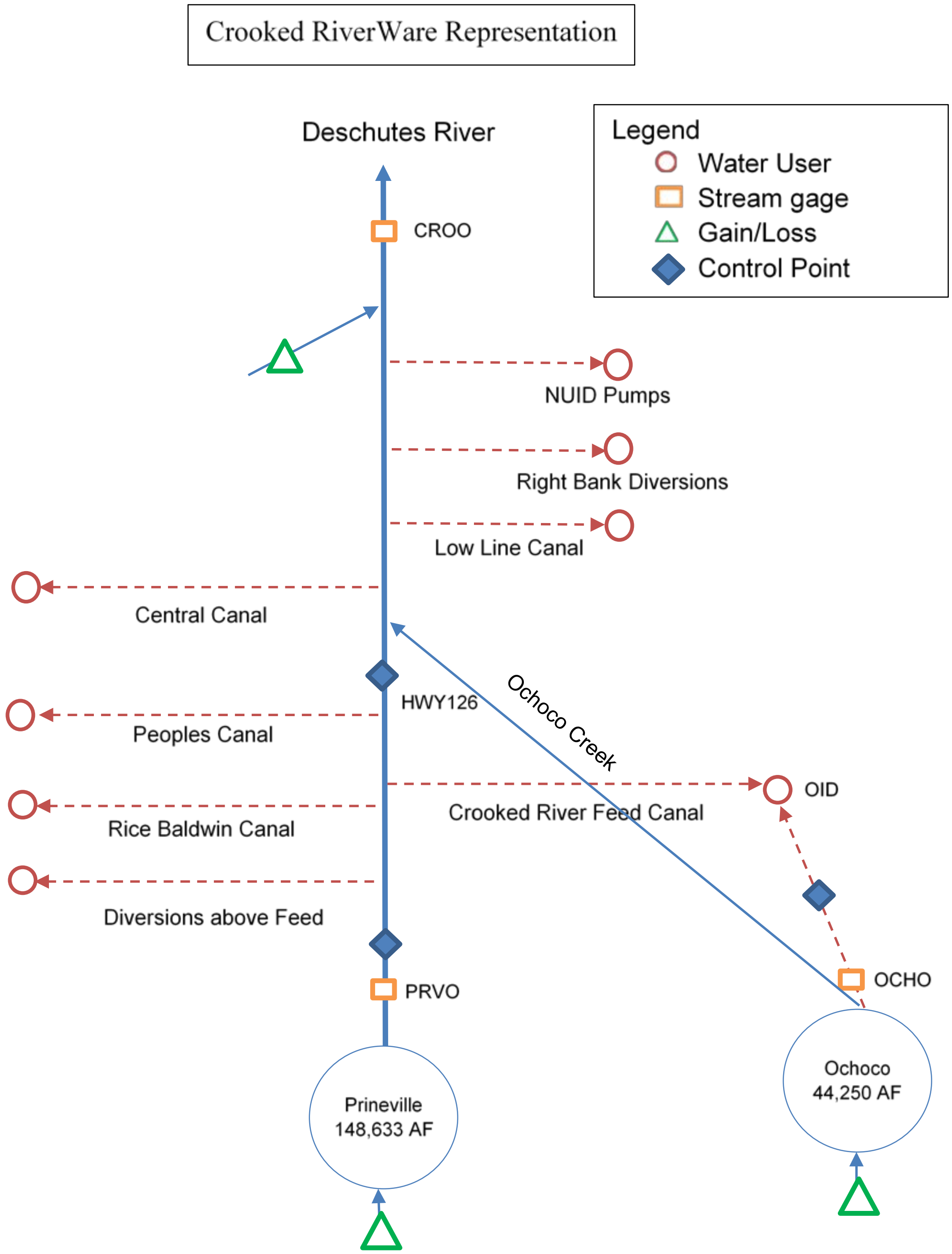


Figure 3. Schematic of RiverWare representation of Crooked River.

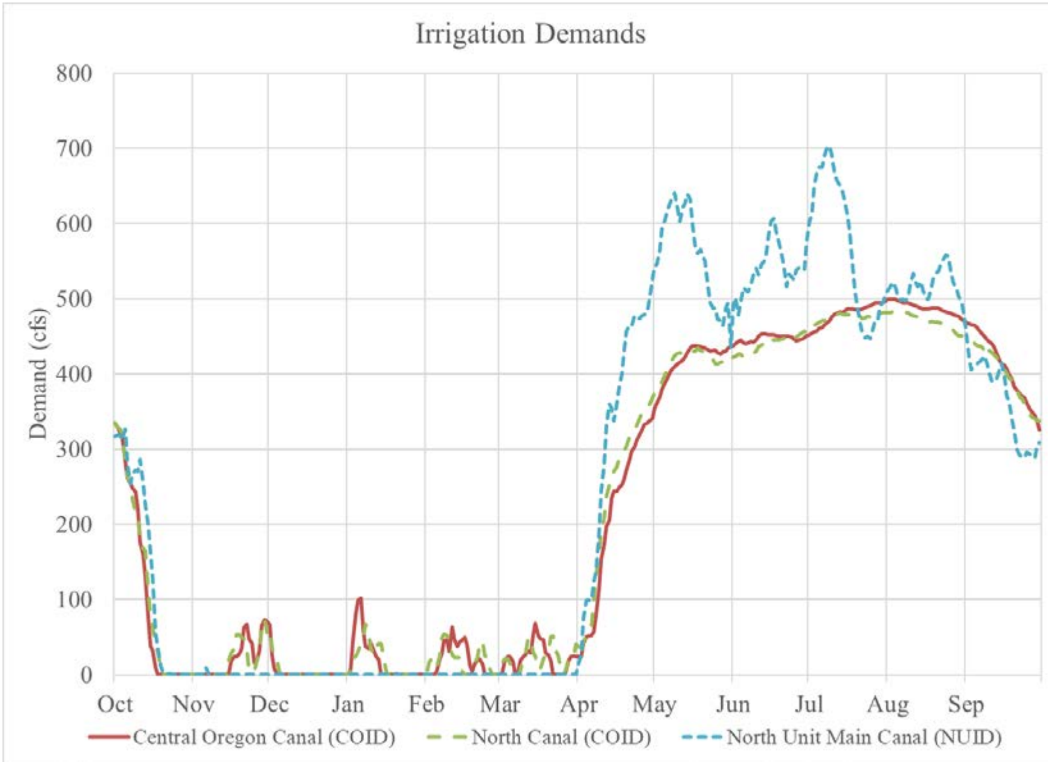
Operating rule logic was first developed to simulate historical operations from 1984 through 2009[1], the years in which measured data could be compared to model output to ensure proper operation. The model used water rights, diversion patterns, and inflow hydrology representative of the time period. Detailed information about the inputs and calibration quality is described in Reclamation 2017a. Then, the operating logic was updated to incorporate recent changes in the basin including the Oregon Spotted Frog (OSF) Biological Assessment (Reclamation 2017b) and the Crooked River Collaborative Water Security and Jobs Act of 2014. The details of those operations are described in Section 2.2 and Section 2.3.

It is important to recognize that there are many assumptions and simplifications that are required when developing a model. The data and operating logic attempt to simulate realistic conditions and water management as closely as possible, but it is likely there will be some operations that are handled differently in real time. The operations described in this report are relatively new and are still undergoing changes as real-time experience informs the operation.

2.1. Irrigation Demand Pattern

For scenario-based studies, it is common to develop a version of the model that simulates current conditions (baseline model). This model is meant to indicate the response of a system using the current operation definition to historical inflow hydrology. For the baseline model, diversions were changed from the historical daily time series that varies from year to year to a single daily pattern that repeats annually representing average irrigation diversions calculated from measured data for recent years. By using a single year pattern for diversion, the effects of management changes can be examined more easily because they are not combined with the effects of changing demands. Figure 4 shows the daily diversion pattern that is repeated every year for the model simulation period for the eight DBHCP applicant irrigation districts. Table 1 shows the year ranges and total average annual volume for each district.

[1] Measured data was available for most locations in the basin starting in 1984. Model development began shortly after 2010, so 2009 was used as the end year for calibration.



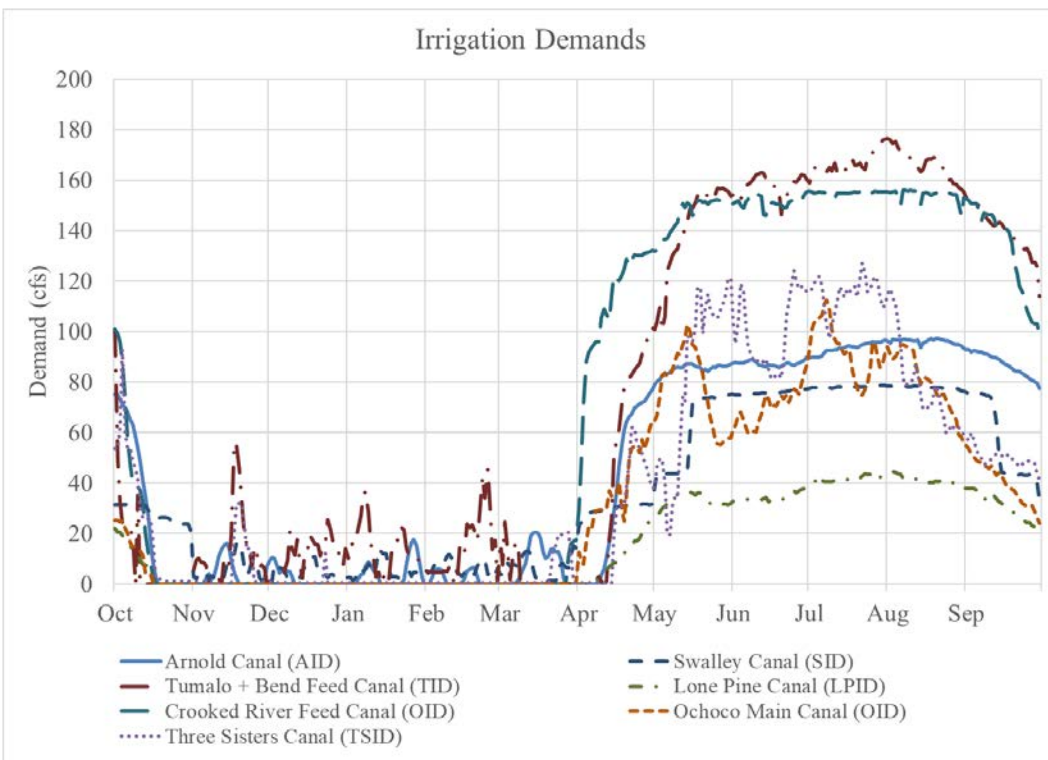


Figure 4. Daily diversion pattern that is repeated for every year in the model simulations. Top: larger diversions for COID and NUID. Bottom: smaller diversions for remaining districts.

Table 1. Total annual demand used in modeling along with years used to calculate demand.[2]

District	Years Used in Average	Total Annual Demand (acre-feet)
AID	2010-2017	32,266
COID	2010-2017	303,703
LPID	2010-2017	16,017
NUID	2010-2017	182,963
OID	2010-2017	77,824
SID	2013-2017	26,372
TSID	2011-2016, with manual adjustments for recent operational changes outside the irrigation season	35,004
TID	2009, 2010, 2011, 2013, 2014	53,517

2.2. Baseline Upper Deschutes River Operation

Baseline operating rules for the Upper Deschutes River reflect the operating criteria in the Oregon Spotted Frog Biological Assessment (Reclamation 2017b). Generally, the operation is intended to minimize elevation changes in Crane Prairie Reservoir and set a minimum outflow from Wickiup Reservoir. In addition, winter outflows from Crane Prairie Reservoir, Wickiup Reservoir, and Crescent Lake were all larger than historical releases to enhance habitat conditions in the downgradient stream network.

2.2.1. Crane Prairie Reservoir

Crane Prairie Reservoir is operated to minimize elevation changes throughout the year to maximize habitat for the OSF. The reservoir is operated between 35,000 acre-feet and 50,000 acre-feet. In the model, this is accomplished by including a storage account that is dedicated to the OSF with a senior priority date (August 30, 1899; one day earlier than the most senior water right on the system, Swalley), which ensures that the highest priority in the model is to maintain 35,000 acre-feet of storage in Crane Prairie Reservoir. Three other storage accounts represent 5,000 acre-feet of storage each for Arnold

[2] The total demand for COID was slightly larger in the modeling because the LPID diversion was not subtracted from the NCAO [North Canal (part of COID)] diversion. This will be updated in later versions.

Irrigation District (AID), Central Oregon Irrigation District (COID), and Lone Pine Irrigation District (LPID).

Because of the senior priority date of the OSF account (35,000 acre-feet), it is kept full unless evaporation or seepage reduce its volume and it cannot be made up with inflows. The 15,000 acre-foot operating range is used to meet seasonal OSF habitat and irrigation needs according to the following schedule:

- January 1 to March 15: Crane Prairie Reservoir begins to store water, if available, until the reservoir reaches 45,000 acre-feet.
- March 16 to May 1: Crane Prairie Reservoir passes inflow to hold the storage volume achieved on March 15. Ideally, this volume would be 45,000 acre-feet.
- May 2 to May 15: Crane Prairie Reservoir stores water up to 1.1 feet above the elevation achieved on March 15. Ideally, this volume would be 50,000 acre-feet.
- May 16 to July 15: Crane Prairie Reservoir passes inflow to hold the storage volume achieved on May 15.
- July 15 to October 1: Crane Prairie Reservoir releases water in the irrigation district's accounts to reduce the reservoir back down to 35,000 acre-feet.
- October 2 to December 30: Crane Prairie Reservoir passes inflow to maintain 35,000 acre-feet.

Outflows from Crane Prairie Reservoir are generally managed to release a maximum of 400 cubic feet per second (cfs) throughout the year. The minimum release varies depending on the time of the year with 100 cfs released from December 1 through August 30 and 75 cfs released the remainder of the year. These flow criteria are considered less important than reaching and maintaining the elevations in Crane Prairie Reservoir. Therefore, there are times when the minimum outflow is allowed to decrease down to a minimum of 30 cfs in support of the higher priority criteria. Outflows are allowed to increase above 400 cfs when there is an elevation restriction and inflows exceed 400 cfs minus seepage.

Although the location and timing of returns from Crane Prairie Reservoir seepage is not fully understood, it is generally believed seepage losses return to the stream network upstream of Wickiup Reservoir. This is based on physical observations and geological knowledge of the area that include: (1) the proximity of a major groundwater discharge area (approximately 300 cfs to Sheep Springs), (2) the change in the underlying geology to low permeability of the sedimentary deposits of the La Pine sub-basin, (3) the location of a fault at Sheep Springs (a likely impediment to groundwater flow), and (4) the groundwater head gradient. All of these point to Wickiup Reservoir (Sheep Springs) being the location of returns from Crane Prairie Reservoir seepage (LaMarche 2018, pers. comm.).

For the calibration/historical model, it was assumed that any returns from Crane Prairie Reservoir seepage would be captured in the gains between Crane Prairie Reservoir and Wickiup Reservoir. However, since the seepage is dependent on elevation, it is expected that seepage from the No Action operation would be different than historical. So, the change in potential seepage was calculated by taking historical seepage calculation and subtracting it from a new seepage calculation using the new reservoir elevations. Based on conversations with Oregon Department of Water Resources, a 3 month lag time was assumed to route the change in seepage back to the reach above Wickiup Reservoir. This addition to the model was done with equations that use the current Crane Prairie Reservoir elevation as input, so any new changes to Crane Prairie Reservoir elevation would adjust the seepage return.

2.2.2. Wickiup Reservoir

Outflows from Wickiup Reservoir are managed to maintain a minimum between September 16 and March 30 based on the storage contents in Wickiup Reservoir on November 1 of the previous year using a variable outflow equation. The minimum outflow for the upcoming year is chosen on November 1 using a linear interpolation between 10,000 and 100,000 acre-feet to choose a minimum outflow between 100 and 500 cfs for the non-irrigation season. Higher flows are chosen for higher November 1 storage contents.

$$\begin{aligned}\text{Minimum Outflow in acre} - \text{feet (AF)} \\ &= 100\ cfs + (Wickiup\ Storage\ on\ November\ 1 - 10{,}000\ AF) \\ &\quad * \frac{500\ cfs - 100\ cfs}{100{,}000\ AF - 10{,}000 AF}\end{aligned}$$

Between March 30 and September 15, a minimum outflow of 600 cfs is used, if possible. Once irrigation releases begin, outflows from Wickiup Reservoir often exceed 600 cfs to meet downstream irrigation demand. If required releases exceed 600 cfs prior to April 30, the outflows are required to be at or above the previous day's outflows. Maximum non-irrigation season outflows are kept below 800 cfs until April 15, unless the reservoir needs to make flood releases.

2.2.3. Crescent Lake

As long as there is enough inflow and stored water, outflows from Crescent Lake are managed to maintain a minimum flow of 30 cfs from March 15 through November 30 and 20 cfs from December 1 through March 14. If the reservoir storage drops below 7,000 acre-feet, outflows are reduced to 6 cfs.

2.3. Crooked River Operation

Operating rules on the Crooked River, particularly at Prineville Reservoir, reflect changes that were made in the Crooked River Collaborative Water Security and Jobs Act of 2014 (also called Crooked River Legislation). Changes are still being made to the operations as real time implications are observed and discussed. As additional experience is gained, the model logic will continue to be refined, but, for the purpose of this study, the logic described below is used.

Prineville Reservoir has seven storage accounts that fill in priority by the dates shown in Table 2. All of the accounts except for the uncontracted account fill in proportion to their space with equal priority. The uncontracted space fills last and is used to augment flows seasonally for fishery purposes as coordinated by U.S. Fish and Wildlife Service and Reclamation.

Table 2. Prineville Reservoir storage rights from Prineville legislation.

Model Water Right Name	Priority Date	Maximum Storage Volume
CityOfPrineville	4/8/1914	5,100 AF
LowLine	4/8/1914	330 AF
Ochoco	4/8/1914	60,640 AF
Others	4/8/1914	6,527 AF
Peoples	4/8/1914	3,497 AF
RentalNUID	4/8/1914	10,000 AF
Uncontracted	4/9/1914	65,520 AF
Total		***151,614 AF***

Releases from the uncontracted account (also known as the fish and wildlife account) are calculated for the irrigation (April 1 to October 15) and non-irrigation seasons (October 16 to March 30) using the storage in the account on April 1. To calculate the irrigation season, the model first reserves a volume of water for the non-irrigation season equal to 50 cfs released each day from October 16 to March 30 or the volume of water in the uncontracted account on April 1, whichever is greater (Minimum Winter Release Volume [MWRV]). The remaining volume is then divided equally among the 365 days and that value is released each day (Irrigation Season Release).

$$\text{MWRV} = \text{Max}\begin{cases} V * 50\ \text{cfs} * 1.98\ \text{AF/d/cfs} \\ \text{UV} \end{cases} \text{ where}$$

MWRV = Minimum Winter Release Volume

V = Number of days between April 1 next year and October 15 current year

UV = Storage in the uncontracted Account on April 1

$$\text{Irrigation Season Release} = \text{Max}\begin{cases} (\text{UV} - \text{MWRV})/(365\ \text{d} * \frac{1.98\frac{\text{AF}}{\text{d}}}{\text{cfs}}) \\ 0\ \text{cfs} \end{cases}$$

For the non-irrigation season, the irrigation season release flow rate is added to the minimum winter release flow rate and is released from the uncontracted account.

Non-Irrigation Season Release = Irrigation Season Release + MWRV

Table 3 shows example irrigation season and non-irrigation season releases from the uncontracted account given April 1 storage volumes in the uncontracted account. These releases are added to irrigation season storage releases, runoff season flood releases, and other minimum flow requirements described below.

Table 3. Calculated irrigation and non-irrigation season releases based on April 1 uncontracted volume in Prineville Reservoir.

Total Storage Prineville Reservoir (acre-feet)	Uncontracted Volume April 1 (acre-feet)	Irrigation Season Release (cfs)	Non-irrigation Season Release (cfs)
148,633	62,520	63.3	113.4
118,000	36,987	21	71.1
88,000	6,987	0	5.7
78,000	0	0	0

Other minimum releases include a minimum of 10 cfs release maintained from Bowman Dam and a 7 cfs release from the City of Prineville mitigation account. These releases are executed in the model using the following logic:

If releases from Bowman Dam are less than 10 cfs, then:

1. The first 7 cfs will be released from the City of Prineville mitigation account, if available. If the City of Prineville mitigation account did not fill, the release will be the amount of storage in the account on April 1 divided by 365 days.
2. The remainder will be made up with water from the uncontracted/fish and wildlife account.
3. If the uncontracted/fish and wildlife account is empty, the remainder will be made up with live flow.
4. If there is insufficient live flow, the remainder will be made up with stored water from the first fill accounts in proportion to their storage.

2.4. Special Diversion Operations

TID, OID, and NUID divert water from multiple streams to satisfy demand for their districts. All three of these diversions require unique model constructs and rules to ensure the correct amount of water is diverted from the appropriate tributary.

TID diverts water from Tumalo Creek and supplements with water from Crescent Lake via the Upper Deschutes. It also has a live flow of 9.5 cfs directly from the Deschutes. TID first tries to satisfy its demand using natural flow rights, the majority of which are on Tumalo Creek. If there is still shortage, TID will request stored water from Crescent Lake via the Upper Deschutes.

OID diverts from both the Crooked River and Ochoco Creek and first tries to satisfy the historical demand from each tributary, Crooked River and Ochoco Creek, using both natural flow and stored water rights. If there is still a shortage, OID will divert additional water from Prineville Reservoir.

NUID diverts water from both the Upper Deschutes and the Crooked Rivers. On the Upper Deschutes, NUID can divert water under its 1913 live flow water right and can request stored water from Wickiup Reservoir. On the Crooked River, it can divert under its 1955 live flow right and request rental water from Prineville Reservoir [3].

When the model is running, it will first try to satisfy the total demand for the district using historical diversion rates for each tributary. If there are still shortages, additional water will be diverted from the Crooked River to satisfy the demand limited by the pump capacity, amount of water in the rental account on Prineville Reservoir, and the requirement to leave water instream per an agreement between Deschutes River Conservancy and NUID (called the DRC agreement [OWRD 2013]). This agreement, signed in 2013, requires that NUID allow flow to bypass its pumps. The amount of flow varies depending on water year conditions and month (Table 4). A dry year is defined if the storage in Prineville Reservoir is less than 135,000 acre-feet after March 30, or if the outflow from the reservoir is less than 75 cfs for the previous 30 days.

[3] NUID also has a 1968 priority water right. However, the maximum diversion rate for the 1955 water right is 200 cfs which is the maximum physical pump capacity. For simplicity, the model only simulates the 1955 right since there is no case when the other right would be used.

Table 4. Deschutes River Conservancy Bypass Flows for Dry and Non-dry Years[4]

Month	Dry Year	Non-dry year
Jan	0	0
Feb	0	0
Mar	0	0
Apr	120.617	181.417
May	43.798	95.598
Jun	54.381	86.081
Jul	51.451	61.451
Aug	56.846	68.146
Sep	57.599	114.219
Oct	121.874	151.574
Nov	0	0
Dec	0	0

3. Modeling Assumptions

The RiverWare model assumptions were adjusted for each of the four alternatives evaluated for the DBHCP EIS.

3.1. Alternative 1: No Action

The No Action model is the baseline model described in Chapter 2. No additional changes were made to the model for the No Action.

[4] The model used values from a slightly earlier version of the agreement that were at most about 5 cfs less. This was considered to be acceptable as it showed lower flows in the Crooked River. It will be updated in future versions of the model.

3.2. Alternative 2: Districts' DBHCP Proposal

The Alternative 2 model includes the assumptions defined in the Districts' DBHCP proposal. Alternative 2 starts with all of the assumptions in Alternative 1 and then adds to them. The primary changes include changes to Crane Prairie, Wickiup, Crescent, and Crooked River operations.

3.2.1. Crane Prairie Reservoir

Crane Prairie Reservoir is operated to minimize elevation changes throughout the year to maximize habitat for the OSF. The reservoir is operated between 38,000 acre-feet and 48,000 acre-feet, which is different from the no action operating range of 35,000 to 50,000 acre-feet. In the model, this is accomplished by including a storage account that is dedicated to the OSF with a senior priority date—August 30, 1899; one day earlier than the most senior water right on the system, Swalley. This ensures that the highest priority in the model is to maintain 38,000 acre-feet of storage in Crane Prairie. Three other storage accounts represent 10,000 acre-feet of storage for AID (3,500 acre-feet), COID (3,000 acre-feet), and LPID (3,500 acre-feet)[5].

Due to the senior priority date of the OSF account, it is kept full unless evaporation or seepage reduce its volume and it cannot be made up with inflows. The 10,000 acre-feet of active storage that results from operation of the reservoir for OWF is utilized in the following way:

> November 1 to March 14: Crane Prairie Reservoir begins to store water, if available, until the reservoir reaches 48,000 acre-feet.
>
> March 15 to July 15: Crane Prairie Reservoir passes inflow to hold the storage volume achieved on March 15. Ideally, this volume would be between 46,800 and 48,000 acre-feet.
>
> July 16 to July 31: Crane Prairie Reservoir storage is reduced at a maximum rate of 225 acre-feet per day.
>
> July 31 to October 31: Crane Prairie Reservoir storage is reduced at a maximum rate of 450 acre-feet per day until storage in Crane Prairie is 38,000 acre-feet, then 38,000 acre-feet is maintained until November 1.

Outflows from Crane Prairie Reservoir are generally managed to maintain a minimum release of 75 cfs, if possible. If flows cannot be maintained at 75 cfs, the model will allow the flows to drop to a minimum of 30 cfs.

3.2.2. Wickiup Reservoir

Outflows from Wickiup Reservoir are managed to maintain a minimum between September 16 and March 30 based on the storage contents in Wickiup Reservoir on November 1 of the previous year using

[5] The distribution of the accounts is still being negotiated, but these were the distributions used for modeling purposes.

a variable outflow equation. The minimum outflow for the upcoming year is chosen on November 1 using a linear interpolation between 10,000 and 100,000 acre-feet. This interpolation produces a minimum outflow between 400 and 500 cfs for the non-irrigation season. Higher flows are chosen for higher November 1 storage contents.

$$Minimum\ Outflow = 400\ cfs + (Wickiup\ Storage\ on\ Nov\ 1 - 10{,}000\ AF) * \frac{500\ cfs - 400\ cfs}{100{,}000\ AF - 10{,}000 AF}$$

Between March 30 and September 15, a minimum outflow of 600 cfs is used, if possible. Once irrigation releases begin, outflows from Wickiup Reservoir often exceed 600 cfs to meet downstream irrigation demand. If required releases exceed 600 cfs prior to April 30, the outflows are required to be at or above the previous day's outflows. Maximum non-irrigation season outflows are kept below 800 cfs until April 15, unless the reservoir needs to make flood releases.

Additional variations on Alternative 2 were run for informational purposed where the minimum outflow from Wickiup Reservoir was set to vary from 100 to 500, 200 to 500, and 300 to 500 cfs. Two additional variations set the non-irrigation season minimum to a constant 500 and 600 cfs.

3.2.3. Crescent Lake

Crescent Lake is operated to ensure minimum outflows are 20 cfs throughout the year. In July through September, the minimums are kept to 50 cfs if there is enough water in the lake.

3.2.4. Crooked River

Ochoco Irrigation District will supplement winter flows on the Crooked River up to 50 cfs if outflows from Prineville Reservoir are less than 50 cfs. Water from the City of Prineville Mitigation Account will be released only in the months of December and January, and the daily release quantity will be the volume on November 30 divided by 61 days.

3.3. Alternative 3

The Alternative 3 model is the same as the No Action and Alternative 2 model, except that the outflow from the uncontracted account in Prineville Reservoir was protected from being diverted.

3.3.1. Crooked River

The uncontracted releases are assumed to be protected past the NUID pumps in this alternative. Specifically, the NUID pumps were modeled to bypass the larger of minimum requirements from the DRC agreement or the release from the uncontracted account.

3.4. Alternative 4

The Alternative 4 model is the same as Alternative 3 except that the variable outflow equation was modified slightly for Wickiup Reservoir and the minimum winter requirement from the uncontracted account on Prineville Reservoir was increased to 80 cfs.

3.4.1. Wickiup Reservoir

The variable outflow equation uses the storage in Wickiup Reservoir on November 1 to determine the minimum flow throughout the upcoming winter. The calculated minimum flow is limited to a lower bound of 400 cfs and an upper bound of 600 cfs. The model will prevent Wickiup Reservoir from overtopping, so if it needs to release more water than the calculated minimum, it will.

$$Minimum\ Outflow = 400\ cfs + (Wickiup\ Storage\ on\ Nov\ 1 - 10{,}000\ AF) * \frac{600\ cfs - 400\ cfs}{100{,}000\ AF - 10{,}000 AF}$$

3.4.2. Crooked

Releases from the uncontracted account (also known as the fish and wildlife account) are calculated for the irrigation (April 1 to October 15) and non-irrigation seasons (October 16 to March 30) using the storage in the account on April 1. To calculate the irrigation season, the model first reserves a volume of water for the non-irrigation season equal to 80 cfs released each day from October 16 to March 30 or the volume of water in the uncontracted account on April 1, whichever is greater (Minimum Winter Release Volume). The remaining volume is then divided equally among the 365 days and that value is released each day (Irrigation Season Release).

$$\text{MWRV} = \text{Max}\begin{cases} V * 80\ \text{cfs} * 1.98\ \text{AF/d/cfs} \\ \text{UV} \end{cases}$$ where

M = Minimum Winter Release Volume

V = Number of days between April 1 next year and October 15 current year

UV = Storage in the uncontracted account on April 1

$$\text{Irrigation Season Release} = \text{Max}\begin{cases} (\text{UV} - \text{MWRV})/(365\ \text{d} * \frac{1.98\frac{\text{AF}}{\text{d}}}{\text{cfs}}) \\ 0\ \text{cfs} \end{cases}$$

For the non-irrigation season, the irrigation season release flow rate is added to the minimum winter release flow rate and is released from the uncontracted account.

Non- Irrigation Season Release = Irrigation Season Release + MWRV

4. Scenario Results

The RiverWare model produces many different types of output that can be used to interpret the implications of the alternatives, including reservoir storage, flow at gages, and water delivered to water users. The reservoir storage and flow at gages were primarily used to determine if the model was performing as expected under the defined scenario. Shortages were calculated by subtracting the amount of water delivered to water users from the amount of water that was requested. The shortages were used to determine the potential impacts of the various scenarios and to determine the volume of water that would be required to satisfy all of the objectives in the scenario.

Alternative results are displayed in a number of formats. Summary hydrographs are used to show the potential range of reservoir storage, reservoir outflow, and flow at gages. The summary hydrographs show the median value (the daily flow or storage value achieved in 50 percent of the years) in a colored line, and a shaded area showing the daily range of 20 to 80 percent exceedance.[6] Reservoir storage and outflow are shown together so that the relationship between storage and outflow can be observed. Irrigation deliveries are shown as annual exceedance graphs where total annual irrigation volumes are sorted in order of largest to smallest to indicate the frequency of delivering a particular volume. The ability to meet in-stream and out-of-stream model flow objectives is shown using shortage graphs, where the shortage represents the difference between a model objective and the modeled output. Shortages are summed annually and shown in exceedance graphs similar to irrigation deliveries.

4.1. Alternative 1: No Action

The No Action results are displayed to establish a baseline against which to compare the alternatives. Only the locations that experience a change in the alternatives are shown in the No Action section.

4.1.1. Upper Deschutes

Figure 5 shows summary hydrographs of the simulated storage (top) and outflow (bottom) from Crane Prairie Reservoir for the No Action Alternative. The storage graph shows the summary of the 20 to 80 percent range of storage for the scenario. Recall that the intended operation at Crane Prairie Reservoir was as follows:

1. To be at or above 35,000 acre-feet for the entire year
2. Increase from 35,000 acre-feet to 45,000 acre-feet by March 15
3. Maintain 45,000 acre-feet from March 15 through May 1
4. Increase from 45,000 to 50,000 acre-feet from May 1 to May 15
5. Maintain the storage achieved on May 15 through July 15
6. Release storage down to 35,000 acre-feet by November 1

[6] The 20% exceedance value shows the value where only 20% of the values are larger; the 80% exceedance value shows the value where 80% of the values are larger. For example, the 20% exceedance storage in Crane Prairie Reservoir on June 1 is 49,000 acre-feet and the 80% is 47,500 acre-feet.

Figure 5 shows that this operation can be achieved.

The relationship between changes in storage and outflow can also be seen in these graphs. For example, on January 1, outflows decrease to fill Crane Prairie Reservoir to 45,000 acre-feet by February 15. The model shows abrupt changes in outflows because storage objectives are prioritized in the model. Real time operations may be different than the model output because the model logic is based on rules that may turn on and off suddenly as conditions change, whereas real time operations may be able to smooth out the operational changes.

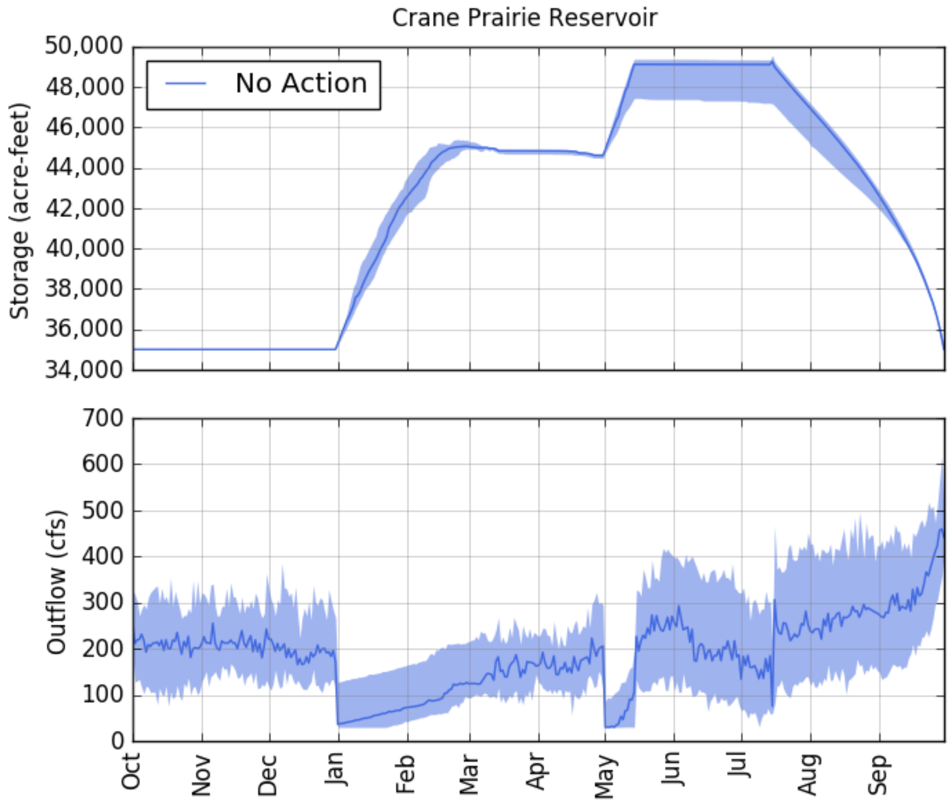


Figure 5. Summary hydrographs of simulated storage (top) and outflow (bottom) from Crane Prairie Reservoir showing the No Action Alternative. The dark blue line represents the median and the shaded blue areas represent the 20 to 80 percent exceedance.

Figure 6 shows summary hydrographs of the simulated storage and outflow from Wickiup Reservoir for the No Action Alternative. Recall that the intended operation at Wickiup Reservoir was to maintain a minimum of between 100 and 500 cfs outflow year-round and to meet downstream irrigation requests. From this graph, it can be seen that the model objectives were met. In addition, the storage in Wickiup Reservoir that results from the upstream operation at Crane Prairie Reservoir and the outflow requirements is shown. The summer-time outflow pattern reflects Wickiup Reservoir releases to meet downstream irrigation demands, particularly for the North Unit Irrigation District.

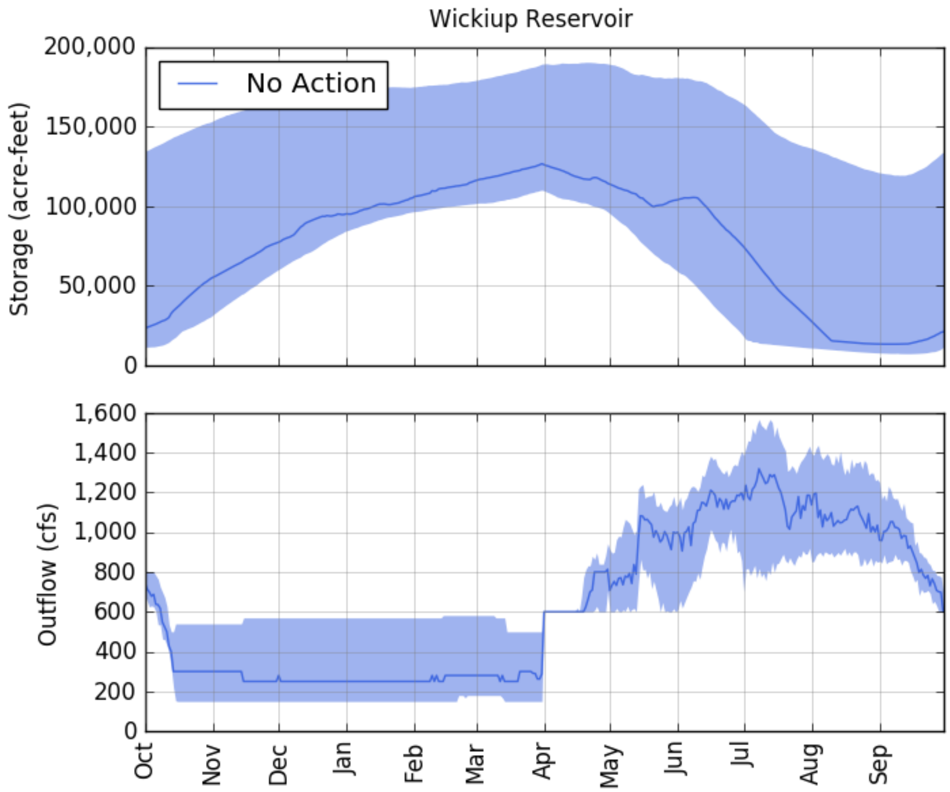


Figure 6. Summary hydrographs of simulated storage (top) and outflow (bottom) from Wickiup Reservoir showing the No Action Alternative. The dark blue line represents the median and the shaded blue areas represent the 20 to 80 percent exceedance.

Figure 7 shows summary hydrographs for the storage and outflow from Crescent Lake for the No-Action Alternative. Recall that the intended operation for Crescent Lake was to maintain a minimum outflow of 30 cfs from March 15 to November 30 and 20 cfs from December 1 to March 14. The outflow graph shows that this operation is achievable in all years above the 80 percent flow exceedance, and the storage graph shows the statistical range of storage on any given day during the year for the simulation period. While mode summary hydrographs generally show the annual pattern of storage or flow, that is not the case for Crescent Lake storage. This is because the reservoir can store water for many irrigation seasons and therefore the annual storage pattern can be very different from year to year.

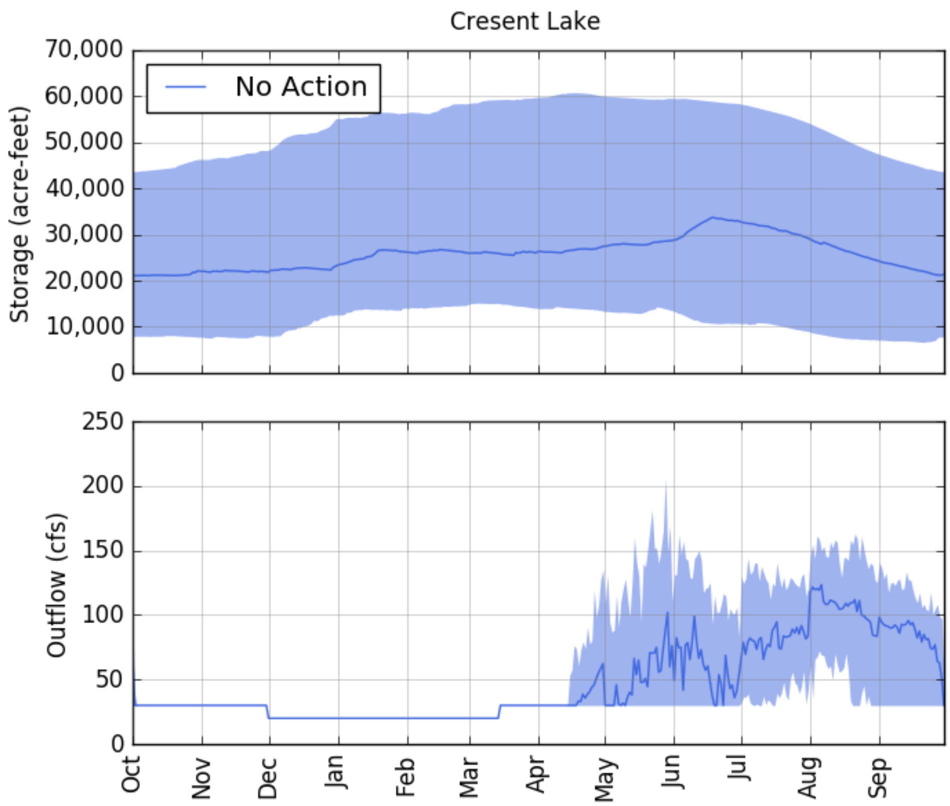


Figure 7. Summary hydrographs of simulated storage (top) and outflow (bottom) from Crescent Lake showing the No Action Alternative. The dark blue line represents the median and the shaded blue areas represent the 20 to 80 percent exceedance.

Figure 8 shows a summary hydrograph of the simulated flow in Little Deschutes River at La Pine for the No Action Alternative. The flow at this gage is largely unregulated with only a small contribution from Crescent Creek and Crescent Lake.

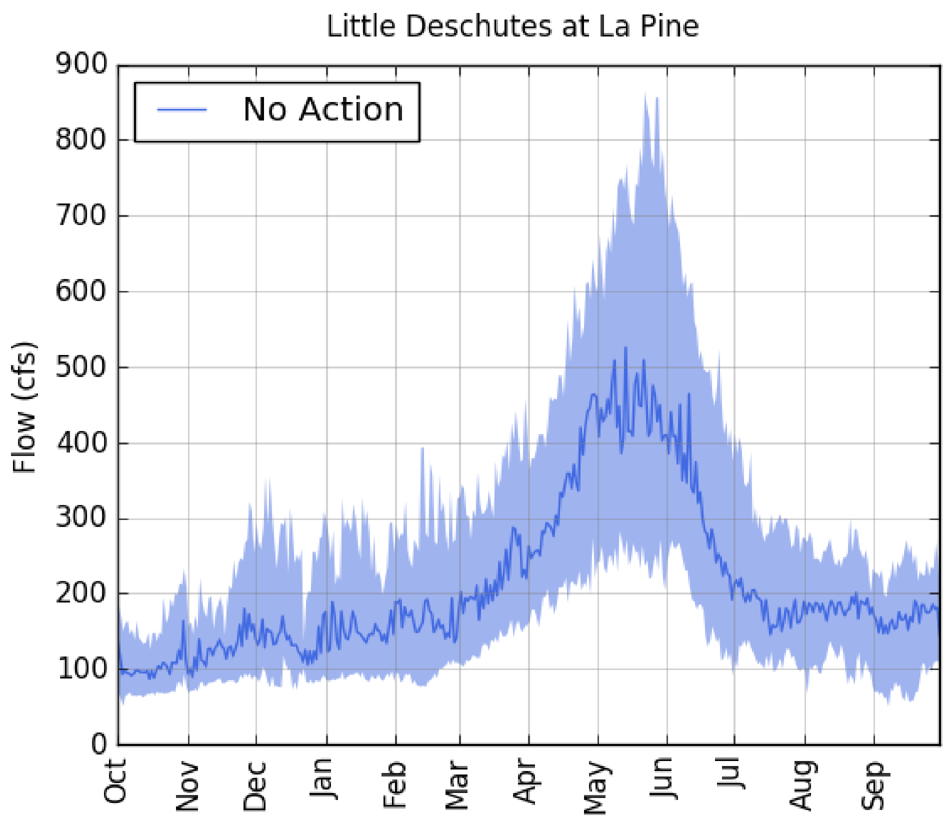


Figure 8. Summary hydrograph of simulated flow in the Little Deschutes River at La Pine showing the No Action Alternative. The dark blue line represents the median and the shaded blue areas represent the 20 to 80 percent exceedance.

Figure 9 shows a summary hydrograph of the simulated flow in the Deschutes River at Benham Falls for the No Action Alternative. This gage is upstream of the major diversions, but downstream of the reservoirs. It is heavily influenced by the outflow from Wickiup Reservoir and the flow from the Little Deschutes.

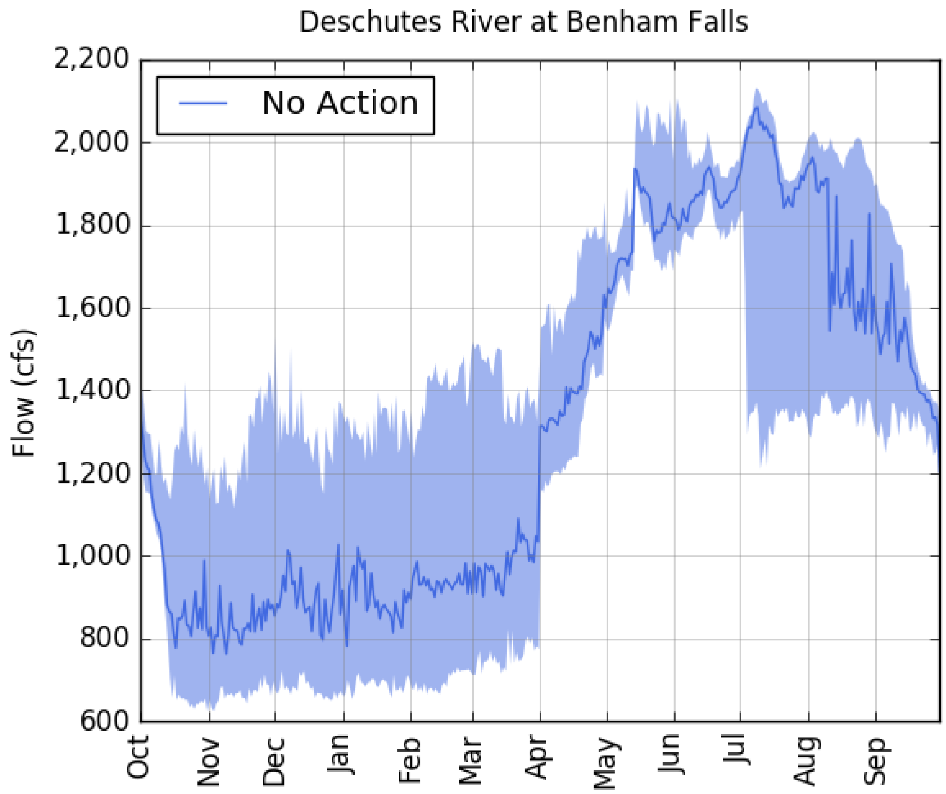


Figure 9. Summary hydrograph of simulated flow in the Deschutes River at Benham Falls showing the No Action Alternative. The dark blue line represents the median and the shaded blue areas represent the 20 to 80 percent exceedance.

Figure 10 shows a summary hydrograph of the simulated flow in the Deschutes River below Bend for the No Action Alternative. The gage is located downstream of all of the major irrigation diversions and; therefore, is representative of the potential lowest flow in that reach of the river.

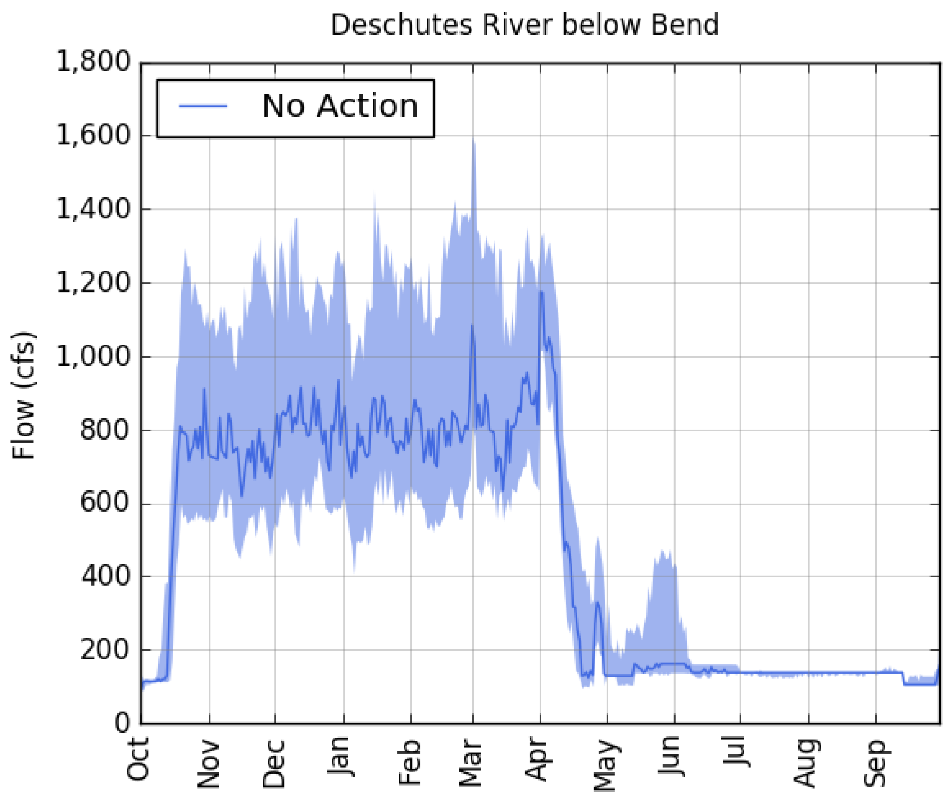


Figure 10. Summary hydrograph of simulated flow in the Deschutes River below Bend showing the No Action Alternative. The dark blue line represents the median and the shaded blue areas represent the 20 to 80 percent exceedance.

4.1.2. Tumalo Creek

Figure 11 shows a summary hydrograph of the simulated flow in Tumalo Creek below the TID diversion for the No Action Alternative. Tumalo Creek is a tributary to the Upper Deschutes that does not have any on-channel storage and supplies water for the City of Bend and TID. The hydrograph represents the lowest flow on the creek below all diversions.

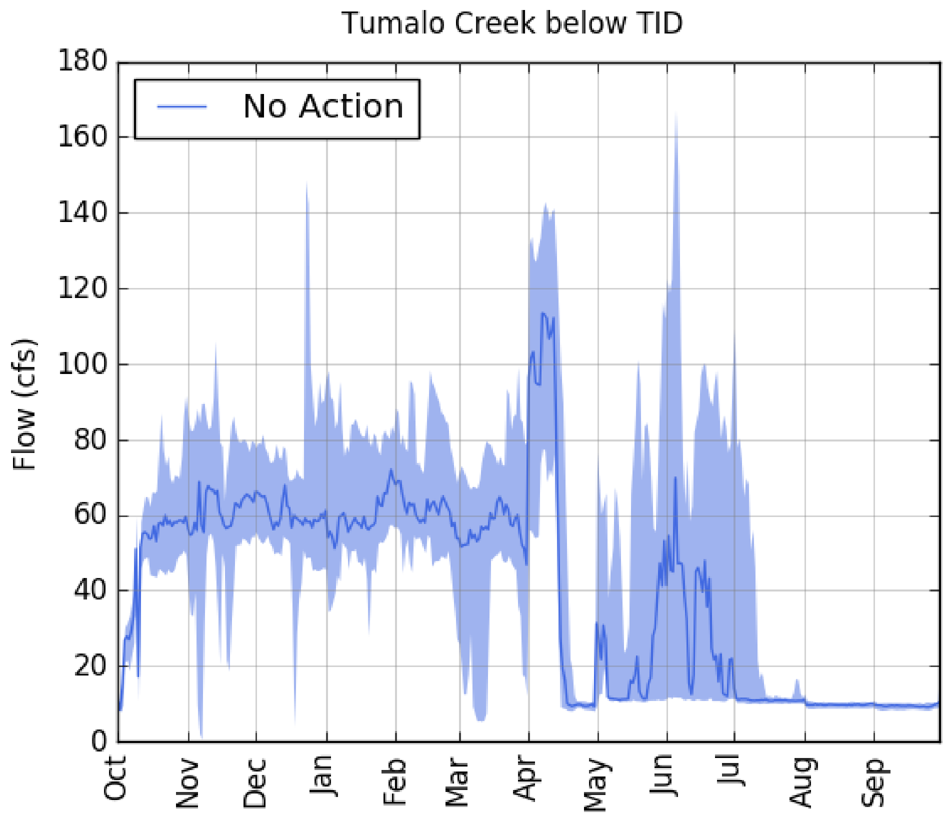


Figure 11. Summary hydrograph of simulated flow in Tumalo Creek below the TID diversion showing the No Action Alternative. The dark blue line represents the median and the shaded blue areas represent the 20 to 80 percent exceedance.

4.1.3. Whychus Creek

Figure 12 shows a summary hydrograph of the simulated flow in Whychus Creek at Sisters for the No Action Alternative. Whychus Creek is a tributary to the Upper Deschutes River that does not have any on-channel storage and supplies water for three small irrigation districts (Edgington, Sokol, and Plainview), along with the much larger Three Sisters Irrigation District (TSID). Output at this control point represents the lowest flow on the creek.

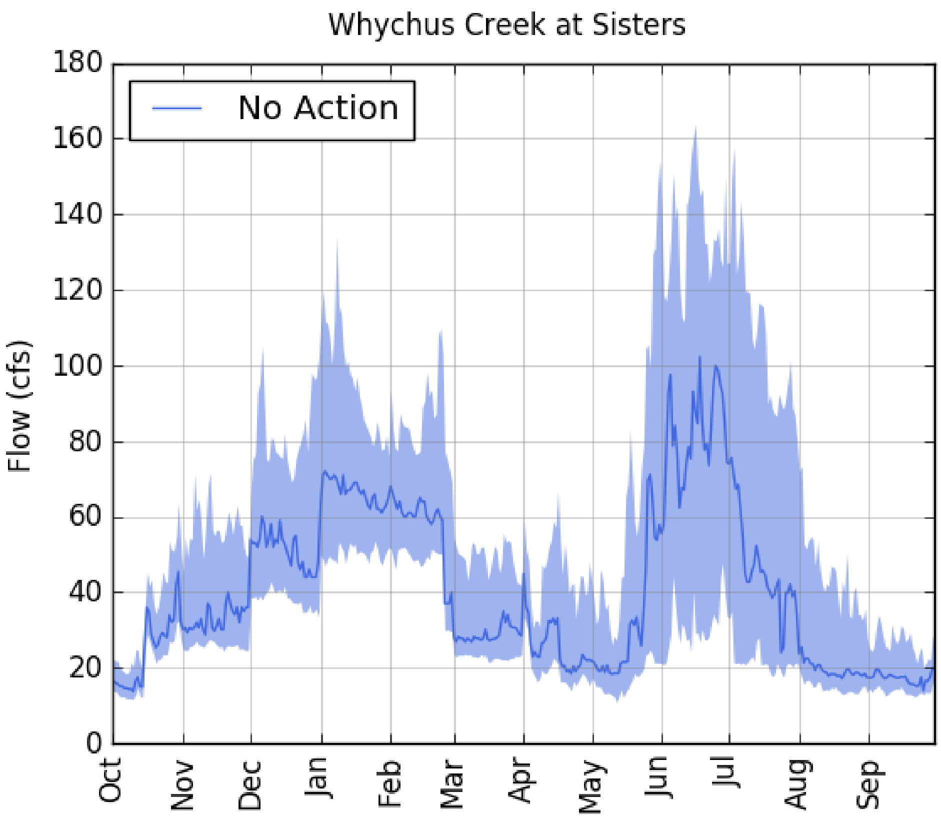


Figure 12. Summary hydrograph of simulated flow in Whychus Creek at Sisters showing the No Action Alternative. The dark blue line represents the median and the shaded blue areas represent the 20 to 80 percent exceedance.

4.1.4. Crooked River

Figure 13 shows summary hydrographs for simulated storage and outflow from Prineville Reservoir for the No Action Alternative. Prineville Reservoir typically reaches its peak storage volume between April and June and releases water throughout the irrigation season to meet downstream demand and ecological flow objectives. During the spring, it releases water to make space in the reservoir to capture spring runoff and prevent flooding downstream of the dam. In the winter, it releases flows based on the uncontracted flow equations described in Section 2.3.

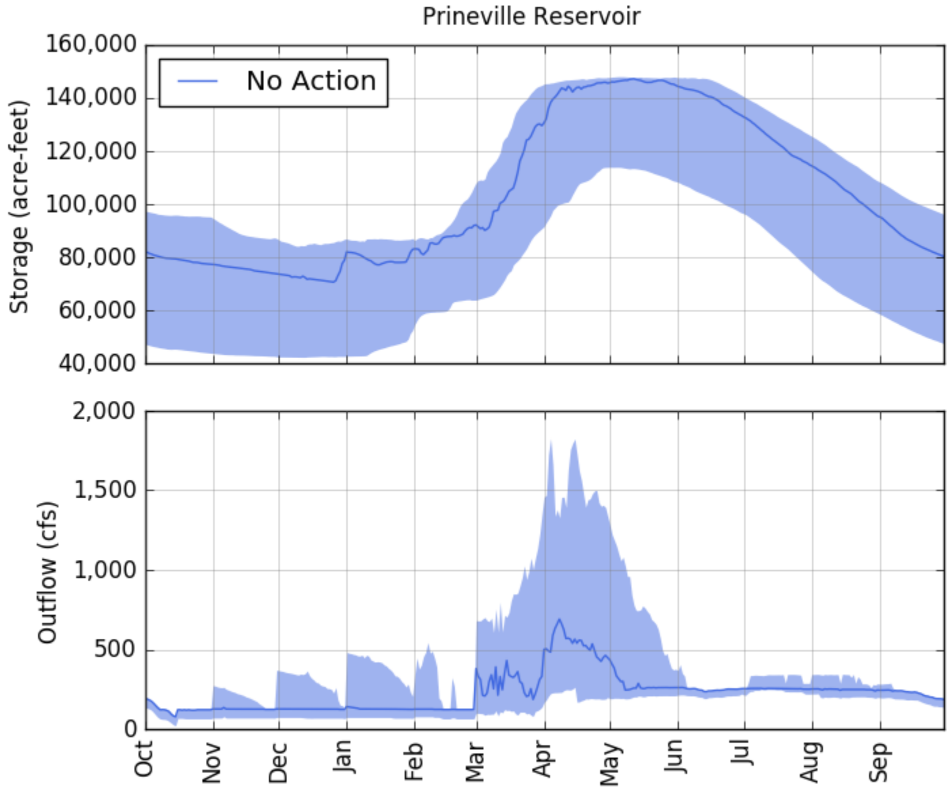


Figure 13. Summary hydrographs of simulated storage (top) and outflow (bottom) from Prineville Reservoir showing the No Action alternative. The dark blue line represents the median and the shaded blue areas represent the 20 to 80 percent exceedance.

Figure 14 shows summary hydrographs for simulated storage and outflow from Ochoco Reservoir for the No Action Alternative. Like Prineville Reservoir, Ochoco Reservoir typically reaches its peak storage volume between April and June and releases water throughout the irrigation season to meet downstream demand and ecological flow objectives. During the spring, it releases water to make space in the reservoir to capture spring runoff and prevent flooding downstream of the dam. During the winter it releases enough to maintain 5 cfs in the creek.

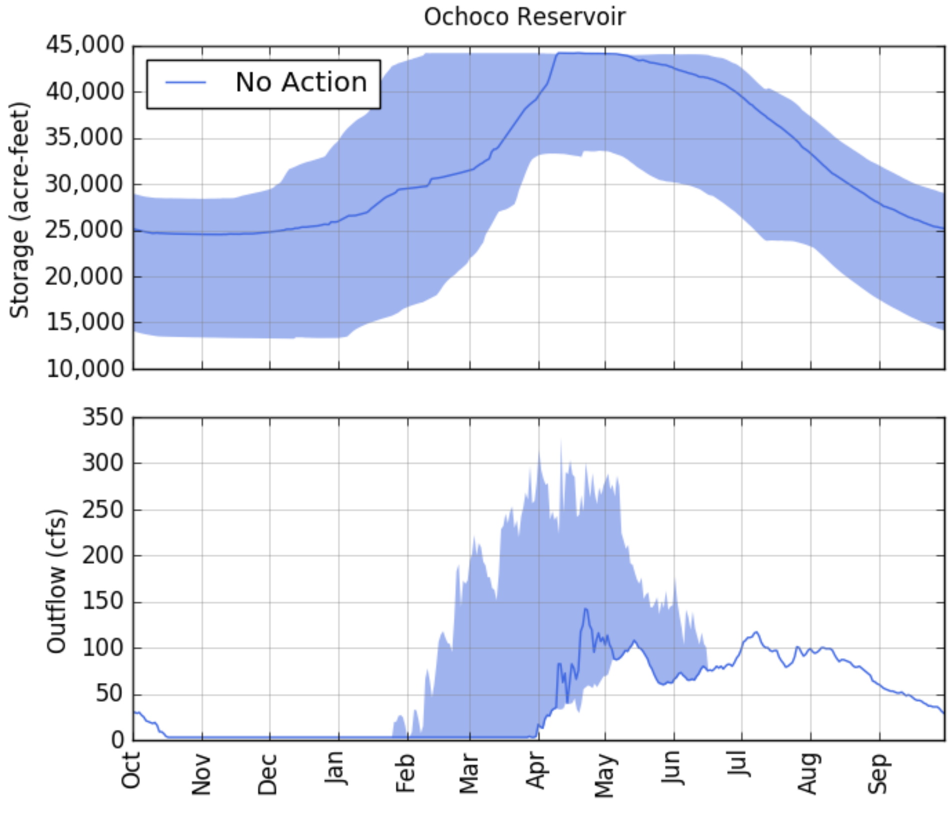


Figure 14. Summary hydrographs of simulated storage (top) and outflow (bottom) from Ochoco Reservoir showing the No Action Alternative. The dark blue line represents the median and the shaded blue areas represent the 20 to 80 percent exceedance.

Figure 15 shows a summary hydrograph of the simulated flow in the Crooked River at Highway 126 for the No Action Alternative. The flow at this gage generally represents a low flow point in the river below some of the major diversions and above most return flows. It is largely influenced by the outflow from Prineville Reservoir in the winter and the upstream diversions and contracted reservoir releases in the summer.

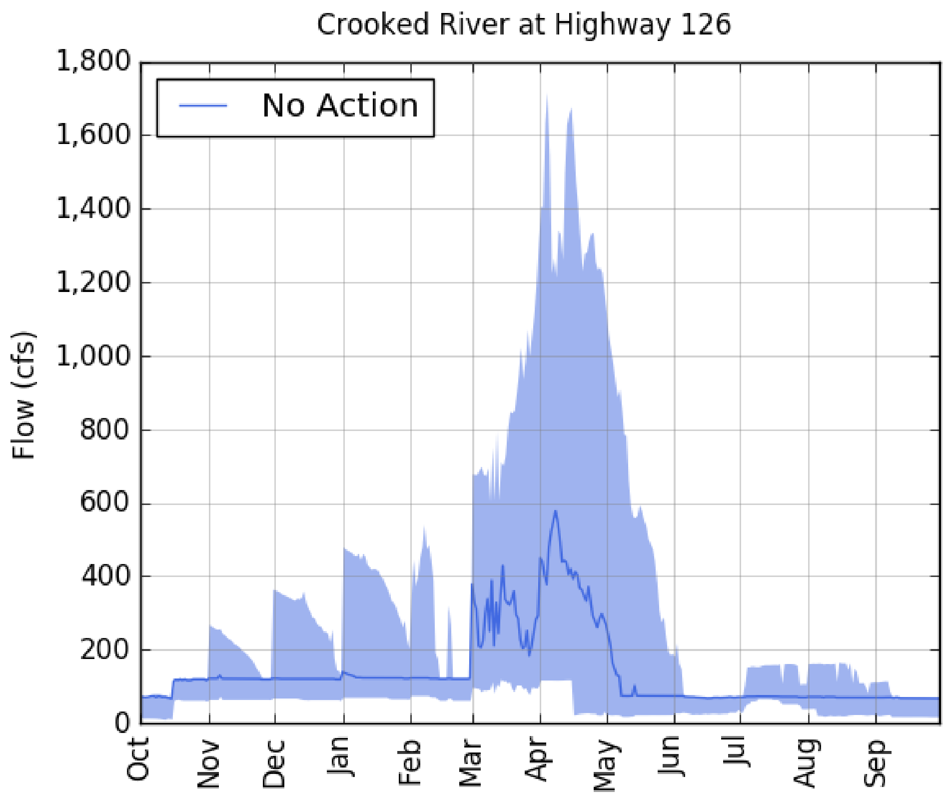


Figure 15. Summary hydrograph of simulated flow in the Crooked River at Highway 126 showing the No Action Alternative. The dark blue line represents the median and the shaded blue areas represent the 20 to 80 percent exceedance.

Figure 16 shows a summary hydrograph of the simulated flow in the Crooked River below the NUID pumps for the No Action Alternative. The flow at this gage generally represents another low flow point in the river below major diversions and above the return flows at Opal Springs. It is largely influenced by the outflow from Prineville Reservoir in the winter and the upstream diversions in the summer.

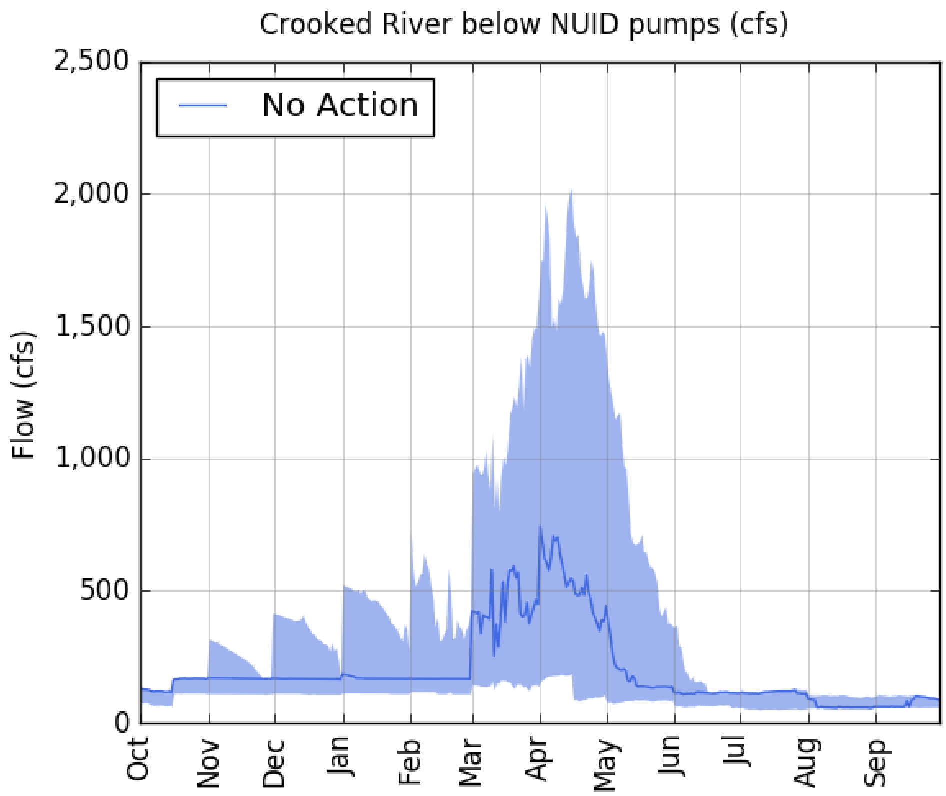


Figure 16. Summary hydrograph of simulated flow in the Crooked River below the NUID pumps showing the No Action Alternative. The dark blue line represents the median and the shaded blue area represents the 20 to 80 percent exceedance.

4.1.5. Irrigation Shortages

Irrigation shortages are calculated every model year and are the difference between the requested demand and the amount of water delivered to each district. The total annual shortages for the No Action Alternative are ranked and shown in Figure 17. NUID has the largest shortage in the No Action Alternative because it is the junior water user on the system.

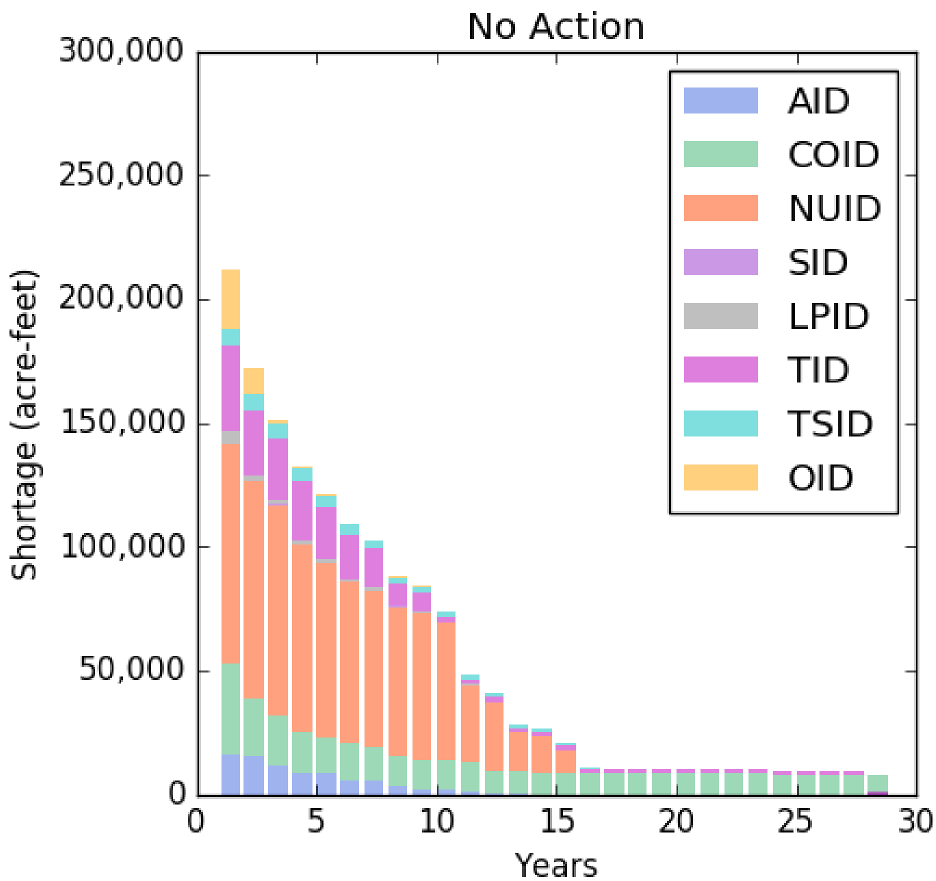


Figure 17. Irrigation shortages for the eight major districts in the basin for the No Action Alternative.

4.2. Alternative 2: Districts' DBHCP Proposal

The Alternative 2 results are displayed along with the No Action Alternative results for comparison. Only the locations that experienced a change from the No Action Alternative are shown in this section.

4.2.1. Upper Deschutes

Figure 18 shows summary hydrographs of the simulated storage (top) and outflow (bottom) from Crane Prairie Reservoir for the No Action Alternative (blue) compared to Alternative 2 (green). Recall that the intended operation for Alternative 2 was as follows:

1. Store water from November 1 to March 14 to reach 48,000 acre-feet
2. Pass inflow from March 15 to July 15 to maintain between 46,800 and 48,000 acre-feet
3. Release storage at a maximum rate of 225 acre-feet per day from July 16 to July 31
4. From July 31 to October 31, release up to 450 acre-feet per day until 38,000 acre-feet and then maintain 38,000 acre-feet until October 31
5. Outflows are managed to maintain a minimum release of 75 cfs, if possible, and an absolute minimum of 30 cfs

Figure 18 shows that this operation can be maintained. The difference between the Alternative 2 operation and the No Action Alternative operation is primarily due to the change in operating rules. However, the fill period between November 1 and March 14 also varies due to changes in inflow to the reservoir. Outflows from the reservoir are generally more consistent using the operation in Alternative 2 with less dramatic changes than in the No Action Alternative.

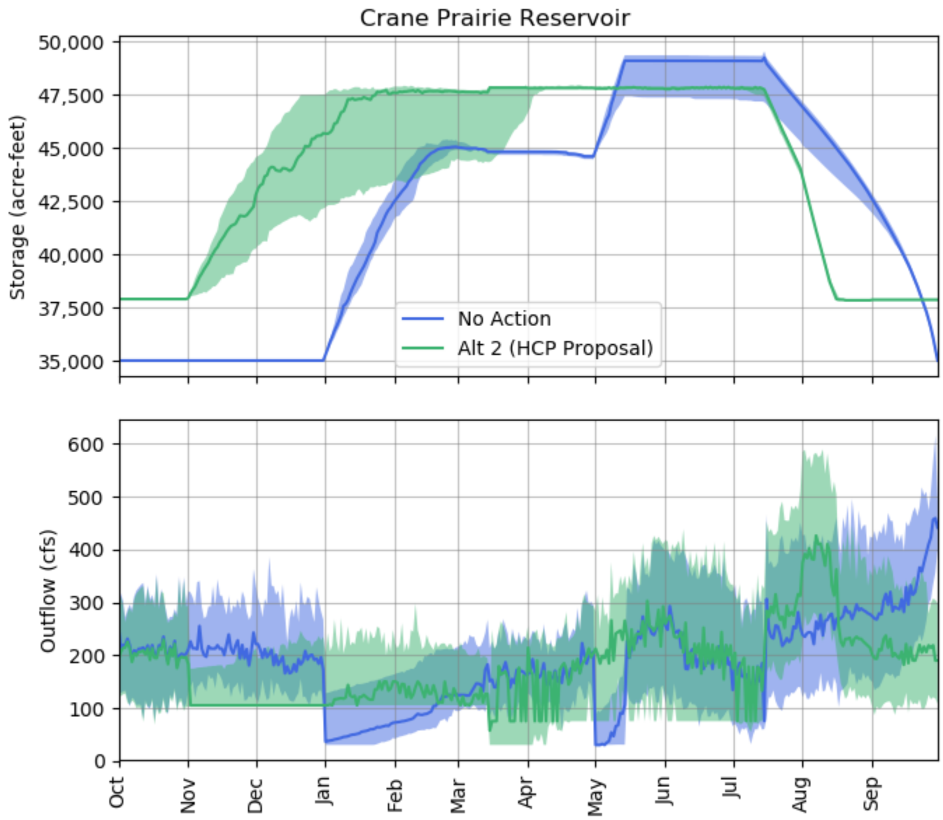


Figure 18. Summary hydrographs of simulated storage (top) and outflow (bottom) from Crane Prairie Reservoir for the No Action Alternative (blue) compared to Alternative 2 (green). The dark blue or green line represents the median and the shaded blue or green areas represent the 20 to 80 percent exceedance.

Figure 19 shows summary hydrographs of the simulated storage and outflow from Wickiup Reservoir for the No Action Alternative (blue) compared to Alternative 2 (green). The graph shows the results of the scenario where minimums between 400 and 500 cfs were maintained and defined by November 1 Wickiup Reservoir storage contents. From this graph, it can be seen that the model objectives were met. However, the increase in winter storage from Wickiup Reservoir results in a much lower storage overall.

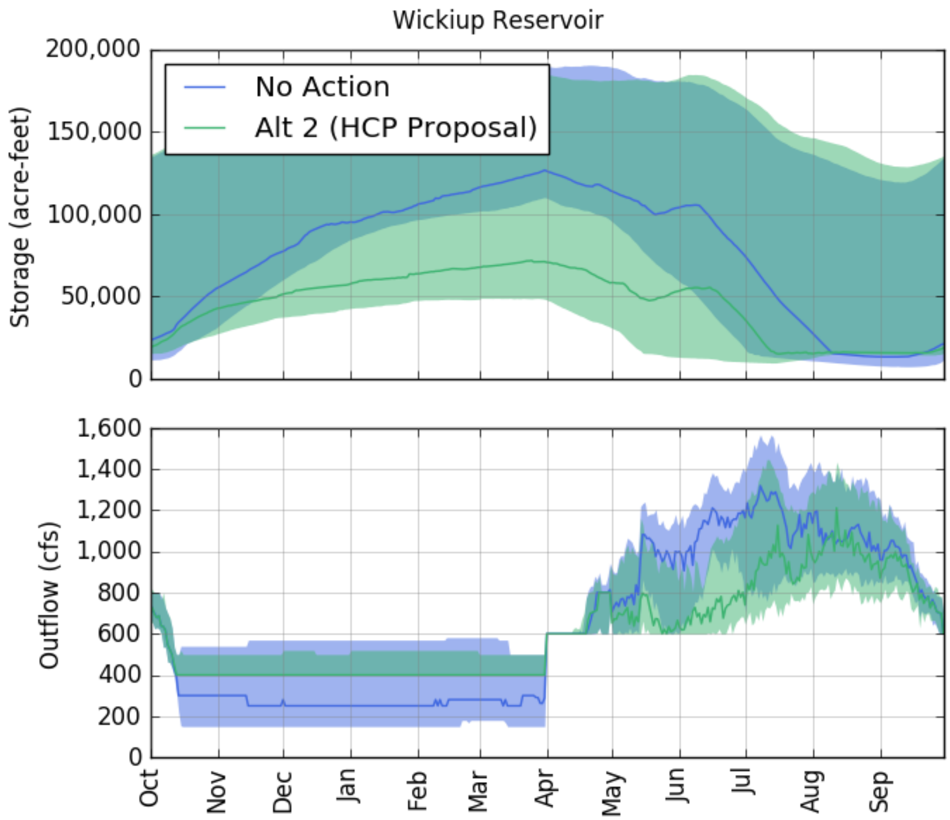


Figure 19. Summary hydrographs of simulated storage (top) and outflow (bottom) from Wickiup Reservoir for the No Action Alternative (blue) compared to Alternative 2 (green). The dark blue or green line represents the median and the shaded blue or green areas represent the 20 to 80 percent exceedance.

Figure 20 shows summary hydrographs for the storage and outflow from Crescent Lake for the No Action Alternative (blue) compared to Alternative 2 (green). Recall that the intended operation for Crescent Lake in Alternative 2 was to maintain a minimum of 20 cfs throughout the year and 50 cfs from July 1 through September 30, if there is enough water in the lake. This graph indicates that the minimum flow requirements can be met in all years above the 80 percent flow exceedance. The storage in Crescent Lake is slightly higher in this scenario because the larger releases (and therefore live flow) from Wickiup Reservoir allow it to store more water that would have been requested by senior live flow diverters downstream, along with the reduced winter minimum flow releases from Crescent Lake.

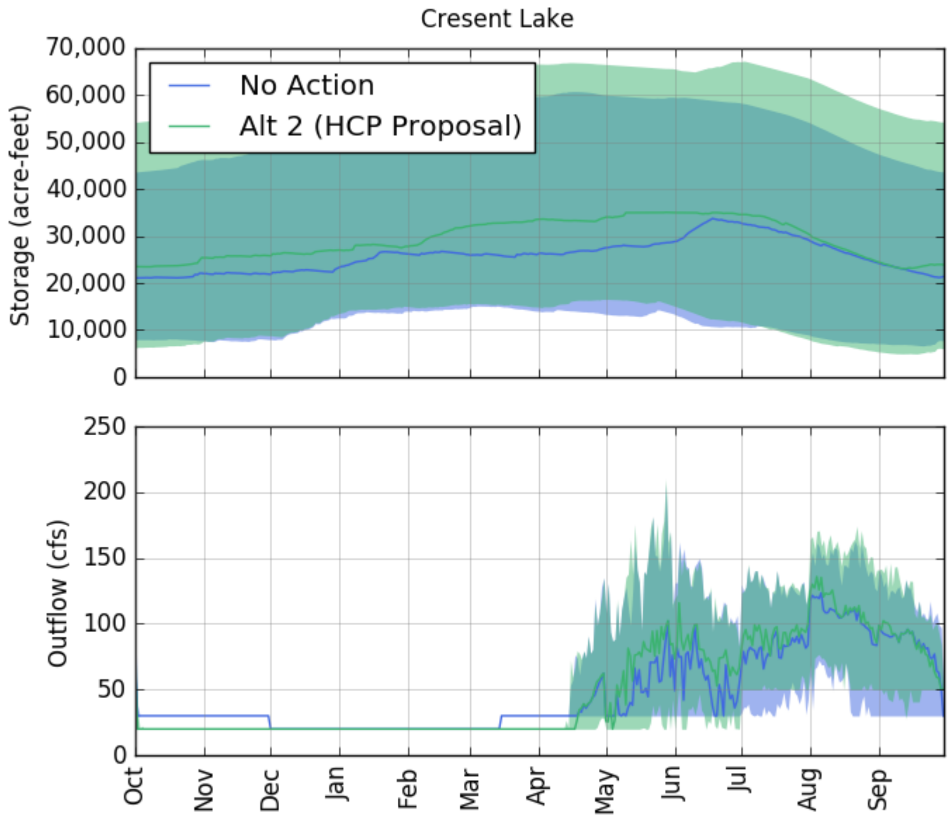


Figure 20. Summary hydrographs of simulated storage (top) and outflow (bottom) from Crescent Lake for the No Action Alternative (blue) compared to Alternative 2 (green). The dark blue or green line represents the median and the shaded blue or green areas represent the 20 to 80 percent exceedance.

Figure 21 shows a summary hydrograph of the simulated flow in the Little Deschutes River at La Pine for the No Action Alternative (blue) compared to Alternative 2 (green). As mentioned previously, the flow at this gage is largely unregulated with a small contribution from Crescent Creek and Crescent Lake. The changes in the releases from Crescent Lake can be seen primarily in the summer months, but, overall, the flow is relatively similar at this gage for both alternatives.

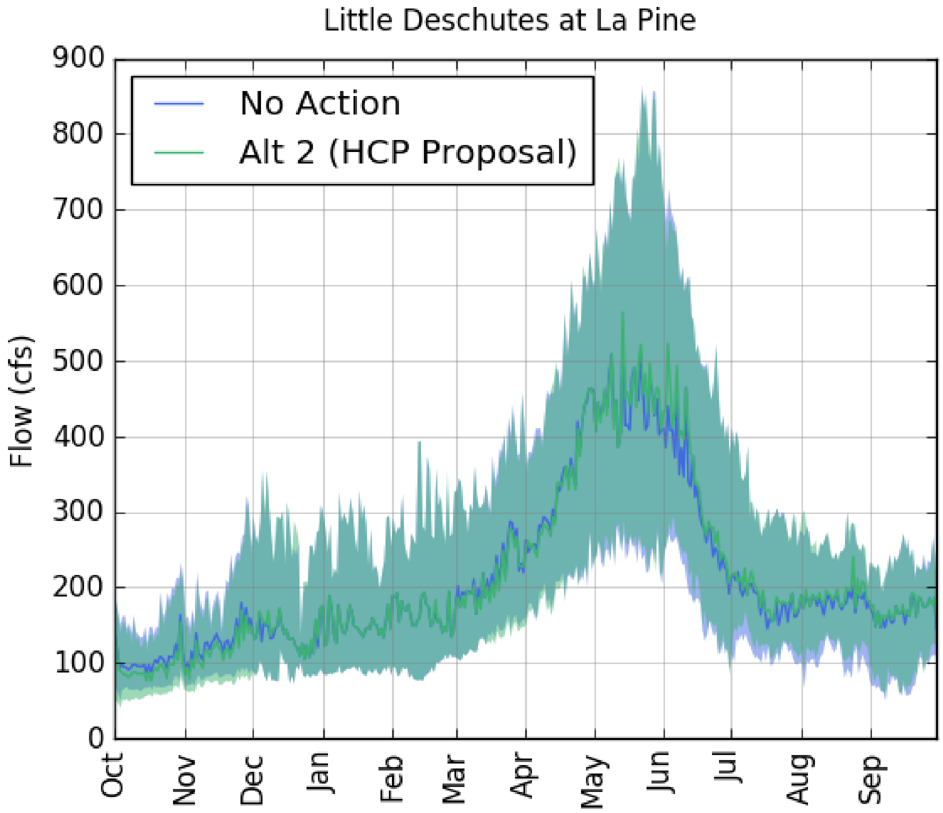


Figure 21. Summary hydrograph of simulated flow in the Little Deschutes River at La Pine for the No Action Alternative (blue) compared to Alternative 2 (green). The dark blue and green lines represent the median and the shaded area represents the 20 to 80 percent exceedance.

Figure 22 shows a summary hydrograph of the simulated flow in the Deschutes River at Benham Falls for the No Action Alternative (blue) compared to Alternative 2 (green). This gage is heavily influenced by the outflow from Wickiup Reservoir. Consequently, the changes from the No Action Alternative mimic the changes at Wickiup Reservoir.

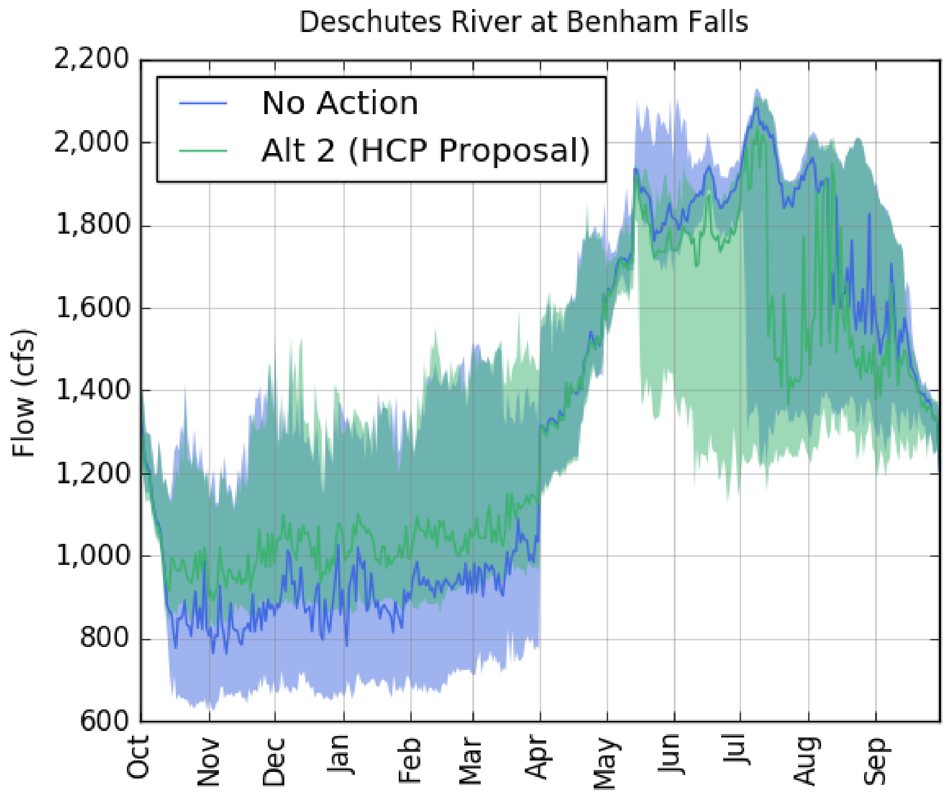


Figure 22. Summary hydrograph of simulated flow in the Deschutes River at Benham Falls for the No Action Alternative (blue) compared to Alternative 2 (green). The dark blue and green lines represent the median and the shaded area represents the 20 to 80 percent exceedance.

Figure 23 shows a summary hydrograph of the simulated flow in the Deschutes River below Bend for the No Action Alternative (blue) compared to Alternative 2 (green). The effects of the increased release from Wickiup Reservoir can be seen in the winter months when the range and median of flow is about 200 cfs larger than in the No Action Alternative. The summer flows at this location are similar for both alternatives.

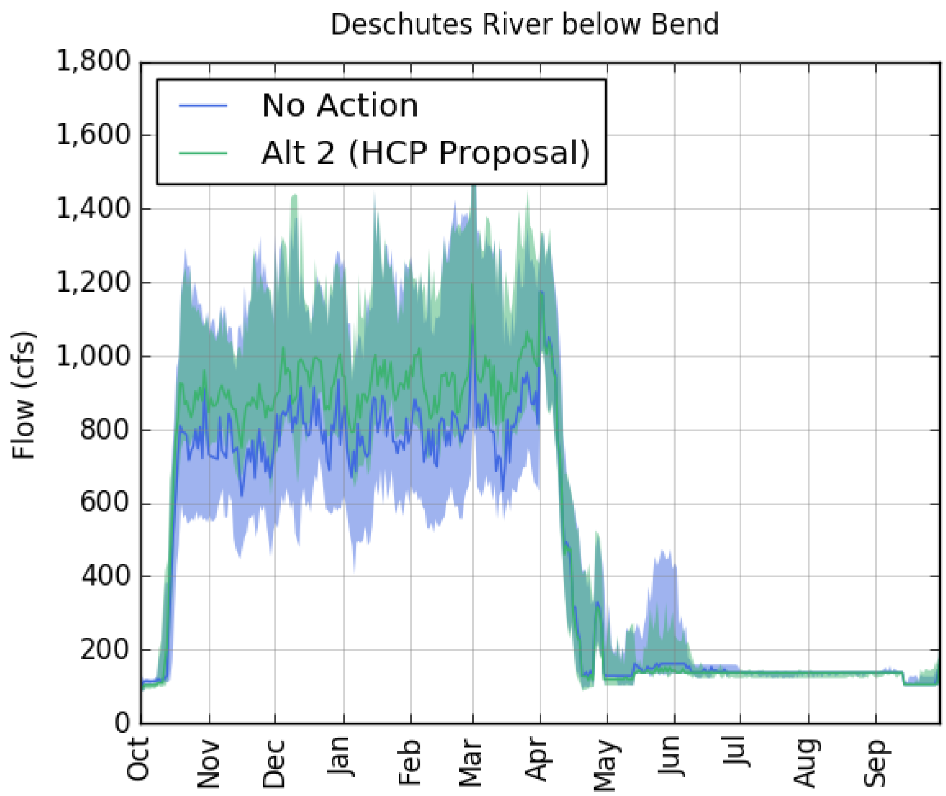


Figure 23. Summary hydrograph of simulated flow in the Deschutes River below Bend for the No Action Alternative (blue) compared to Alternative 2 (green). The dark blue or green lines represent the median and the shaded areas represent the 20 to 80 percent exceedance.

4.2.2. Tumalo Creek

There is no change in Tumalo Creek flows from the No Action Alternative to Alternative 2.

4.2.3. Whychus Creek

There is no change in Whychus Creek flows from the No Action Alternative to Alternative 2.

4.2.4. Crooked River

Figure 24 shows summary hydrographs for simulated storage and outflow from Prineville Reservoir for the No Action Alternative (blue) compared to Alternative 2 (green). Prineville Reservoir's operation in Alternative 2 reflects the changes in the Upper Deschutes. Since more water is released from Wickiup Reservoir for minimum flows, there is less available for NUID during the irrigation season. This causes Prineville Reservoir to release more water from NUID's rental account resulting in higher outflows and lower reservoir storage.

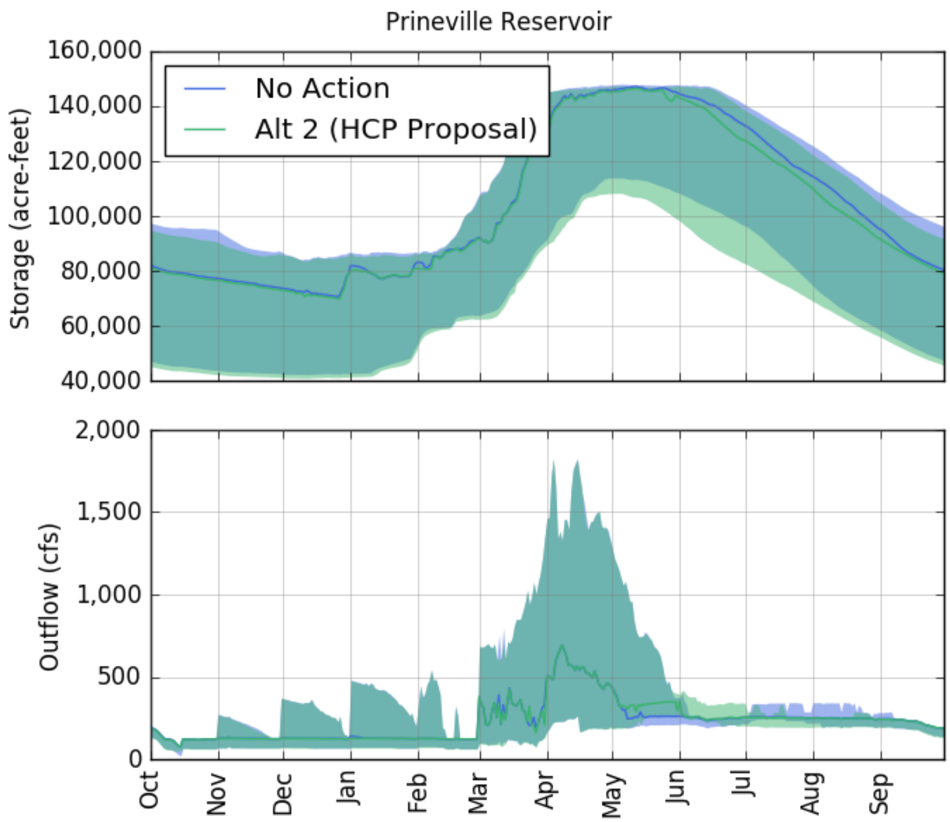


Figure 24. Summary hydrographs of simulated storage (top) and outflow (bottom) from Prineville Reservoir for the No Action Alternative (blue) compared to Alternative 2 (green). The dark blue or green line represents the median and the shaded areas represent the 20 to 80 percent exceedance.

Figure 25 shows a summary hydrograph of the simulated flow in the Crooked River at Highway 126 for the No Action Alternative (blue) compared to Alternative 2 (green). The effects of the change in Prineville Reservoir releases can be seen at this location.

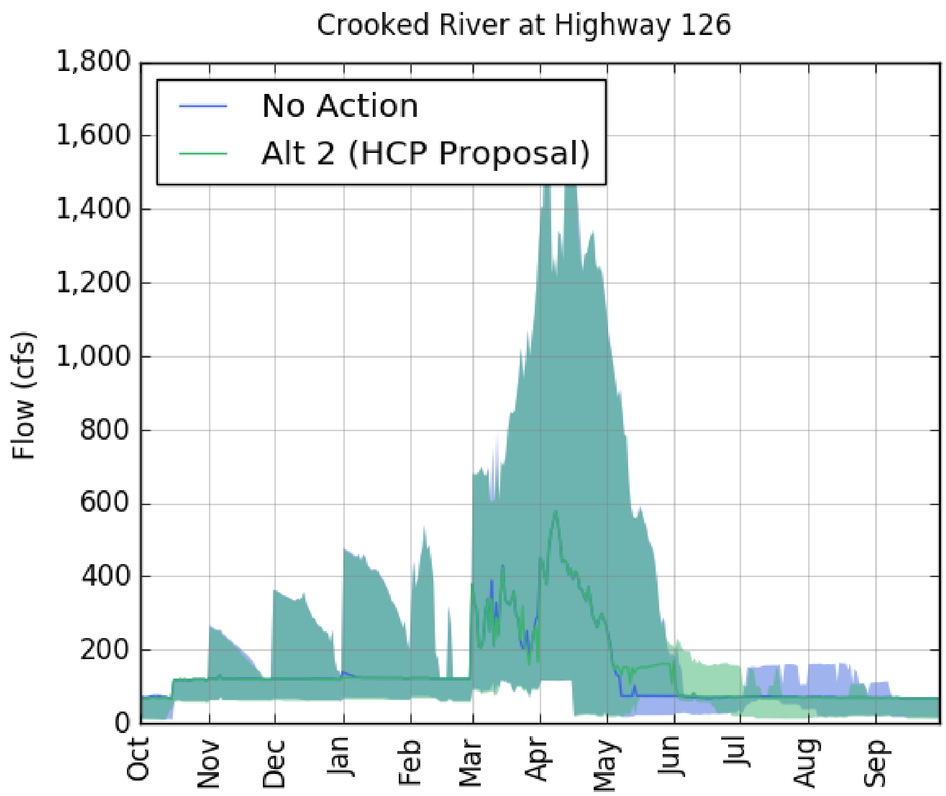


Figure 25. Summary hydrograph of simulated flow in the Crooked River at Highway 126 for the No Action Alternative (blue) compared to Alternative 2 (green). The dark blue or green lines represent the median and the shaded areas represent the 20 to 80 percent exceedance.

Figure 26 shows a summary hydrograph of the simulated flow in the Crooked River below the NUID pumps for the No Action Alternative (blue) compared to Alternative 2 (green). The effects of the change in Prineville Reservoir releases can be seen at this location.

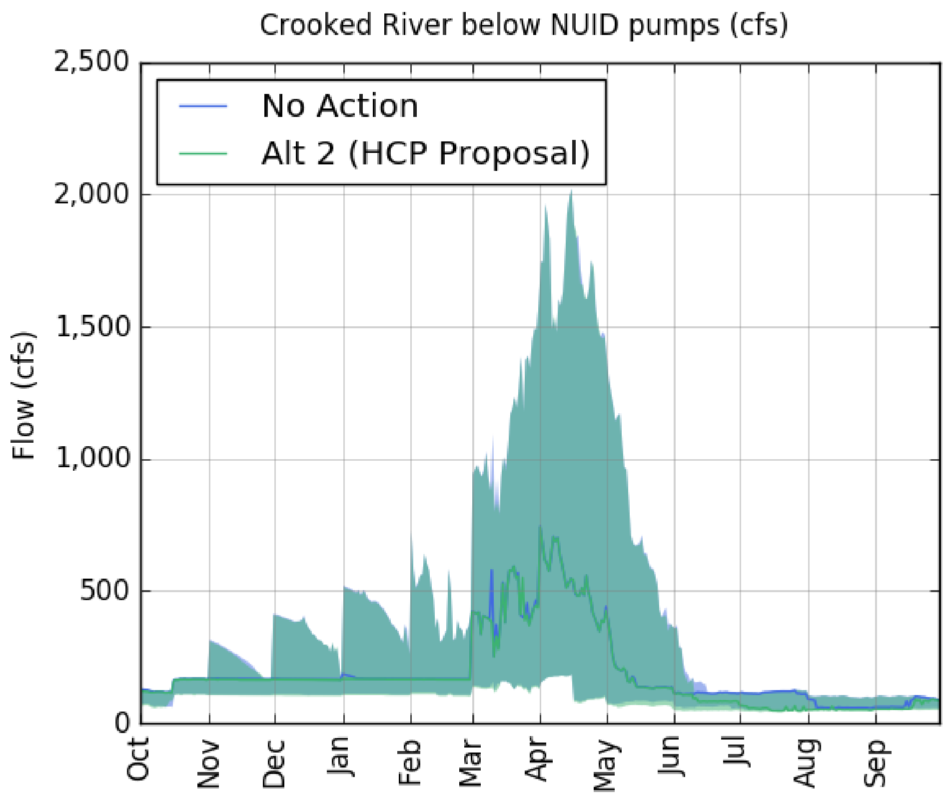


Figure 26. Summary hydrograph of simulated flow in the Crooked River below NUID pumps for the No Action Alternative (blue) compared to Alternative 2 (green). The dark blue or green lines represent the median and the shaded areas represent the 20 to 80 percent exceedance.

4.2.5. Irrigation Shortages

Irrigation shortages are calculated every model year and are the difference between the requested demand and the amount of water delivered to each district. The total annual shortages for Alternative 2 are ranked and shown in Figure 27. NUID has the largest shortage in Alternative 2 because it is the junior water user on the system. This shortage is increased because the non-irrigation season flows out of Wickiup Reservoir reduce the amount of stored water available for NUID. Other districts also experience increased shortage because of the increased non-irrigation season flow requirement.

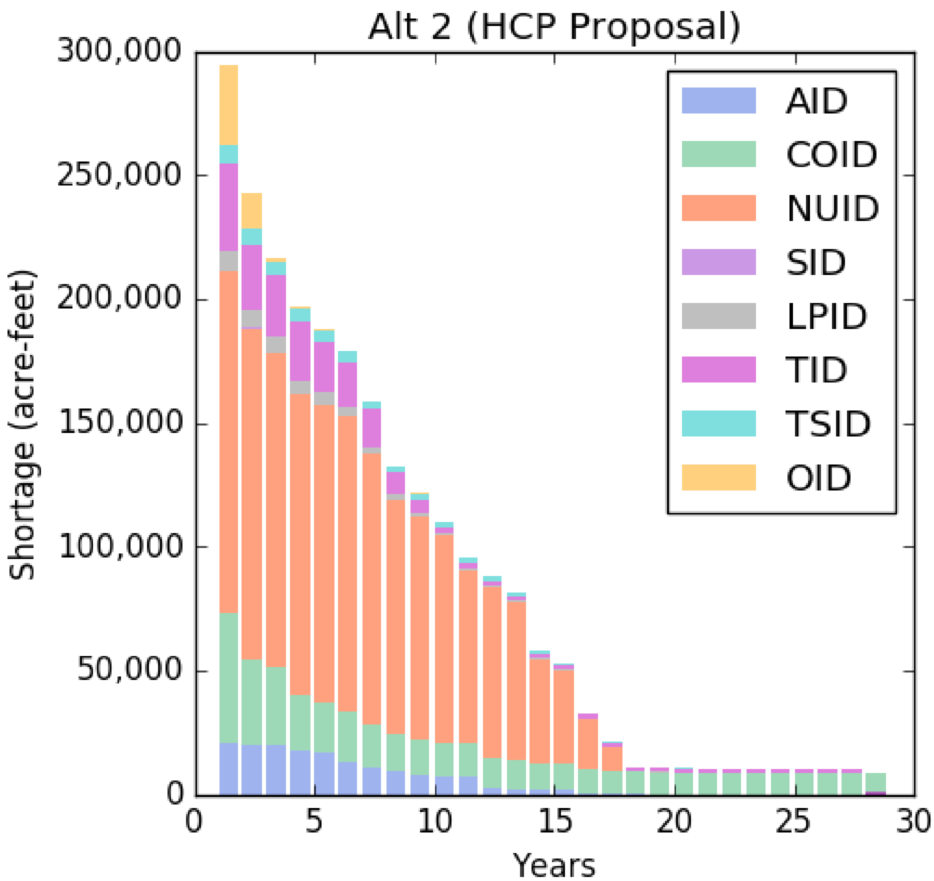


Figure 27. Irrigation shortages for the eight major irrigation districts for Alternative 2.

4.3. Alternative 3

Alternative 3 results are displayed along with the No Action Alternative results for comparison. Only the locations that experienced a change from the No Action Alternative are shown in this section.

4.3.1. Upper Deschutes

The operations in the Upper Deschutes are the same in Alternative 3 as in Alternative 2. Refer to the results in Alternative 2 for the Upper Deschutes.

4.3.2. Tumalo Creek

There is no change in Tumalo Creek flows from the No Action Alternative to Alternative 3.

4.3.3. Whychus Creek

There is no change in Whychus Creek flows from the No Action Alternative to Alternative 3.

4.3.4. Crooked River

The Crooked River has a difference in operations because the uncontracted releases are protected from diversion for irrigation. This is modeled by requiring NUID to bypass the larger of the minimum flows required by the DRC agreement and the releases out of the uncontracted account.

Figure 28 shows the storage and outflow from Prineville Reservoir for the No Action Alternative compared to Alternative 3 (left), and Alternative 2 compared to Alternative 3 (right). In Alternative 2, NUID could divert any uncontracted water over and above the DRC agreement flows. Under Alternative 3, they can no longer divert as much water in the river because they need to bypass the larger of the uncontracted release or the DRC agreement. To make up the difference, they request more from their rental account. This causes Prineville Reservoir storage to be slightly lower at the end of the irrigation season and, in some years, reduces storage on April 1. Since the uncontracted account is last to fill, it takes the shortage when Prineville Reservoir does not fill, which affects the amount it can release the following year. Overall, the effect is slightly different outflows and lower reservoir storage in Alternative 3.

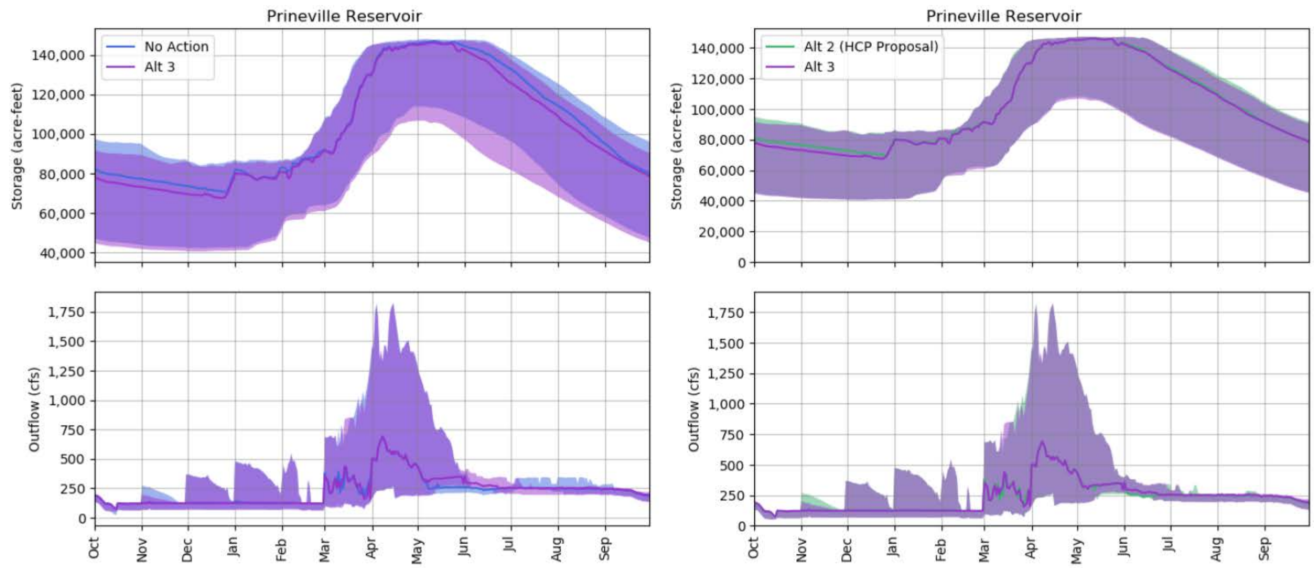


Figure 28. Summary hydrographs of simulated storage (top) and outflow (bottom) from Prineville Reservoir. The graphs on the left show the No Action Alternative (blue) compared to Alternative 3 (purple). The graphs on the right show Alternative 2 (green) compared to Alternative 3 (purple). In all graphs, the colored lines represent the median and the shaded areas represent the 20 to 80 percent exceedance.

In the most extreme years from the simulation period, NUID used approximately 3,500 acre-feet more water from its rental account in Alternative 3 versus Alternative 2. The effect on the uncontracted account was a reduction in storage of 3,400 acre-feet. This ultimately results in lower outflows from the uncontracted account.

Figure 29 shows summary hydrographs of the simulated flow in the Crooked River at Highway 126 for the No Action Alternative (blue) compared to Alternative 3 (purple) (left), and Alternative 2 (green) compared to Alternative 3 (purple) (right). The effects of the change in Prineville Reservoir releases can be seen at this location.

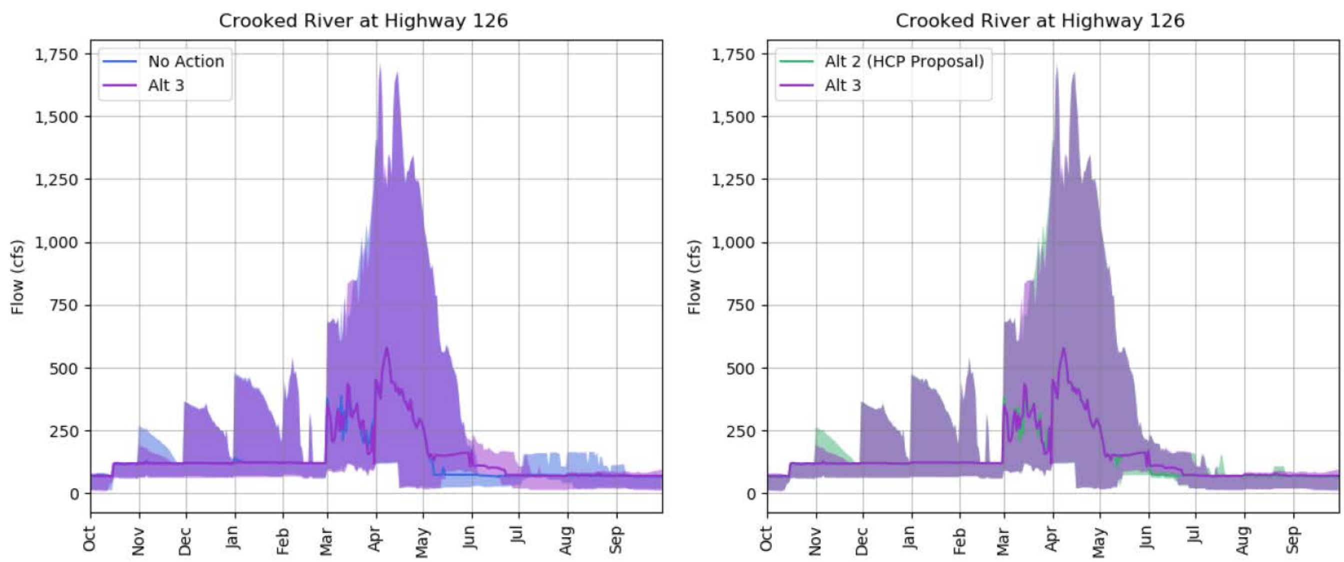


Figure 29. Summary hydrographs of simulated flow in the Crooked River at Highway 126. The graph on the left shows the No Action Alternative (blue) compared to Alternative 3 (purple). The graph on the right shows Alternative 2 (green) compared to Alternative 3 (purple). The colored lines represent the median and the shaded areas represent the 20 to 80 percent exceedance.

Figure 30 shows summary hydrographs of the simulated flow in the Crooked River below the NUID pumps for the No Action Alternative (blue) compared to Alternative 3 (purple), and Alternative 2 (green) compared to Alternative 3 (purple). The effects of the change in Prineville Reservoir releases can be seen at this location. Note that Alternative 3 shows slightly higher median flows than Alternative 2 in the summer.

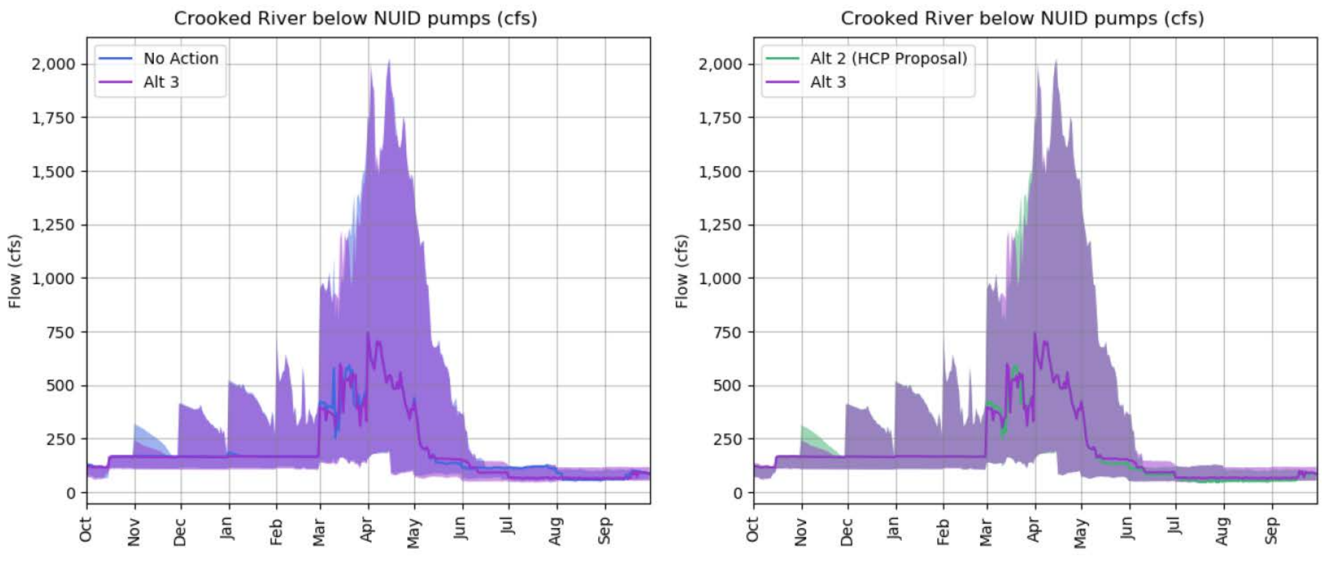


Figure 30. Summary hydrographs of simulated flow in the Crooked River below NUID pumps. The graph on the left shows the No Action Alternative (blue) compared to Alternative 3 (purple) . The graph on the right shows Alternative 2 (green) compared to Alternative 3 (purple). The colored lines represent the median and the shaded areas represent the 20 to 80 percent exceedance.

4.3.5. Irrigation Shortages

Irrigation shortages are calculated every model year and are the difference between the requested demand and the amount of water delivered to each district. The total annual shortages for Alternative 3 are ranked and shown in Figure 31. NUID has the largest shortage in Alternative 3 because it is the junior water user on the system. This shortage is slightly larger than Alternative 2 because of the protection of the uncontracted water out of Prineville Reservoir.

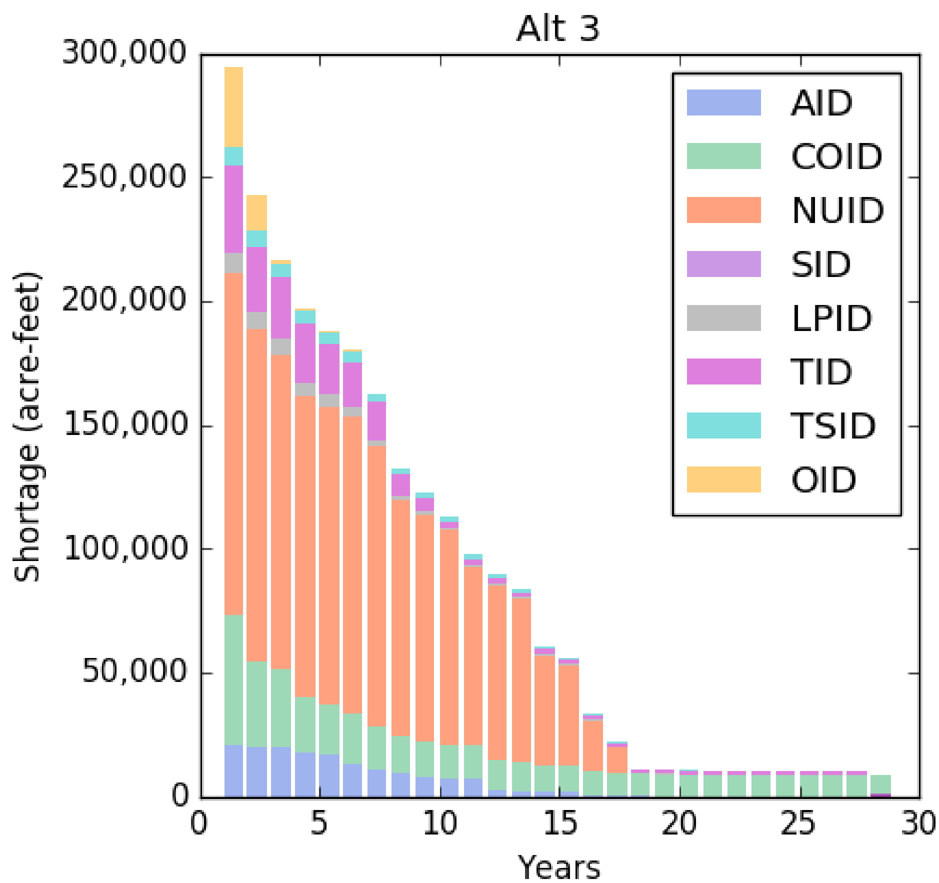


Figure 31. Irrigation shortages for the eight major irrigation districts for Alternative 3.

4.4. Alternative 4

The Alternative 4 results are displayed along with the No Action Alternative results for comparison. Only the locations that experienced a change from the No Action Alternative are shown in this section.

4.4.1. Upper Deschutes

Figure 32 shows summary hydrographs of the simulated storage and outflow from Wickiup Reservoir for the No Action Alternative (blue) compared to Alternative 4 (orange-red) and Alternative 2 (green) compared to Alternative 4 (orange-red). The graph shows the results of the scenario where minimums between 400 and 600 cfs were maintained and defined by November 1 Wickiup Reservoir storage contents as compared to the No Action Alternative where outflows ranged from 100 to 500 cfs and Alternative 2 where outflows ranged from 400 to 500 cfs. The graphs show that the ranges of flows are achievable for each of the alternatives. However, Wickiup Reservoir storage in Alternative 4 is lower than both the No Action Alternative and Alternative 2.

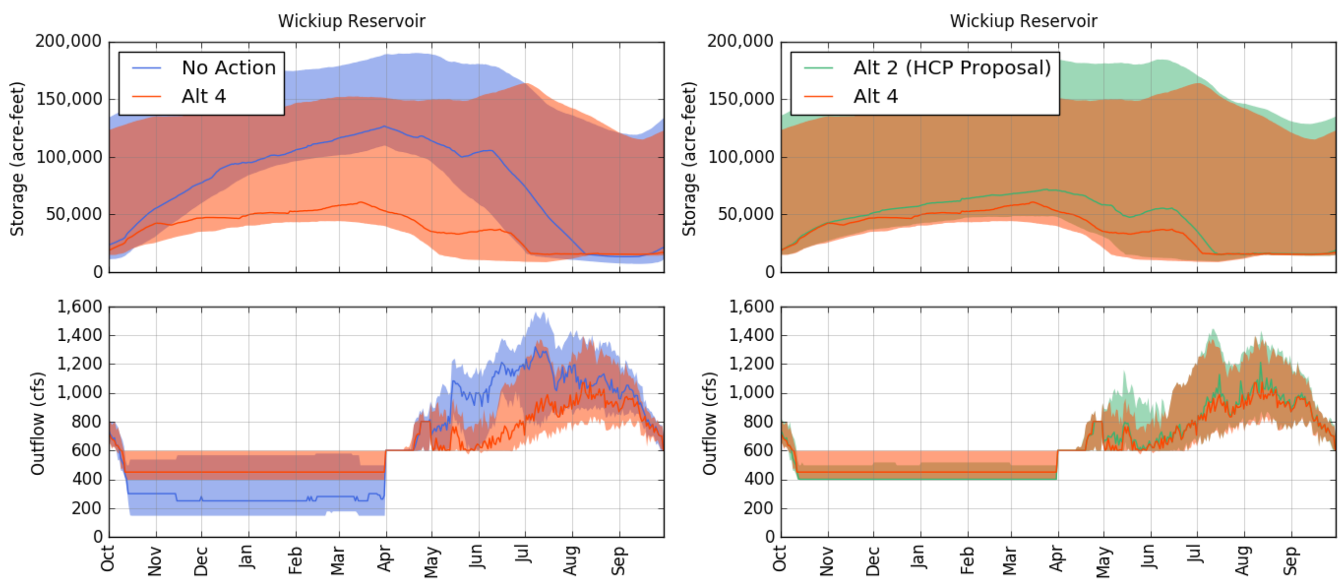


Figure 32. Summary hydrographs of simulated storage (top) and outflow (bottom) from Wickiup Reservoir. The graph on the left shows the No Action Alternative (blue) compared to Alternative 4 (orange-red). The graph on the right shows Alternative 3 (green) compared to Alternative 4 (orange-red). The colored lines represent the median and the shaded areas represent the 20 to 80 percent exceedance.

Figure 33 shows summary hydrographs for the storage and outflow from Crescent Lake for the No Action Alternative (blue) compared to Alternative 4 (orange-red), and Alternative 2 (green) compared to Alternative 4 (orange-red). Recall that the intended operation for Crescent Lake in Alternative 2 was to maintain a minimum of 20 cfs throughout the year and 50 cfs from July 1 through September 30, if there is enough water in the lake. The storage in Crescent Lake is slightly higher than the No Action Alternative because the outflow requirements are lower in Alternative 4. When compared to Alternative 2, Alternative 4 storage is lower. This is due Crescent Lake bypassing water to meet more senior live flow rights downstream that experience less live flow availability due to the higher winter releases from Wickiup Reservoir.

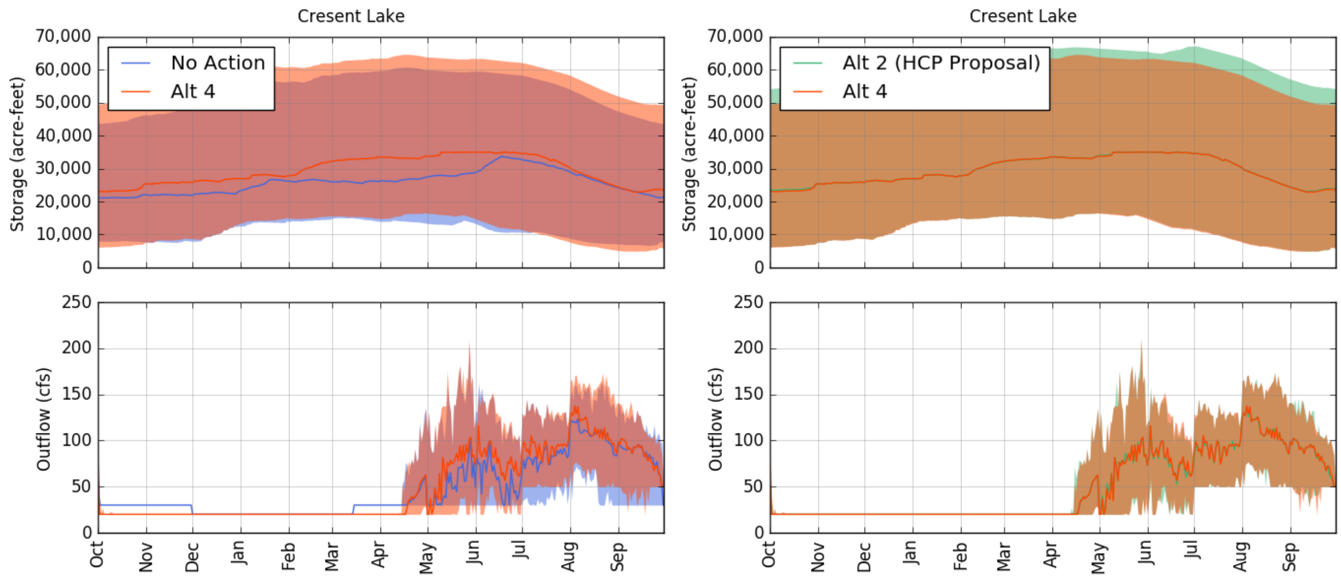


Figure 33. Summary hydrographs of simulated storage (top) and outflow (bottom) from Crescent Lake. The graph on the left shows the No Action Alternative (blue) compared to Alternative 4 (orange-red). The graph on the right shows Alternative 2 (green) compared to Alternative 4 (orange-red). The colored lines represent the median and the shaded areas represent the 20 to 80 percent exceedance.

Figure 34 shows summary hydrographs of the simulated flow in the Little Deschutes River at La Pine for the No Action Alternative (blue) compared to Alternative 4 (orange-red), and Alternative 2 (green) compared to Alternative 4 (orange-red). As mentioned previously, the flow at this gage is largely unregulated with a small contribution from Crescent Creek and Crescent Lake. The changes in the releases from Crescent Lake can be seen primarily in the summer months, but, overall, the flow is relatively similar at this gage for both alternatives. Note that the flow changes between Alternatives 2 and 4 are small relative to the total flow.

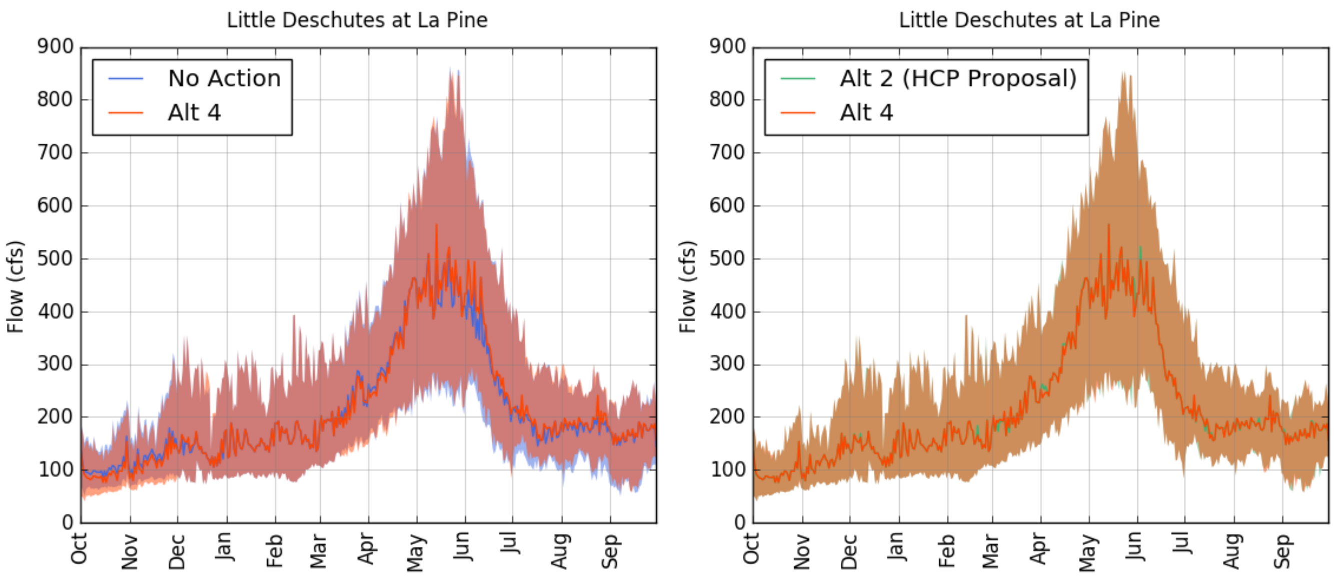


Figure 34. Summary hydrographs of simulated flow in the Little Deschutes at La Pine pumps. The graph on the left shows the No Action Alternative (blue) compared to Alternative 4 (orange-red). The graph on the right shows Alternative 2 (green) compared to Alternative 4 (orange-red). The colored lines represent the median and the shaded areas represent the 20 to 80 percent exceedance.

Figure 35 shows summary hydrographs of the simulated flow in the Deschutes River at Benham Falls for the No Action Alternative (blue) compared to Alternative 4 (orange-red), and Alternative 2 (green) compared to Alternative 4 (orange-red). This gage is heavily influence by the outflow from Wickiup Reservoir so the changes from the No Action Alternative mimic those changes at Wickiup Reservoir. Note that the differences between Alternative 2 and Alternative 4 are small.

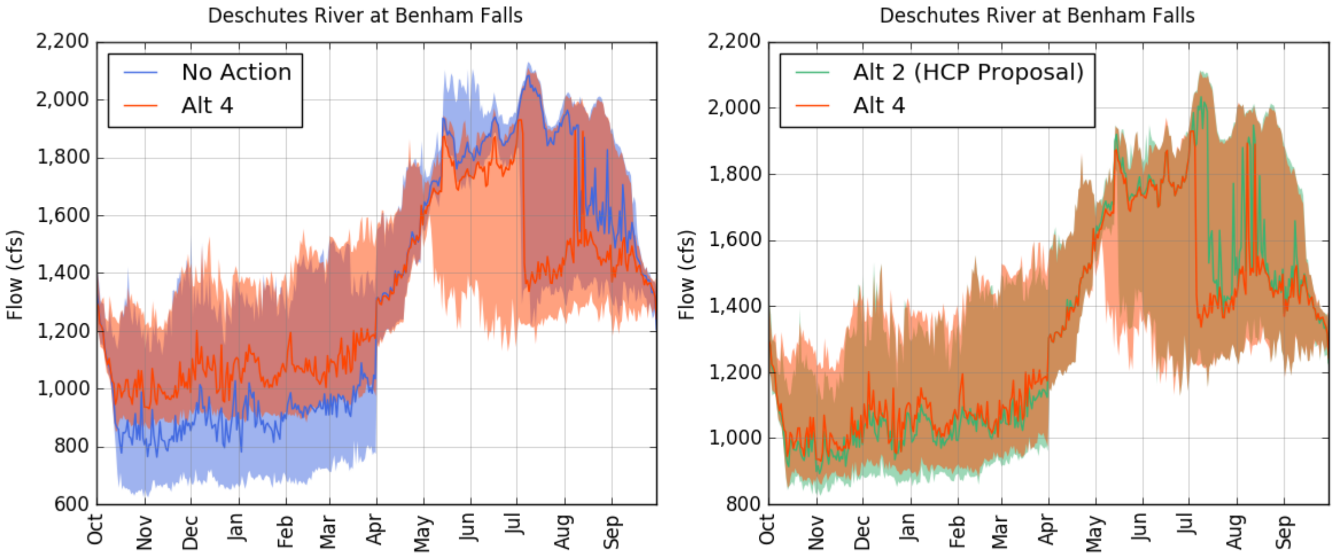


Figure 35. Summary hydrographs of simulated flow in the Deschutes River at Benham Falls. The graph on the left shows the No Action Alternative (blue) compared to Alternative 4 (red). The graph on the right shows Alternative 2 (green) compared to Alternative 4 (orange-red). The colored lines represent the median and the shaded areas represent the 20 to 80 percent exceedance.

Figure 36 shows summary hydrographs of the simulated flow in the Deschutes River below Bend for the No Action (blue) compared to Alternative 4 (orange-red) and Alternative 2 (green) compared to Alternative 4 (orange-red). The effects of the increased release from Wickiup Reservoir can be seen in the winter months when the range and median of flow is larger than in the No Action. The summer flows are similar for all three alternatives.

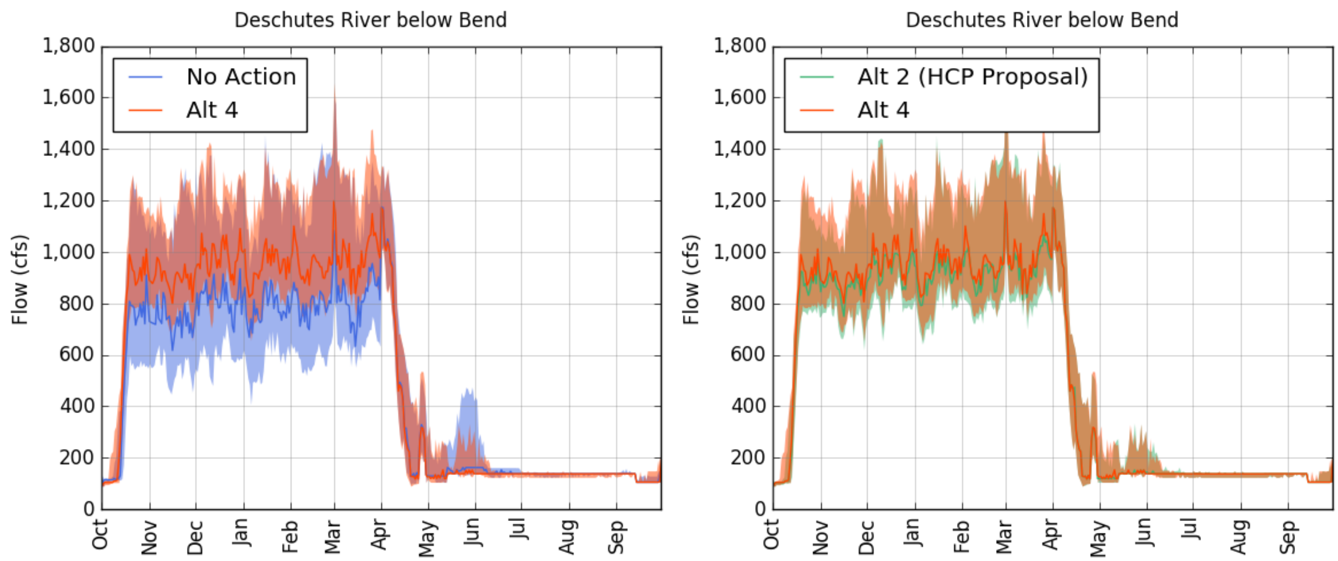


Figure 36. Summary hydrographs of simulated flow in the Deschutes River below Bend. The graph on the left shows the No Action Alternative (blue) compared to Alternative 4 (red). The graph on the right shows Alternative 2 (green) compared to Alternative 4 (orange-red). The colored lines represent the median and the shaded areas represent the 20 to 80 percent exceedance.

4.4.2. Tumalo Creek

There is no change in Tumalo Creek flows from the No Action Alternative to Alternative 4.

4.4.3. Whychus Creek

There is no change in Whychus Creek flows from the No Action Alternative to Alternative 4.

4.4.4. Crooked River

The Crooked River has a difference in operations because the uncontracted releases from Prineville Reservoir are protected from diversion for irrigation. This is modeled by requiring NUID to bypass the larger of the minimum flows required by the DRC agreement and the releases out of the uncontracted account. In addition, the Crooked River is affected by the changes in Wickiup Reservoir outflow.

Figure 37 shows the storage and outflow from Prineville Reservoir for the No Action Alternative and Alternative 4. In Alternative 4, the uncontracted flows are protected, similar to Alternative 3. In addition, higher winter outflows from Wickiup Reservoir reduce the Upper Deschutes supply to NUID, so they request additional rental water from Prineville Reservoir. Overall, the effect is slightly different outflows and lower reservoir storage in Alternative 4.

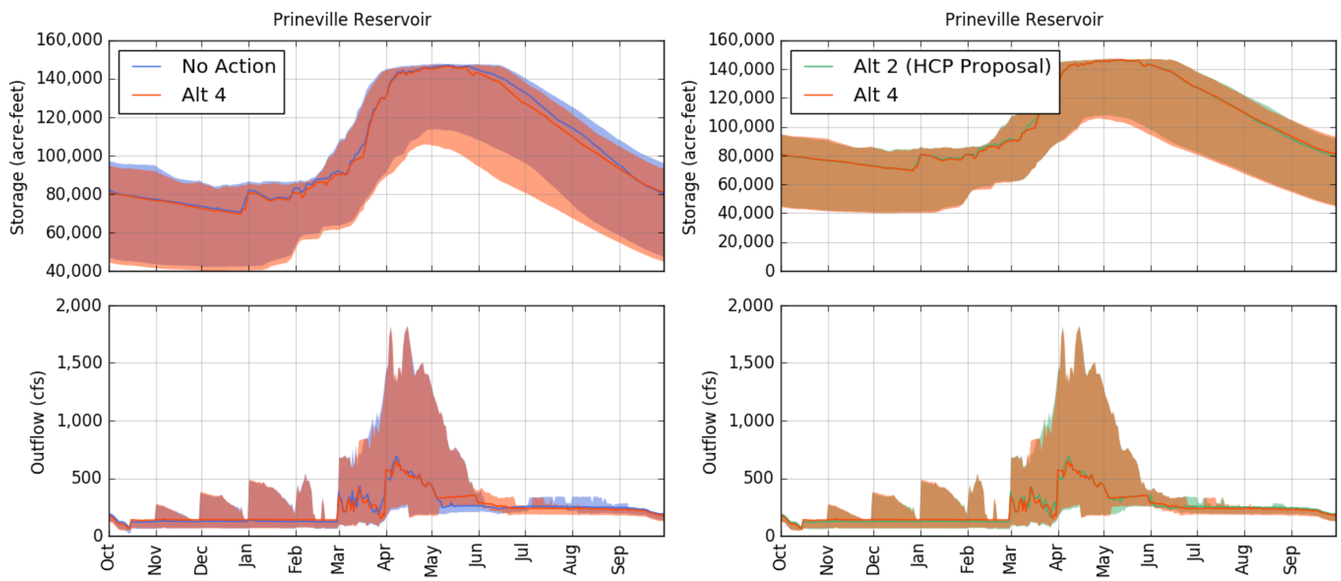


Figure 37. Summary hydrographs of simulated storage (top) and outflow (bottom) from Prineville Reservoir. The graph on the left shows the No Action Alternative (blue) compared to Alternative 4 (orange-red). The graph on the right shows Alternative 2 (green) compared to Alternative 4 (orange-red). The colored lines represents the median and the shaded areas represent the 20 to 80 percent exceedance.

The change in Wickiup Reservoir outflows has a much larger effect on NUID shortages in Alterative 4 than Alternative 3 where, in the most extreme years, it uses almost the entire 10,000 acre-feet in the account. The effect on the uncontracted account is a reduction in storage by 28,000 acre-feet, which results in lower outflows from the uncontracted account.

Figure 38 shows summary hydrographs of the simulated flow in the Crooked River at Highway 126 for the No Action Alternative (blue) compared to Alternative 4 (red), and Alternative 2 (green) compared to Alternative 4 (orange-red). The effects of the change in Prineville Reservoir releases can be seen at this location.

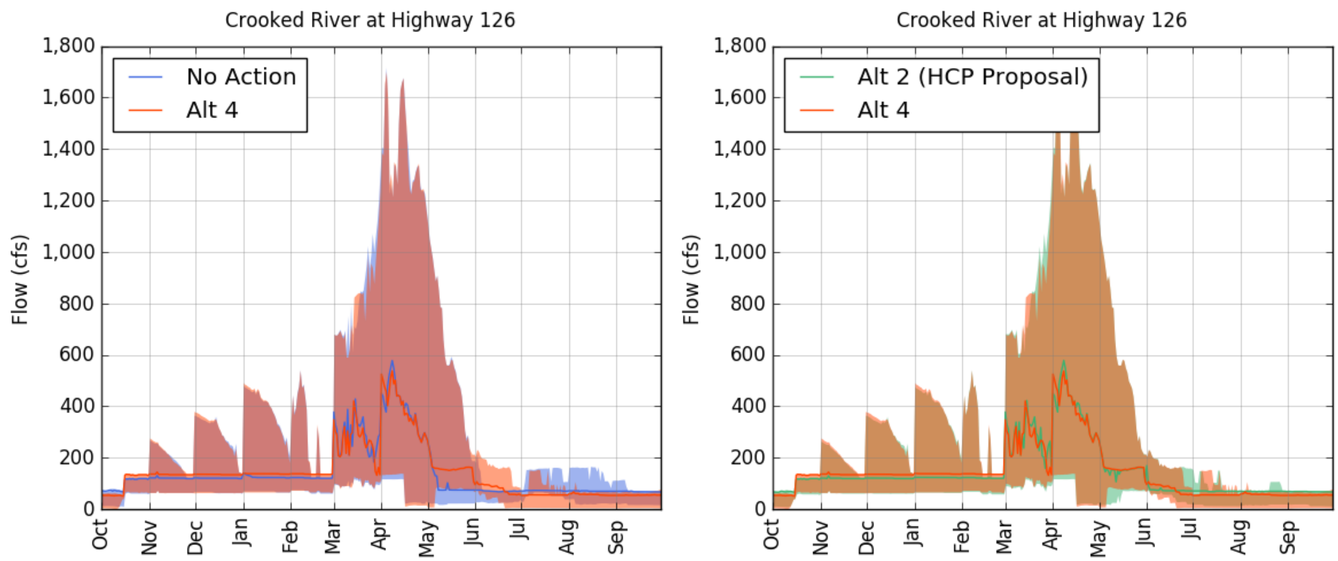


Figure 38. Summary hydrographs of simulated flow in the Crooked River at Highway 126. The graph on the left shows the No Action Alternative (blue) compared to Alternative 4 (red). The graph on the right shows Alternative 2 (green) compared to Alternative 4 (orange-red). The colored lines represent the median and the shaded areas represent the 20 to 80 percent exceedance.

Figure 39 shows summary hydrographs of the simulated flow in the Crooked River below NUID pumps for the No Action Alternative (blue) compared to Alternative 4 (orange-red), and Alternative 2 (green) compared to Alternative 4 (orange-red). The effects of the change in Prineville Reservoir releases can be seen at this location.

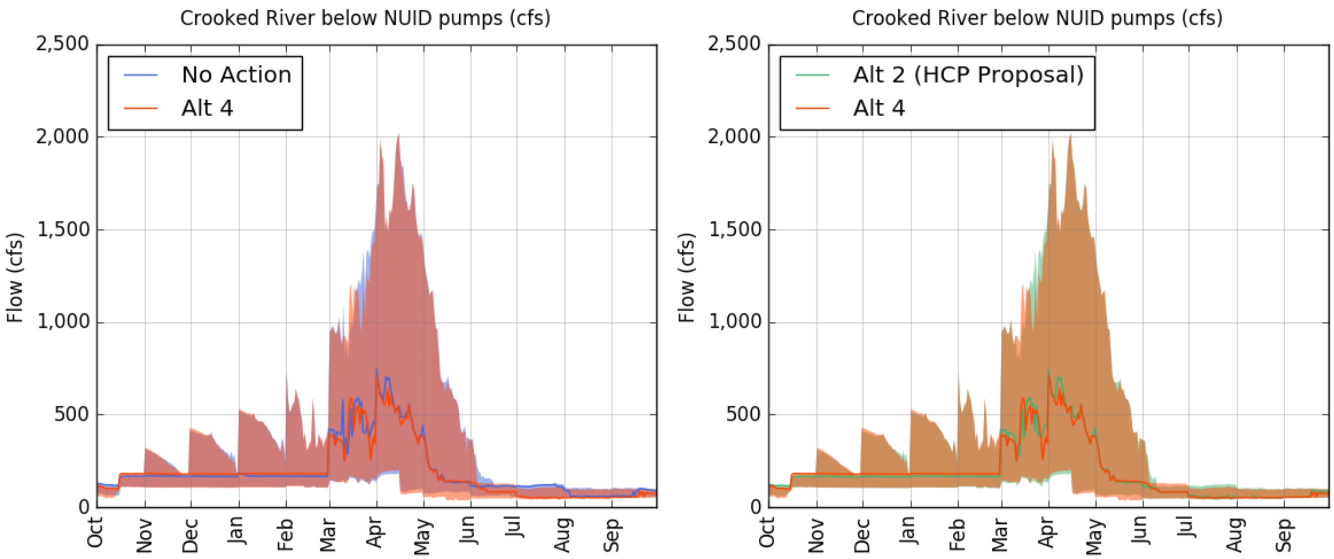


Figure 39. Summary hydrographs of simulated flow in the Crooked River below NUID pumps. The graph on the left shows the No Action Alternative (blue) compared to Alternative 4 (red). The graph on the right shows Alternative 2 (green) compared to Alternative 4 (orange-red). The colored lines represent the median and the shaded areas represent the 20 to 80 percent exceedance.

4.4.5. Irrigation Shortages

Irrigation shortages are calculated every model year and are the difference between the requested demand and the amount of water delivered to each district. The total annual shortages for Alternative 4 are ranked and shown in Figure 40. Like the No Action Alternative, NUID has the largest shortage in Alternative 4 because it is the junior water user on the system. This shortage is increased because the non-irrigation season flows out of Wickiup Reservoir reduce the amount of stored water available for NUID. Other districts also experience increased shortage because of the increased non-irrigation season flow requirement.

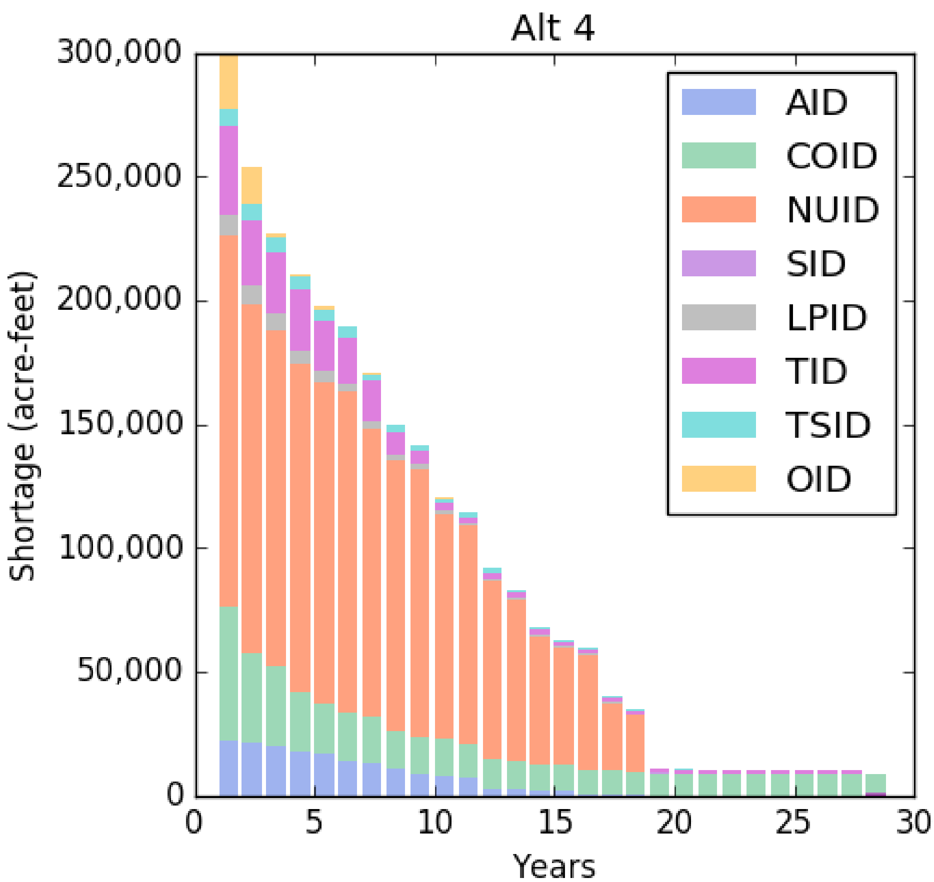


Figure 40. Irrigation shortages for the eight major irrigation districts for Alternative 4.

5. Summary

Four alternatives were simulated for the DBHCP EIS using RiverWare. The major results are summarized as follows:

- Crane Prairie Reservoir can achieve the storage requirements in most years.
- Crescent Lake can achieve minimum flow requirements and it results in:
  - Higher storage when compared to the No Action Alternative and lower storage when combined with higher Wickiup Reservoir outflows.
- Higher winter outflows from Wickiup Reservoir can be achieved and it results in:
  - Higher winter flows below Wickiup Reservoir, at Benham Falls, below Bend, and at Madras. The increase in flows depends on the flow range defined in the scenario.
  - Decreased winter storage in Wickiup Reservoir. This leads to less water available for irrigation releases in the summer.
  - Decreased storage in Crescent Lake due to additional live flow needed for downstream diversion.
  - Increased irrigation shortages with NUID being the most impacted. Since NUID can also receive water from the Crooked River, storage in Prineville Reservoir is also affected.
- Protecting the uncontracted water from Prineville Reservoir results in:
  - Increased use of NUID’s rental account. The amount of water needed is dependent on minimum releases from Wickiup Reservoir.
  - Increased shortage to NUID.
  - Decreased uncontracted water in some years. This results in lower releases in the following year.

6. Literature Cited

Parenthetical Reference	Bibliographic Citation
LaMarche 2018	LaMarche, J. 2018, personal communication. Conversation and emails between Jonathan LaMarche, Hydrologist (Oregon Water Resources Department, Salem, Oregon) and Jennifer Johnson, Hydraulic Engineer, (U.S. Bureau of Reclamation, Boise, Idaho). Subject: The seepage processes between Crane Prairie and Wickiup Reservoirs. August 2018.
OWRD 2013	Oregon Department of Water Resources (OWRD). 2013. Agreement between North Unit Irrigation District and Deschutes River Conservancy regarding minimum stream flows in the Crooked River. Attachment 3 to Conserved Water Application CW-75. Signed September 18, 2013.
Reclamation 2017a	Bureau of Reclamation. 2017a. Development of a Daily Water Management Model of the Deschutes River, Oregon, using RiverWare. March 2017.
Reclamation 2017b	Bureau of Reclamation. 2017b. Hydrologic Evaluation of Baseline and Proposed Management of the Deschutes Project for Oregon Spotted Frog (OSF Proposal). January 2017.
Reclamation 2017c	Bureau of Reclamation. 2017c. Unregulated Flows in the Upper Deschutes Basin, Oregon. October 2017.
Zagona et al. 2001	Zagona, E.A., T.J. Fulp, R. Shane, T.M. Magee, H.M. Goranflo. 2001. RiverWare: A Generalized Tool for Complex Reservoir System Modeling. Journal of the American Water Resources Association, 37(4), 913-929.

7. Appendix – Logarithmic Graphs of Crooked River Flows

Since a large emphasis is placed on the low flows in the Crooked River, logarithmic graphs were developed to better see the model output.

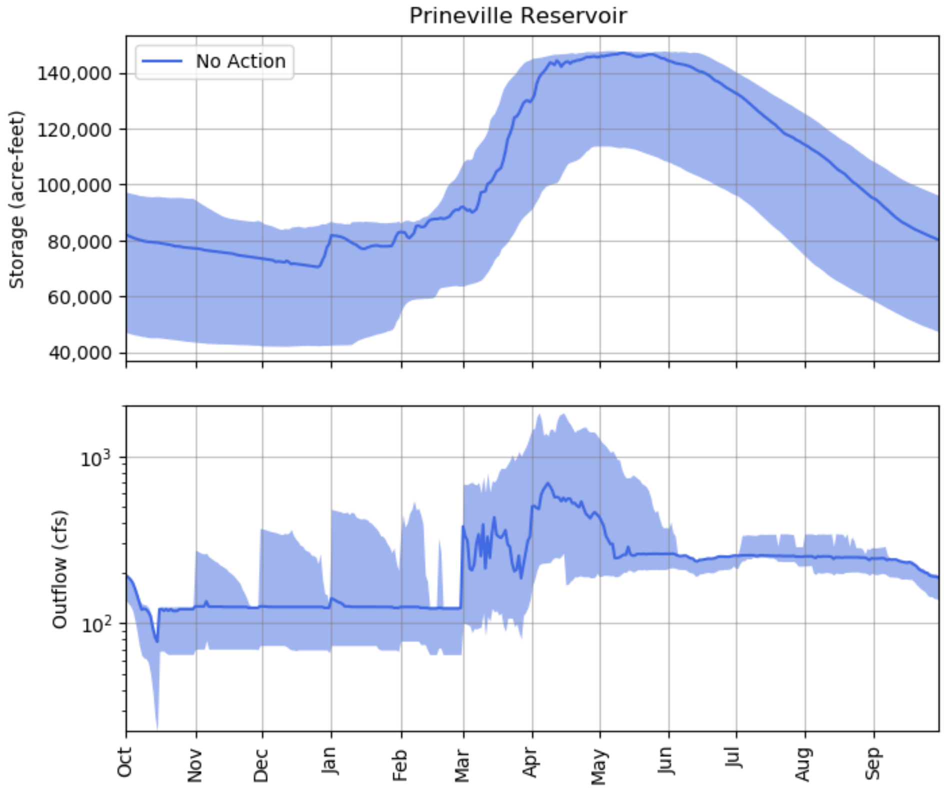


Figure 41. Summary hydrograph of simulated storage (top) and outflow (bottom) from Prineville Reservoir showing the No Action Alternative. The dark blue line represents the median and the shaded blue area represents the 20 to 80 percent exceedance. The y-axis for flows is shown in logarithmic scale.

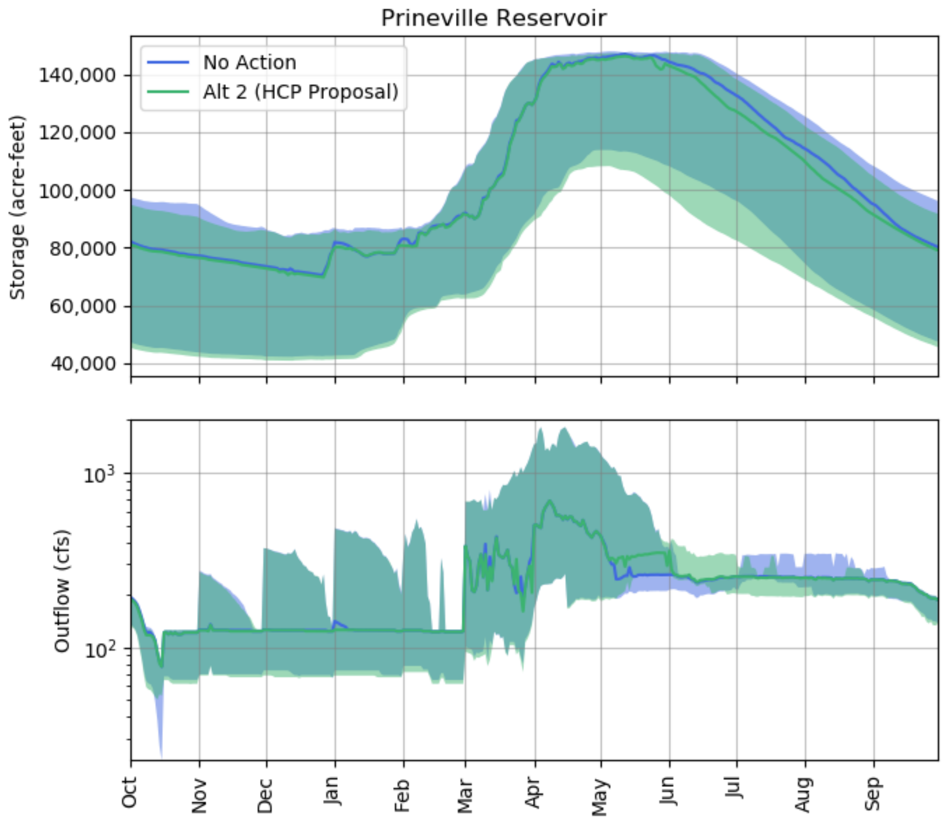


Figure 42. Summary hydrographs of simulated storage (top) and outflow (bottom) from Prineville Reservoir. The graphs show the No Action Alternative (blue) compared to Alternative 2 (green). The dark blue or green line represents the median and the shaded areas represent the 20 to 80 percent exceedance. The y-axis for flows is shown in logarithmic scale.

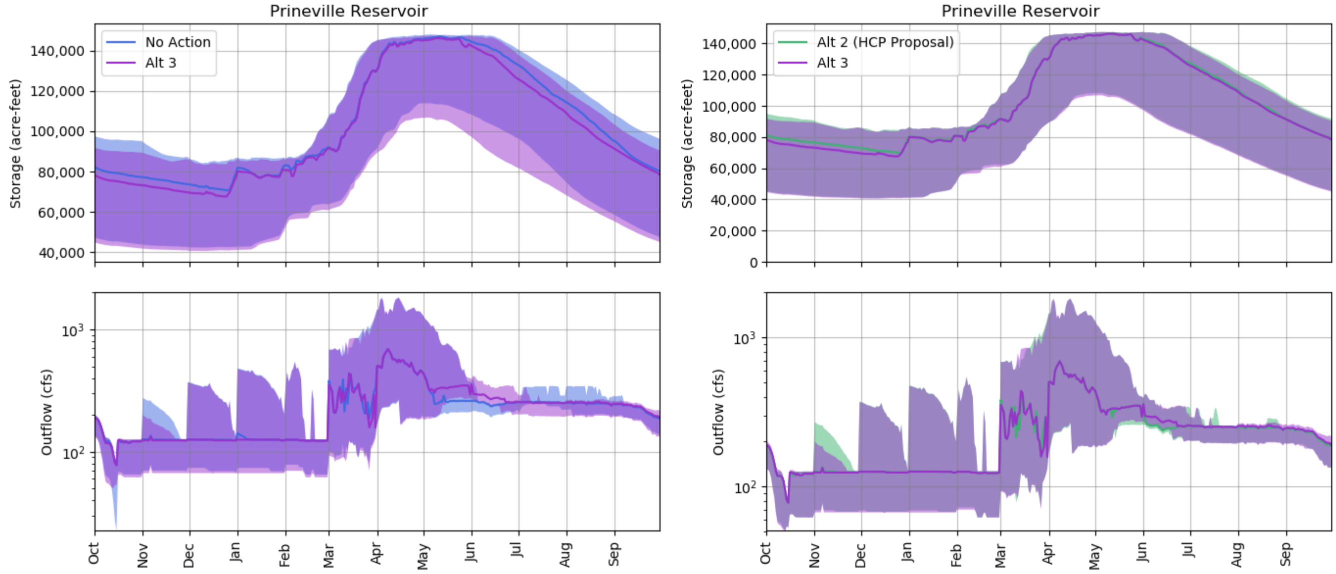


Figure 43. Summary hydrographs of simulated storage (top) and outflow (bottom) from Prineville Reservoir. The graphs on the left show the No Action Alternative (blue) compared to Alternative 3 (purple). The graphs on the right show Alternative 2 (green) compared to Alternative 3 (purple). The colored lines represent the median and the shaded areas represent the 20 to 80 percent exceedance. The y-axis for flows is shown in logarithmic scale.

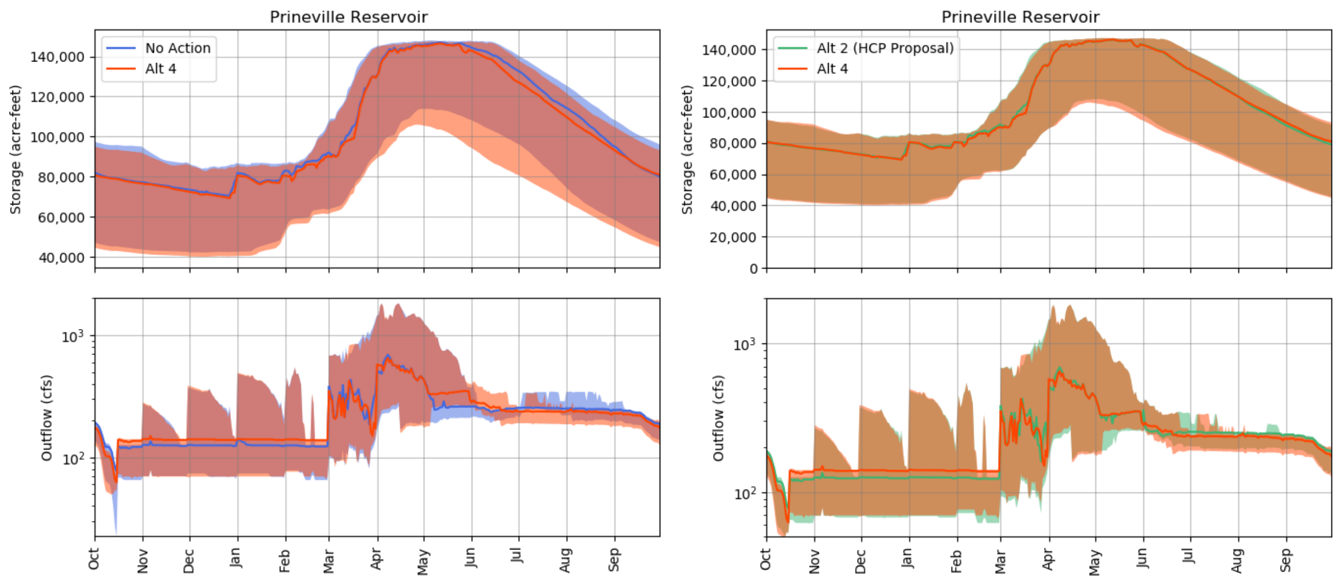


Figure 44. Summary hydrographs of simulated storage (top) and outflow (bottom) from Prineville Reservoir. The graphs on the left show the No Action Alternative (blue) compared to Alternative 4 (orange-red). The graphs on the right show Alternative 2 (green) compared to Alternative 4 (orange-red). The colored lines represents the median and the shaded areas represent the 20 to 80 percent exceedance. The y-axis for flows is shown in logarithmic scale.

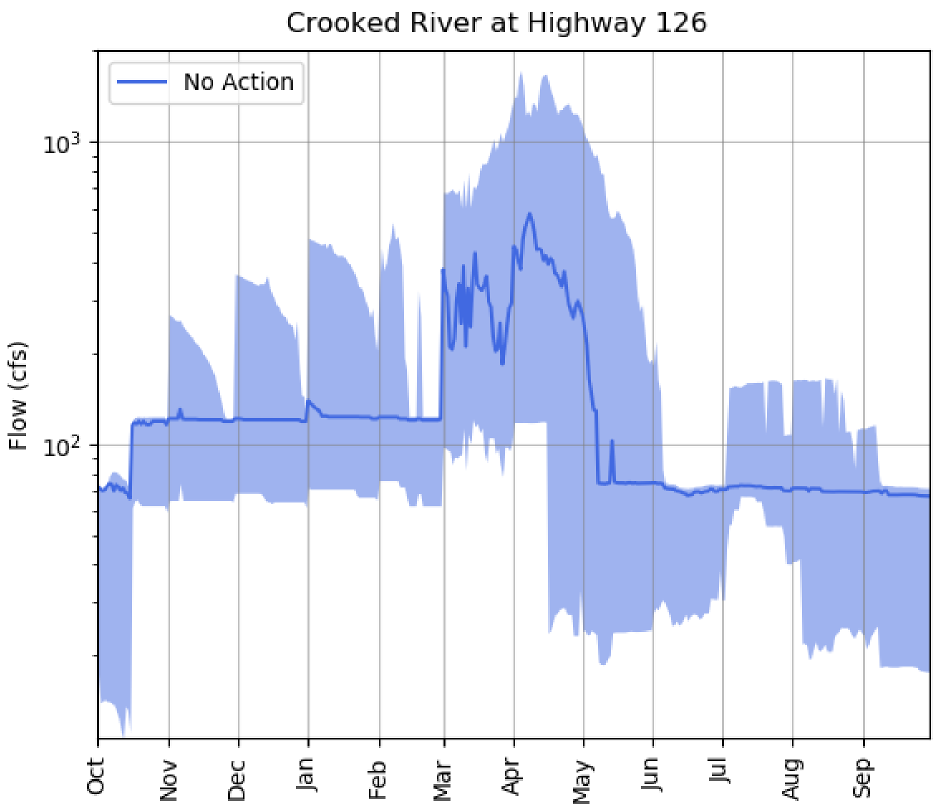


Figure 45. Summary hydrograph of simulated flow in the Crooked River at Highway 126 showing the No Action Alternative. The dark blue line represents the median and the shaded blue area represents the 20 to 80 percent exceedance. The y-axis for flows is shown in logarithmic scale.

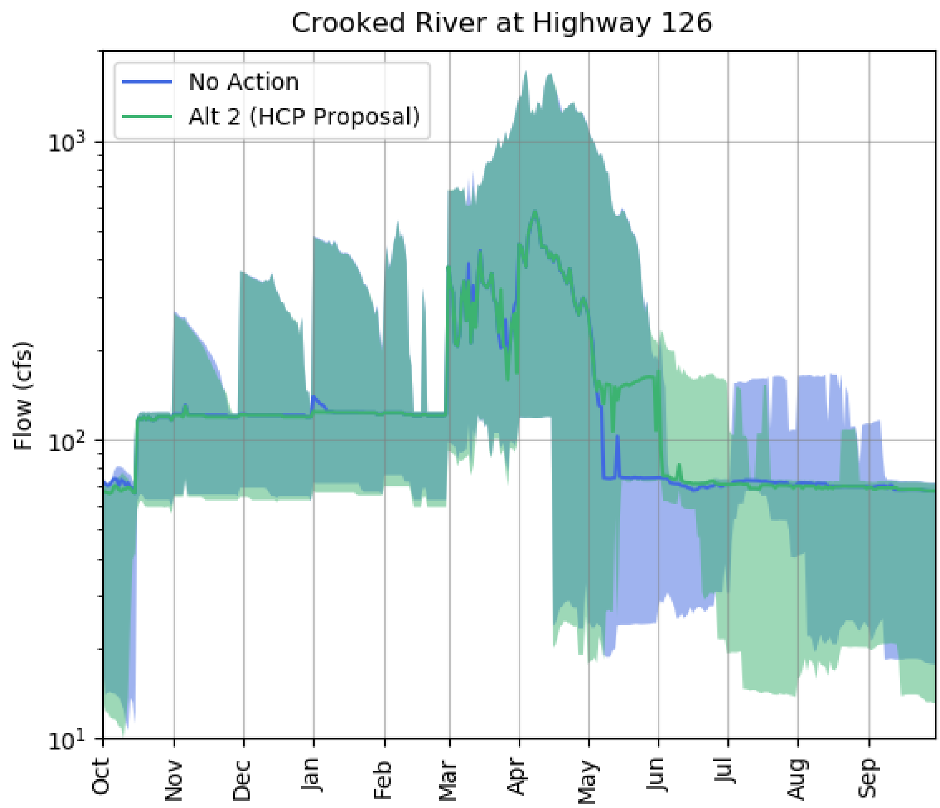


Figure 46. Summary hydrograph of simulated flow in the Crooked River at Highway 126. The graph shows the No Action Alternative (blue) compared to Alternative 2 (green). The dark lines represent the median and the shaded areas represent the 20 to 80 percent exceedance. The y-axis for flows is shown in logarithmic scale.

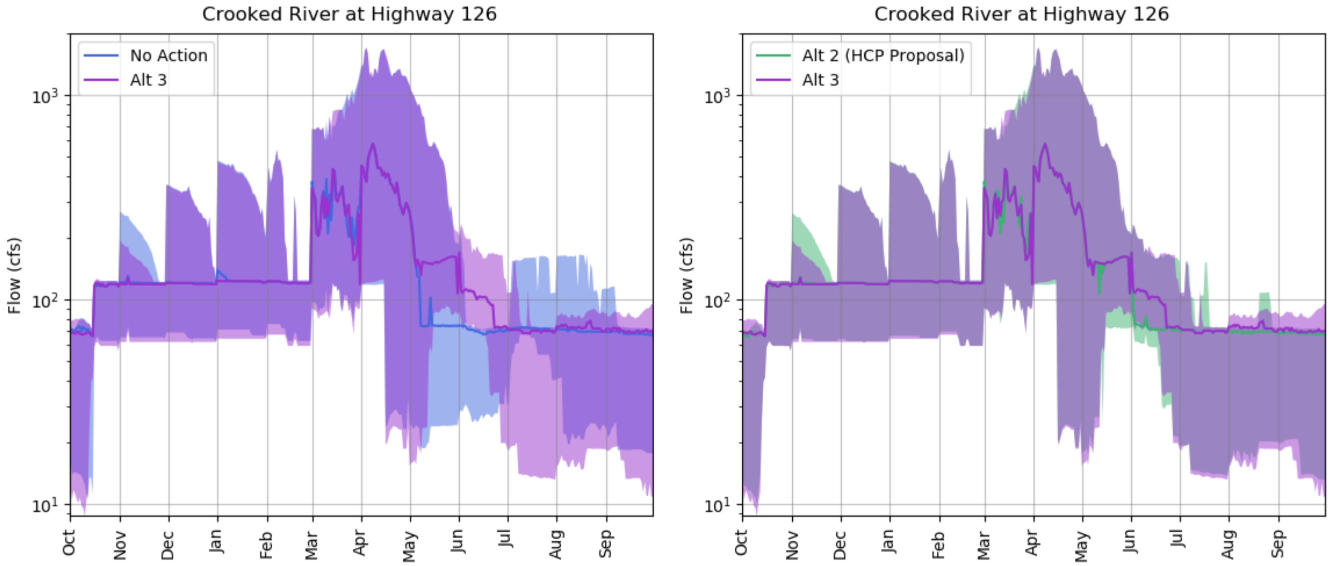


Figure 47. Summary hydrographs of simulated flow in the Crooked River at Highway 126. The graph on the left shows the No Action Alternative (blue) compared to Alternative 3 (purple). The graph on the right shows Alternative 2 (green) compared to Alternative 3 (purple). The colored lines represent the median and the shaded areas represent the 20 to 80 percent exceedance. The y-axis for flows is shown in logarithmic scale.

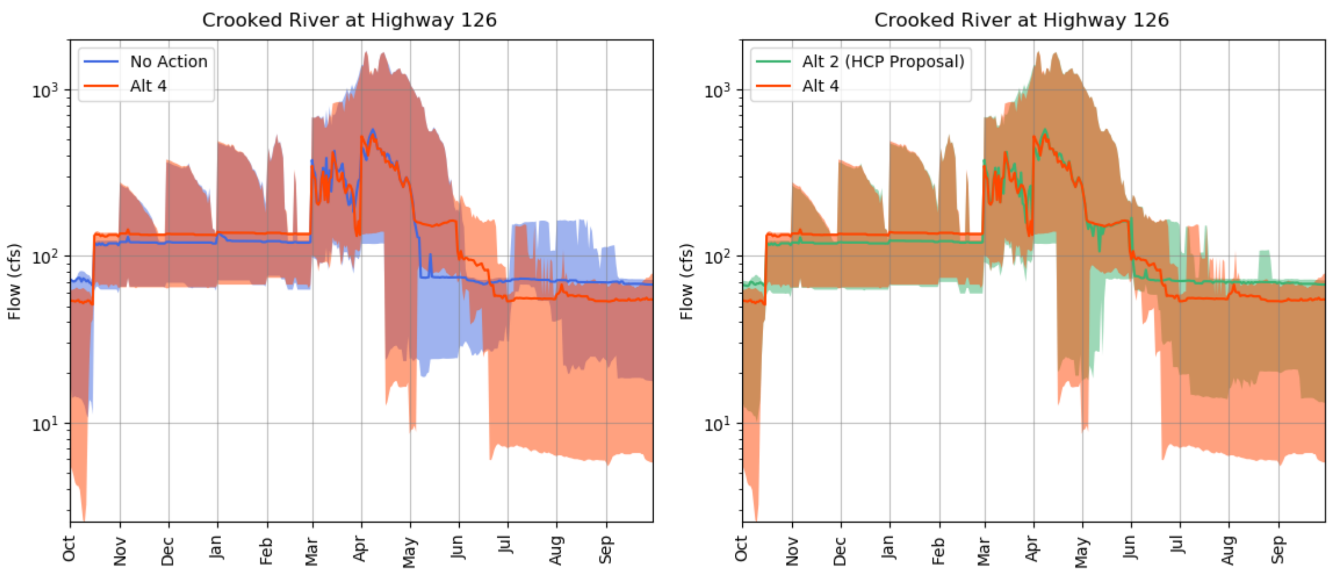


Figure 48. Summary hydrographs of simulated flow in the Crooked River at Highway 126. The graph on the left shows the No Action Alternative (blue) compared to Alternative 4 (red). The graph on the right shows Alternative 2 (green) compared to Alternative 4 (red). The colored lines represent the median and the shaded areas represent the 20 to 80 percent exceedance. The y-axis for flows is shown in logarithmic scale.

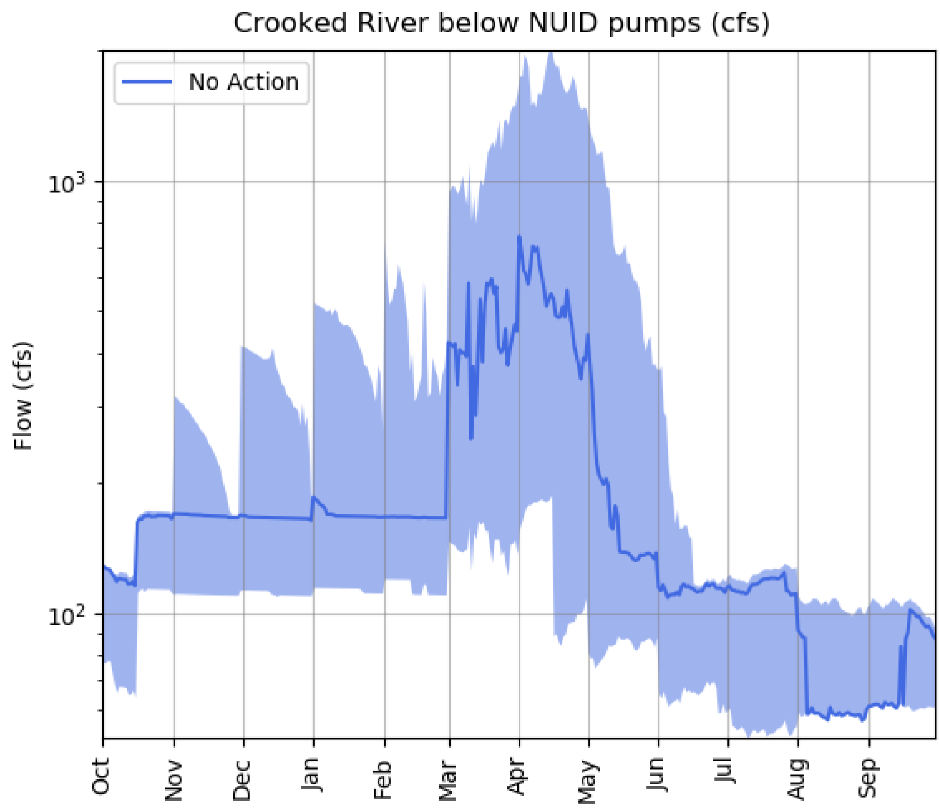


Figure 49. Summary hydrograph of simulated flow in the Crooked River below the NUID pumps showing the No Action Alternative. The dark blue line represents the median and the shaded blue area represents the 20 to 80 percent exceedance. The y-axis for flows is shown in logarithmic scale.

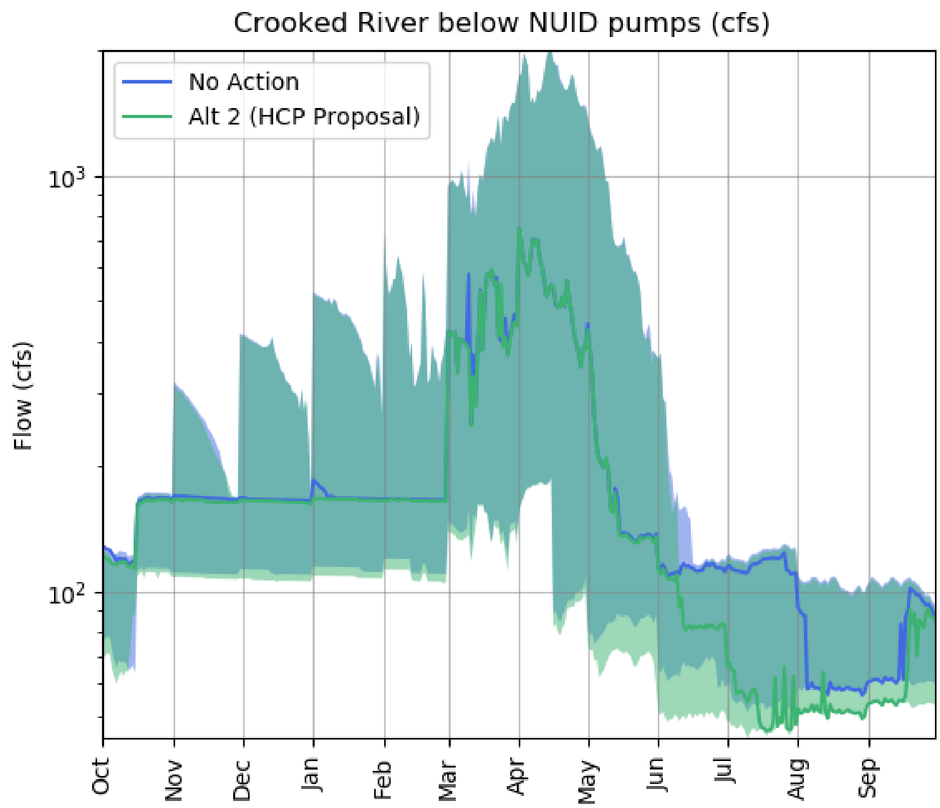


Figure 50. Summary hydrograph of simulated flow in the Crooked River below NUID pumps. The graph shows the No Action Alternative (blue) compared to Alternative 2 (green). The dark blue and green lines represent the median and the shaded areas represent the 20 to 80 percent exceedance. The y-axis for flows is shown in logarithmic scale.

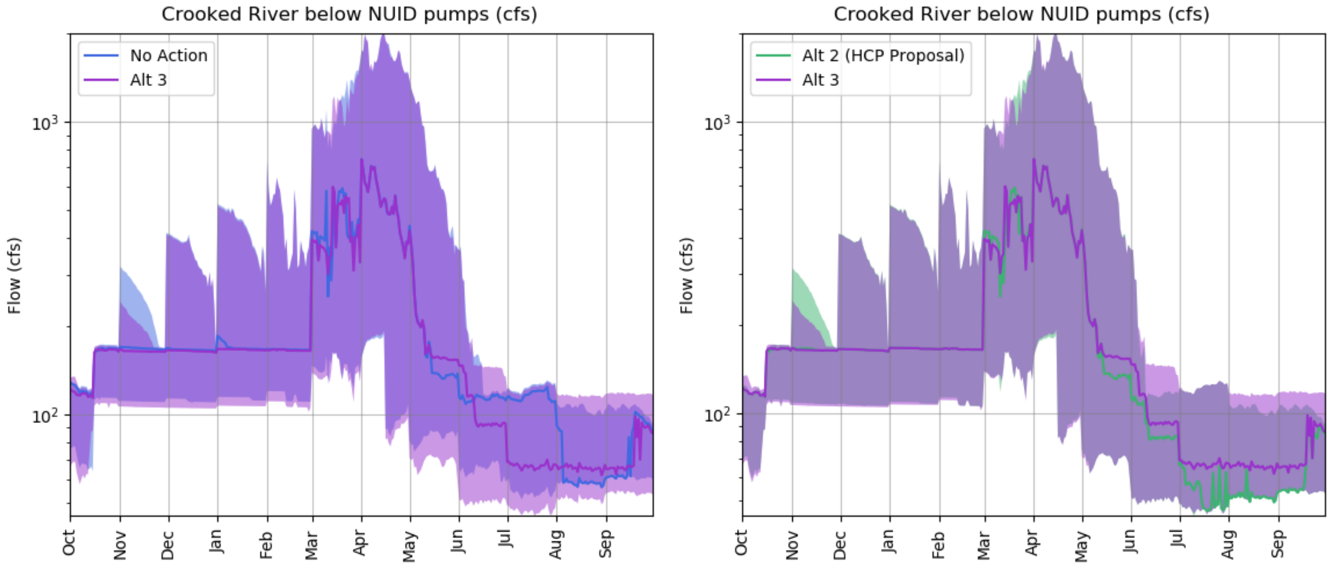


Figure 51. Summary hydrographs of simulated flow in the Crooked River below NUID pumps. The graph on the left shows the No Action Alternative (blue) compared to Alternative 3 (purple). The graph on the right shows Alternative 2 (green) compared to Alternative 3 (purple). The colored lines represent the median and the shaded areas represent the 20 to 80 percent exceedance. The y-axis for flows is shown in logarithmic scale.

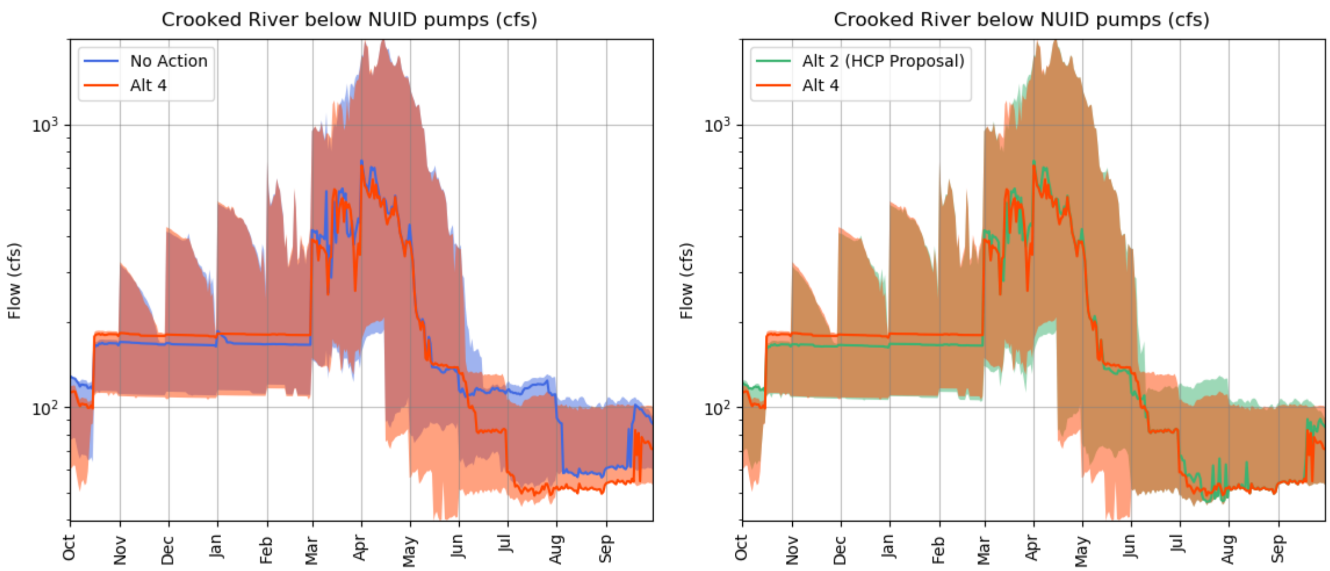


Figure 52. Summary hydrographs of simulated flow in the Crooked River below NUID pumps. The graph on the left shows the No Action Alternative (blue) compared to Alternative 4 (red). The graph on the right shows Alternative 2 (green) compared to Alternative 4 (orange-red). The colored lines represent the median and the shaded areas represent the 20 to 80 percent exceedance. The y-axis for flows is shown in logarithmic scale.

Appendix 3.2-A
Water Resources Technical Supplement

Appendix 3.2-A
Water Resources Technical Supplement

Introduction

This appendix provides the technical supplement to the EIS. In general, the format follows that of the Water Resources EIS section, but not all subsections are addressed.

The study area for water resources is illustrated in Figure 1.

RiverWare Model

The analysis of effects on water resources was based on the review of RiverWare model outputs. RiverWare (Zagona et al. 2001) is a multifunctional river basin modeling tool. The Bureau of Reclamation (Reclamation) developed a daily timestep RiverWare model for the Upper Deschutes Basin[1] (2019) to analyze water distribution, streamflow, reservoir storage, water supply, reservoir water surface elevation and flood storage capacity, and flood flows in the study area. RiverWare model simulations were generated for a 29-water-year period from 1980 to 2009.[2] The selected model time period has a representative range of wet, medium, and dry years for the study area (Johnson pers. comm.).

The model representation of the water resources, infrastructure, and water demands in the basin is a simplification of the physical system, and as such, not every process and element in the physical system is represented in the model. However, the model is informed by existing data sets, water management regimes, and knowledge of the natural system. Appendix 3.1-A, *RiverWare Model Technical Memorandum*, documents the model representation of the alternatives and summarizes a selection of the results.

Model inputs included historical hydrology represented by over 25 streamflow, diversion, and reservoir gauges, water use at 21 surface water diversions, gain/loss flows associated with 12 reaches, properties for 5 reservoirs, and operational rules associated with the proposed action and alternatives. Model output for the proposed action and two action alternatives are compared to the no-action alternative to determine effects on water supply, surface water, and groundwater resources. The no-action alternative is compared to existing conditions. In addition to surface water data, model input included point locations representing groundwater gain and loss, diversions, and control points used to correct flows in the model.

The model-based water use in the basin on actual water use averaged over the 2010 to 2017 period for five of the eight irrigation districts. Water use for the three remaining irrigation districts was averaged over varying time periods (2013 to 2017 was used for Swalley Irrigation District [ID], 2009 was used for Three Sisters ID, and 2009 to 2011, 2013, and 2014 were averaged for Tumalo ID; Reclamation 2019). A calibration model with a calibration period of October 1, 1984, through September 30, 2000, was used to test the operational logic written into the model rules (Bureau of

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[1] Upper Deschutes Basin is defined as the basin upstream from Lake Billy Chinook.

[2] The model period was established for the Upper Deschutes River Basin Study and Reclamation typically uses a 30-year period for hydrologic models based on daily data. Additionally, Reclamation's baseline model datasets are updated every 10 years, so it is common for models to end with a "9" year of the study decade.

Reclamation 2017). The 29-year simulation period was from October 1, 1980 through September 30, 2009.

Reclamation developed and ran the RiverWare model and provided model output to ICF in Microsoft Excel formatted files. ICF summarized model output using the Python Programming Language. Summarized data were exported to Excel for additional data manipulation and to MatLab for visualization.

One potentially significant difference between modeled water supply operations and real-time operational decisions made by water managers is the capability of managers to change operational decisions based on changing conditions. For example, the timing of stored water releases for downstream irrigation diversions is necessarily simplified in the RiverWare model to follow a set of defined assumptions that can affect the timing of reservoir releases and streamflows in the Crooked and Deschutes Rivers. For this EIS, for example, the model anticipates that North Unit ID will manage Wickiup Reservoir releases to meet demands early in the irrigation season, in some cases at the expense of retaining stored water supplies for late season use. Depending on a number of factors, including the potential for water conservation efforts throughout the Upper Deschutes Basin to alleviate North Unit ID water shortages, actual management of Wickiup Reservoir releases may prioritize extending the irrigation season at the expense of meeting maximum demands for a portion of the season.

Because of these differences between modeled operations and real-time operations, this EIS uses RiverWare as a tool to provide the best available information to provide a fair comparison across all of the alternatives. Therefore, although this analysis presents direct RiverWare model results for flow, reservoir elevations etc., as precise numbers, use of these results is not intended to imply unrealistic accuracy. Although RiverWare is a precise simulation model, the accuracy of model output is influenced by input data quality, model assumptions, and the model's ability to simulate complex interactions.

Figure 1. Water Resources Study Area Sheet 1

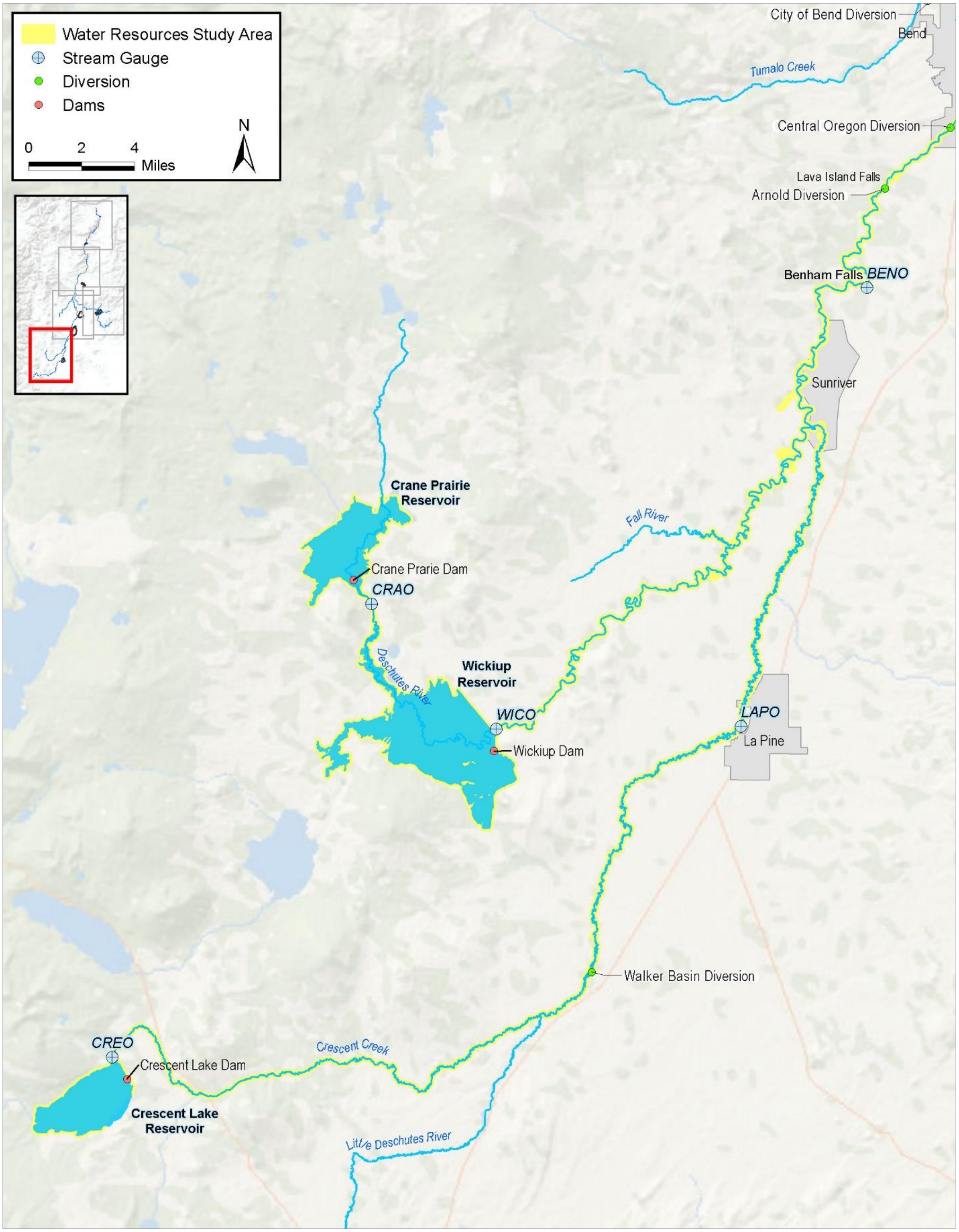


Figure 1. Water Resources Study Area Sheet 2

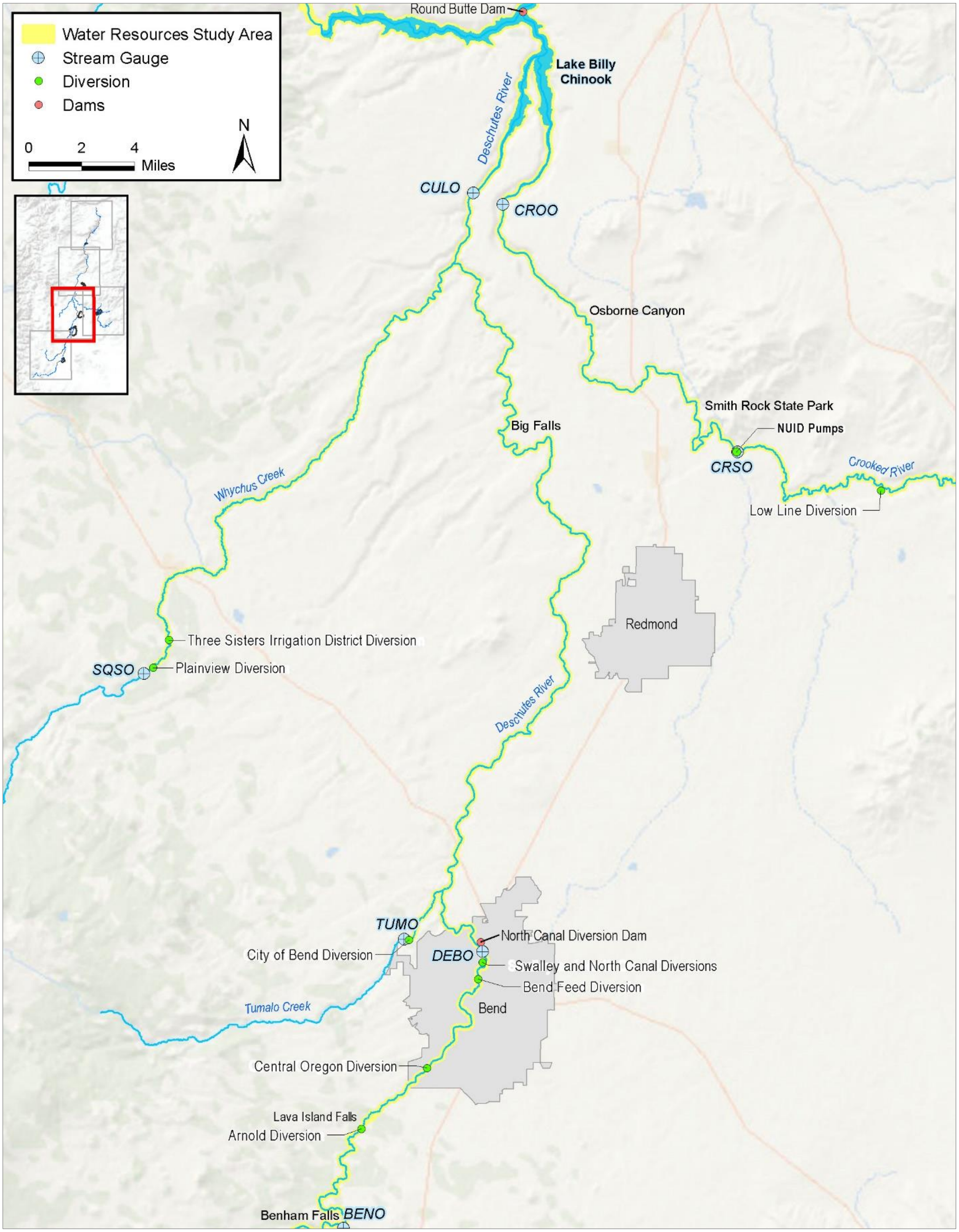


Figure 1. Water Resources Study Area Sheet 3

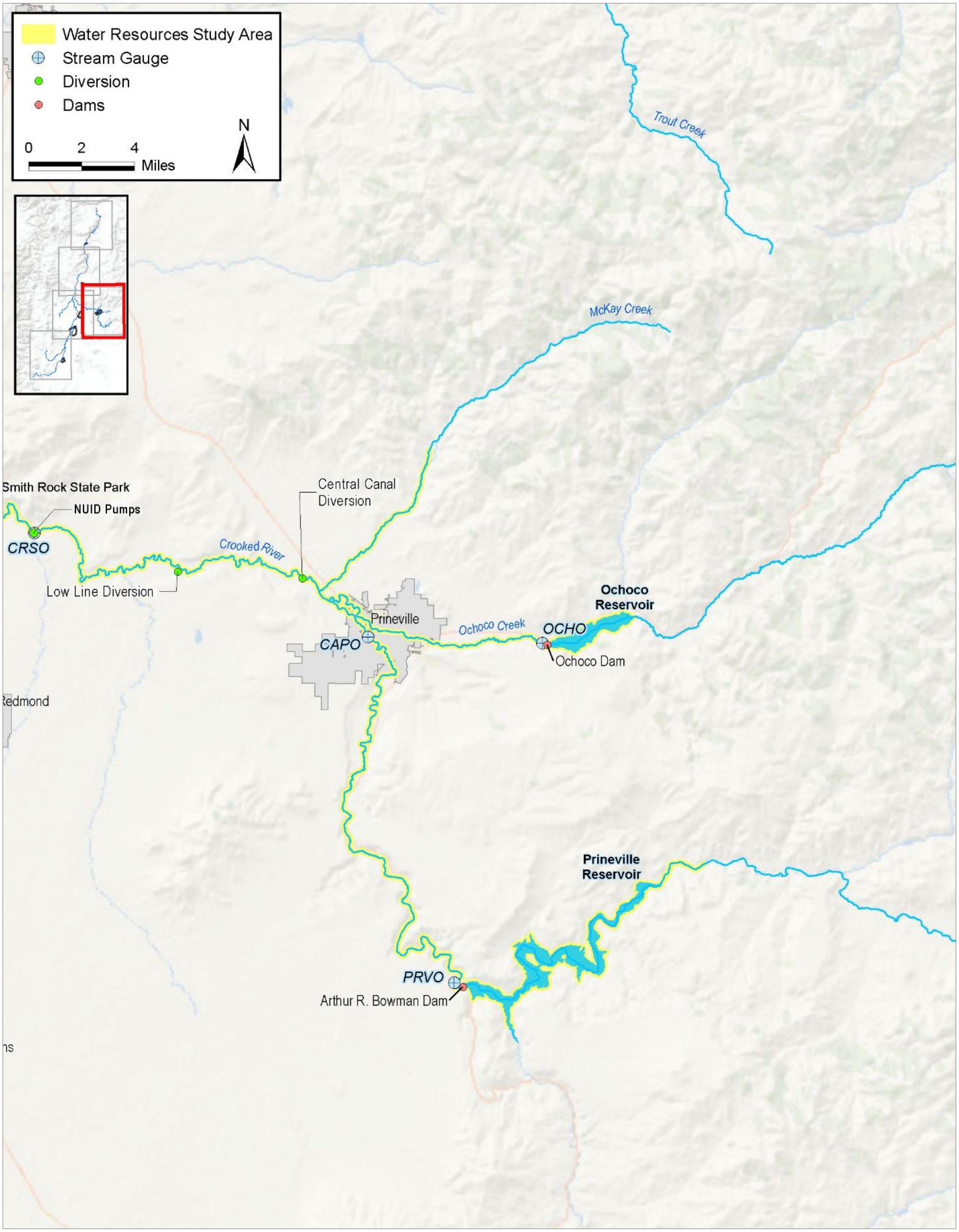


Figure 1. Water Resources Study Area Sheet 4

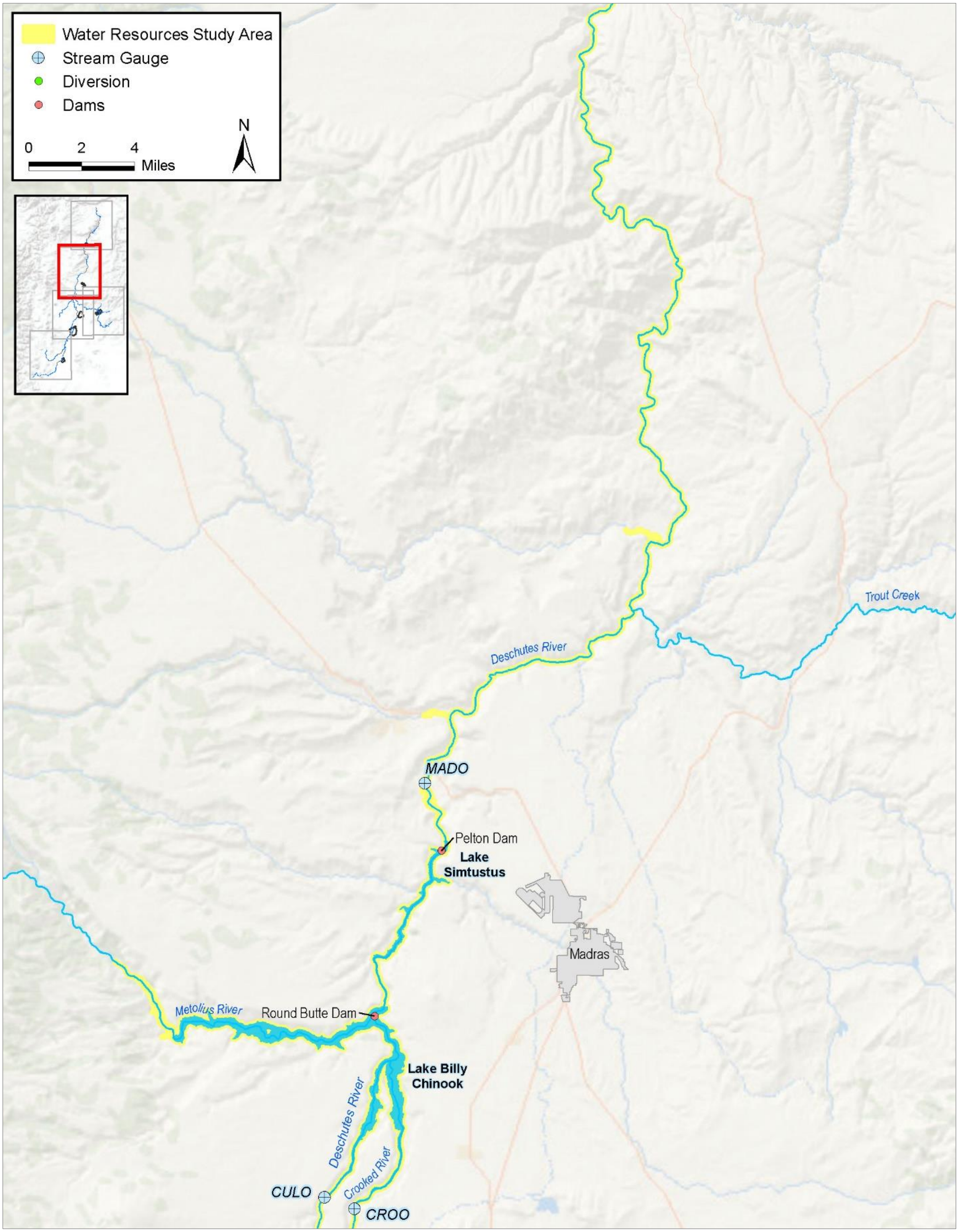
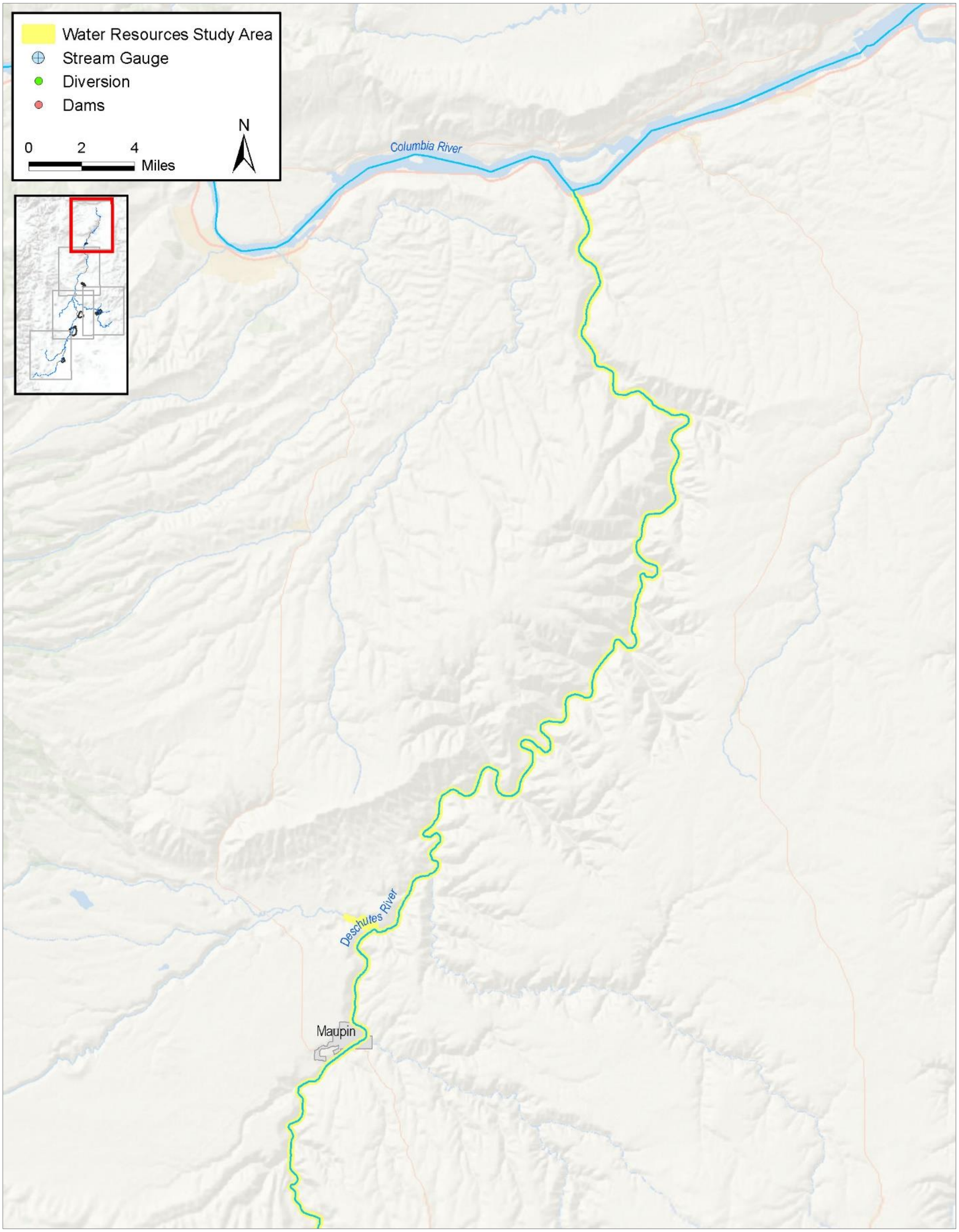


Figure 1. Water Resources Study Area Sheet 5



Affected Environment

Water Uses and Water Rights Administration

Under Oregon water law, with a few exceptions, the use of public water requires a water right from the Oregon Water Resources Department (OWRD). A water right is required to store water in a reservoir, which is referred to as a "primary" water right. Similarly, the use of stored water from a reservoir also requires a water right, which is referred to as a "secondary" water right and is different than the water right authorizing the storage of water. Secondary water rights can authorize the use of stored water for consumptive uses or for instream purposes.

Water rights describe the source of water, priority date, amount of water that can be used, point of diversion, type of water use, season of use, and place of use. The priority date is typically based on the date that the water right application was filed with OWRD.

When there is insufficient water to meet the needs of all water rights, OWRD regulates water rights by relative priority. In other words, senior water rights have priority so the upstream water rights with the most junior (recent) priority dates are the first ones required to cease water use to increase water supply available for senior (older) water rights. OWRD will continue the process of regulating off progressively more senior water rights until sufficient water is available for the most senior water right holders.

Regulation of live flow water rights in a river does not affect secondary water rights for the use of stored water. If stored water is released into a stream, the stored water is considered to be a different source than the live flow in the stream. Consequently, secondary water rights with junior priority dates can continue to divert water when more senior live flow water rights are regulated off.

Regulation can be initiated by OWRD, such as to protect an existing instream water right, or can result from a "call" from a water right holder who is not receiving all of the water to which they are entitled. When a call is made, OWRD validates the call by confirming that the senior right holder is using water as authorized by the water right, and that water is not available from the authorized source. After validating the call, OWRD considers the existing water rights on the stream, and then will identify the priority date to which they will regulate. OWRD then regulates off the water rights junior to that date (and any unauthorized water users). After the junior water users cease using water, the water supply will be re-evaluated and any necessary adjustments made, such as regulating back to a later date. OWRD will not regulate off a junior water user if it would be a "futile call" (i.e. regulating off the junior water users would result in no or an inadequate amount of water reaching the senior water user.)

The reservoirs in the Upper Deschutes Basin are filled during the period outside of the irrigation season.[3] A description of the water rights authorizing storage of water in these reservoirs (the primary water rights) is provided in Table 1.

[3] The water rights authorizing storage of water in these reservoirs do not include a stated storage season. Further, there is not an identified storage season in the Deschutes Basin.

Table 1. Covered Storage Reservoirs, Capacities, and Water Rights

Reservoir	Capacity (af)[a]	Water Right Volume (af)	Primary Water Right Holder	Secondary Water Right Holder
Crane Prairie	55,300	50,000	Central Oregon Irrigation District	Central Oregon Irrigation District Arnold Irrigation District Lone Pine Irrigation District
Wickiup	200,000	200,000	North Unit Irrigation District	North Unit Irrigation District Oregon Water Resources Department (Instream Water Rights)
Crescent Lake	86,900	51,050; 35,000	Tumalo Irrigation District	Tumalo Irrigation District Oregon Water Resources Department (Instream Water Rights)
Prineville	148,640	155,000	Bureau of Reclamation	Bureau of Reclamation and Prineville Reservoir Contract Holders
Ochoco	44,247	47,600	Ochoco Irrigation District	Ochoco Irrigation District

af = acre-feet

[a] This is the capacity listed on Reclamation's Deschutes Hydromet page http://www.usbr.gov/pn/hydromet/destea.html (retrieved February 29, 2016). Note that the listed capacity may be inconsistent with Hydromet data on reservoir storage volume and may vary from the maximum volume listed on the water right.

[b] An inter-district agreement between Central Oregon, Arnold, Lone Pine, and North Unit Irrigation Districts dictates fill order and water allocation between Wickiup and Crane Prairie Reservoirs.

Tables 2 and 3 present live flow and primary storage water rights associated with surface waters of the Deschutes River and Crooked River, respectively.

Table 2. Water Rights for Hydraulically Connected Surface Waters of the Deschutes River and tributaries above the BENO Gauge on the Deschutes River Listed in Order of Priority

Owner	Priority	Source	Irrigation Acres (or character of use, if not Irrigation)	Rate (cfs) or Volume (af)	Certificate
Priority Senior or Equal to Central Oregon and Lone Pine Irrigation District (10/31/1900)					
Private Irrigation	12/31/1893	Little Deschutes River	110	2.75 cfs	13602
Private Irrigation	12/31/1897	Little Deschutes River	29.3	0.73 cfs	68722
Walker Basin Diversion [a]	12/31/1897	Little Deschutes River	699.9	17.498 cfs	90239
Private Irrigation	12/31/1898	Big Marsh Creek	22.02	0.551 cfs	91836
Private Irrigation	12/31/1898	Crescent Creek	176.4	4.41 cfs	13641
Private Irrigation	12/31/1898	Crescent Creek	220.5	5.51 cfs	13640
Private Irrigation	12/31/1898	Crescent Creek	183.6	4.59 cfs	13637
Swalley Irrigation District [a]	9/1/1899	Deschutes River	4561.105	87 cfs	74145
Central Oregon Irrigation District [a]	10/31/1900	Deschutes River	44627	978.297 cfs	83571

Owner	Priority	Source	Irrigation Acres (or character of use, if not Irrigation)	Rate (cfs) or Volume (af)	Certificate
Lone Pine Irrigation District [a]	10/31/1900	Deschutes River	2369	29.1 cfs	72197
Priority Junior to Central Oregon and Lone Pine Irrigation District (10/31/1900), but Junior to North Unit (2/28/1913)					
Walker Basin Diversion	12/31/1900	Little Deschutes River	48.9	1.223 cfs	90239
Walker Basin Diversion	4/30/1902	Little Deschutes River	326.15	8.154 cfs	90239
Tumalo Irrigation District [a]	1905	Deschutes River	Supplemental to All TID acres	9.5 cfs	74149
Arnold Irrigation District [a]	2/1/1905	Deschutes River	4384.05	150 cfs	74197
Walker Basin Diversion	12/31/1907	Little Deschutes River	63.1	1.58 cfs	68721
Tumalo Irrigation District [a]	3/20/1911	Crescent Creek	6590.6	35,000 af	76683
Swalley Irrigation District [a]	4/5/1911	Deschutes River	60	0.85 cfs	509
Private Irrigation	4/19/1911	Little Deschutes River	15	0.19 cfs	3383
North Unit Irrigation District [a]	2/28/1913	Deschutes River	Storage	200,000 af	51229
North Unit Irrigation District [a]	2/28/1913	Deschutes River	133.9	3.35 cfs	72280
North Unit Irrigation District [a]	2/28/1913	Deschutes River	49916	1101 cfs	72279
Central Oregon Irrigation District [a]	2/28/1913	Deschutes River	Storage	50,000 af	76685
Priority Junior to North Unit Irrigation District (2/28/1913)					
U.S. Forest Service Irrigation	5/7/1914	Little Deschutes River	55	0.7 cfs	1064
Private Irrigation	6/24/1915	Long Prairie Slough	20	0.25 cfs	12300
Private Irrigation	7/10/1916	Little Deschutes River	123	1.54 cfs	3368
Private Irrigation	1/30/1923	Little Deschutes River	87	1.25 cfs	9823
Private Irrigation	10/6/1924	Crescent Creek	44	0.85 cfs	7862
Private Irrigation	10/6/1924	Crescent Creek	70	0.88 cfs	6769
Private Irrigation	3/15/1926	Crescent Creek	58	0.73 cfs	7873
Private Irrigation	3/15/1926	Crescent Creek	40	0.5 cfs	6792

Owner	Priority	Source	Irrigation Acres (or character of use, if not Irrigation)	Rate (cfs) or Volume (af)	Certificate
Private Manufacturing	9/4/1929	Little Deschutes River	Manufacturing	2 cfs	12239
Private Water Supply	9/4/1929	Little Deschutes River	Municipal/ Fire Protection	2 cfs	12240
Private Irrigation	8/31/1931	Crescent Creek	35	0.44 cfs	11005
North Unit Irrigation District [a]	7/12/1955	Deschutes River	Storage	5650 af	51230
Tumalo Irrigation District [a]	12/8/1961	Crescent Creek	Storage	51,050 af	76637

[1] Water rights held by applicant irrigation districts.

Table 3. Water Rights for Hydraulically Connected Surface Waters of the Mainstem Crooked River from Bowman Dam to Osborne Canyon and Ochoco Creek below Ochoco Reservoir

<table>
<tr><th>Diversion</th><th>Sources of Water</th><th>Maximum Flow Rate (cfs)</th><th>Maximum Storage Volume (af)</th></tr>
<tr><td>Ochoco Irrigation District - Crooked River Feed Canal, Ochoco Feed Canal, and Other Small Diversions</td><td>Live Flow, Prineville Reservoir Storage, and Ochoco Reservoir Storage</td><td>170</td><td>60,640</td></tr>
<tr><td>People's Canal and Other Small Private Diversions</td><td>Live Flow and Prineville Reservoir Storage</td><td rowspan="2">33.498</td><td>3,497</td></tr>
<tr><td>Crooked River Central Canal and Other Small Private Diversions</td><td>Live Flow and Prineville Reservoir Storage</td><td rowspan="3">6,547</td></tr>
<tr><td>Rice Baldwin and Other Small Private Diversions</td><td>Live Flow and Prineville Reservoir Storage</td><td>35.123</td></tr>
<tr><td>Small Diversions Below Lowline Canal</td><td>Live Flow and Prineville Reservoir Storage</td><td>11.63</td></tr>
<tr><td>Lowline Canal and Other Small Private Diversions</td><td>Live Flow and Prineville Reservoir Storage</td><td>9.54</td><td>330</td></tr>
<tr><td>North Unit Irrigation District Crooked River Pumping Station</td><td>Live Flow and Prineville Reservoir Storage</td><td>200</td><td>10,000</td></tr>
</table>

Prineville Reservoir water use is affected by the Crooked River Collaborative Water Security and Jobs Act of 2014. Under the Act, 83,987 acre-feet (af) of previously uncontracted water was made available for irrigation and to benefit fish and wildlife. This includes the release of up to 5,100 af of stored water from the reservoir annually to serve as mitigation for City of Prineville groundwater pumping, to be released for the benefit of downstream fish and wildlife; the release of up to 62,520 af of stored water for fish and wildlife use; and the release of up to 10,000 af for irrigation or fish and wildlife use.

Crooked River minimum streamflows below North Unit ID's Crooked River Pumping Plant are mandated by an agreement between North Unit ID and the Deschutes River Conservancy (DRC) as part of North Unit ID's conserved water projects. The agreement is intended to limit North Unit ID's exercise of its Crooked River water rights to protect minimum instream flows in the Crooked River below the pumping plant. The agreement includes scenarios for both dry and non-dry years based on the Prineville Reservoir storage and outflows in late March. The minimum streamflow protected in the Lower Crooked River is based on the volume of water conserved through North Unit ID's conserved water project and the district's historical pattern of use from the Crooked River.

Surface Water

The following hydrologic description of the study area is largely adapted from the Chapter 4 of the Draft Deschutes Basin HCP, *Current Conditions of the Covered Lands and Waters* (Deschutes Basin Board of Control and City of Prineville 2019).

Upper and Middle Deschutes River

The headwaters of the Upper Deschutes Basin (the watershed area located upstream from Lake Billy Chinook Reservoir where the Deschutes, Crooked, and Metolius Rivers join) are located within the Cascade Range and Newberry Volcano and Quaternary Sediment deposits, both units are characterized by highly-permeable materials with rapid infiltration rates (Lite and Gannett 2002). Most precipitation that falls in the upper basin becomes groundwater before reemerging at multiple springs and seeps. Direct surface runoff makes up a relatively small percentage of the flow in the Upper Deschutes River. The net effect of this is an unregulated flow regime that shows considerably less seasonal variation than most other Oregon streams that are surface runoff-dominated.

The Upper Deschutes River is generally defined as upstream of the City of Bend ID diversions. The Middle Deschutes River begins below Bend, extending to upstream of Lake Billy Chinook. Current streamflows are heavily influenced by irrigation activities and show considerably more seasonal variation than unregulated flows. The storage, release and diversion of irrigation water results in flows upstream of Bend that are generally high in the late spring and summer and low in the fall, winter and early spring. Flows downstream of Bend are low during the late spring and summer irrigation season because most flow (natural and released storage) is diverted. Peak diversion rates typically occur between May 16 and September 15. During the fall, winter and early spring, flows in the Middle Deschutes River, located between the City of Bend and Lake Billy Chinook, are also reduced from natural conditions by irrigation storage, but natural inflow from tributaries and springs downstream of the reservoirs moderates the influence of storage somewhat and winter flows are not nearly as low at Bend as they are between Wickiup Dam and Fall River. Middle Deschutes River flows fluctuate periodically during the winter when water is diverted into four of the canals (Central Oregon, Pilot Butte, Swalley and Tumalo) for periods of one week or less each month to supply water for livestock.

Crescent Creek and Little Deschutes River

Crescent Creek and the Little Deschutes River have a combined drainage area of 1,050 mi^2. The drainages are located within the La Pine Subbasin, a geologic formation characterized by several hundred feet of low-permeability, fine grained sediment (Lite and Gannett 2002). Unlike other streams within the Upper Deschutes Basin, where flows are supported largely by spring discharge, Crescent Creek and the Little Deschutes show strong seasonal variation driven by surface runoff that is also influenced by operation of Crescent Lake Reservoir. Unregulated surface flows typically peak for short periods during winter storm events and spring runoff, and drop to prolonged annual lows in mid- to late summer. Operation of Crescent Lake Reservoir causes a minor reduction in monthly median flow during the storage season and a pronounced increase in flow during the irrigation season from immediately downstream of Crescent Dam, to 60 miles downstream on the Little Deschutes River.

Tumalo Creek

The entire Tumalo Creek watershed lies within the Cascade Range and Newberry Volcano Deposits hydrogeologic unit described by Lite and Gannett (2002). Although there are large springs (>10 cfs) in the upper portion of Tumalo Creek, the subsurface permeability in Tumalo Creek is less than in other portions of the Upper Deschutes Basin. With less permeable geology, Tumalo Creek has a greater contribution of surface runoff and a more pronounced seasonal fluctuation in flow relative to more groundwater-dominated streams in the basin. Upstream of the TID diversion at RM 2.8, the unregulated Tumalo Creek shows a substantial and predictable peak during spring runoff, moderate flows during the summer, and annual low flows during the winter. Downstream of the diversion, the lower 2.8 miles of creek experience substantially reduced spring and summer flows, but fall and winter flows are relatively unaffected.

Whychus Creek

Natural flows in Whychus Creek are influenced predominantly by snowmelt. Upstream of the irrigation diversions, flows consistently peak at 200 to 400 cfs in June and drop to 60 cfs or less in late winter. Extreme peak flows as high as 1,000 cfs have been reported during episodic winter storms and rain-on-snow events. Downstream of the Three Sisters ID diversion at RM 25.8, flows are considerably reduced from April through October and slightly reduced from November through March. Flows increase downstream of Sisters due to a number of sources, including, multiple small springs near Camp Polk Road (RM 17) and Alder Springs (RM 1.4).

Lower Deschutes River

Flows in the Deschutes River increase more than twofold between Culver (RM 120) and Madras (RM 100), mostly due to inflow that originates as spring discharge to the Metolius River and lower Crooked River. Inputs to the Lower Deschutes River include approximately 800 cfs of groundwater inputs, 1,000 cfs on the Crooked River, and 1,500 cfs on the Metolius River. The net effects of this large, relatively constant inflow are a reduction in the relative influence of upstream irrigation activities and less seasonal fluctuation in flow compared to the Middle Deschutes River.

Crooked River, Ochoco Creek, and McKay Creek

The hydrology of the Crooked River Subbasin upstream from Smith Rock State Park, is distinct from the western portions of the Upper Deschutes Basin for two reasons. First, the Crooked River Subbasin receives substantially less precipitation than tributaries in the Cascade Mountains to the west of the Deschutes River. Average annual precipitation in Prineville, near the lower end of the Crooked River Subbasin, is only 9.9 inches, to 17.0 inches at Rager Ranger Station, located at 4,000 feet elevation (Western Regional Climate Center 2017). In contrast, average annual precipitation at Santiam Pass on the Cascade crest is 85.6 inches.

The second reason for the difference in hydrology for the Crooked River Subbasin upstream of Smith Rock State Park, is the absence of deep, highly-permeable geologic surface deposits of the type present in other portions of the Deschutes Basin. Much of the Crooked River Subbasin is in close contact with the John Day Formation, which is older and much less permeable than the Newberry Volcanic Deposits and Quaternary Sediments that overlie it to the south and west (Lite and Gannett 2002). The result is limited interchange between surface and ground water in the Crooked River Subbasin. Rather than recharging groundwater, most precipitation that falls in the subbasin becomes surface runoff that peaks rapidly and briefly during storm events and spring snowmelt.

Unlike the Deschutes River, which receives relatively constant groundwater discharge throughout the year, the Crooked River and its tributaries receive little groundwater support and tend to drop dramatically after the end of snowmelt in early spring. Groundwater discharge (originating from the Upper Deschutes Basin, including irrigation canal leakage) only becomes a significant source of streamflow in the lower 10 miles of the Crooked River above Lake Billy Chinook, where the canyon is of sufficient depth to intersect the regional groundwater table and the river gains as much as 1,100 cfs (Gannett and Lite 2004).

Current hydrologic conditions in the Crooked River and Ochoco Creek are illustrated by flow data for five locations with significance to ongoing irrigation activities. Flow above Prineville Reservoir typically peaks in spring during snowmelt, and falls close to zero by late summer. In many years, storm events and/or heavy snowpack can result in short-term runoff events upstream of the reservoir well in excess of 3,000 cfs. Downstream of Bowman Dam, the combination of irrigation storage and flood control eliminates flows over 3,000 cfs, reduces average winter flow, and increases average summer flow compared to unregulated conditions. At Terrebonne, which is downstream of all irrigation diversions, the cumulative effects of diversions and tributary inflow are apparent. Peak winter flow in the Crooked River at Terrebonne again exceeds 3,000 cfs in some years due to flow inputs from Prineville Reservoir, Ochoco Creek, and McKay Creek, but summer flow is much less than below Bowman Dam due to multiple irrigation diversions. Further downstream at Opal Springs, groundwater discharge increases flow in the Crooked River by more than 1,000 cfs during all seasons.

Flow in Ochoco Creek below Ochoco Dam shows a seasonal pattern similar to the Crooked River below Bowman Dam, though much smaller in magnitude. Ochoco Creek flow is high immediately below the dam during the irrigation season when water is released, and low during the winter when water is stored. In 13 of 23 years between 1994 and 2016, it was necessary to release additional water from Ochoco Reservoir during the storage season to maintain flood storage capacity. Between Ochoco Dam and the mouth of Ochoco Creek, summer flow is reduced by multiple irrigation diversions covered by the Deschutes Basin HCP.

McKay Creek flows into the Crooked River 0.5 mile downstream of Ochoco Creek, also within the City of Prineville. The lower 9 miles of the river pass through the Crooked River Gorge, which is up to 500 feet deep in places. McKay Creek does not have storage facilities although there are a number of diversions and returns that affect streamflow. Ochoco ID manages diversions downstream from Jones Dam (RM 5.8).

Historically low flows in the Crooked River downstream of Bowman Dam have been improved in recent years by two actions. The Crooked River Collaborative Water Security and Jobs Act of 2014 (Crooked River Act) made over 62,000 af of previously-uncontracted storage in Prineville Reservoir available for fish and wildlife use. This water is released from storage at various times of year to increase instream flow in the reach from Bowman Dam to Lake Billy Chinook. In addition, summer flows at Terrebonne have been increased through an agreement between North Unit ID and the Deschutes River Conservancy (DRC) that ensures North Unit ID will not operate the Crooked River pump station to divert water unless minimum flows of 43 cfs to 181 cfs can be maintained at the Terrebonne gauge (CRSO). The result of this agreement is that Crooked River flow at Terrebonne will not drop appreciably below the historical median in non-dry years or below the historical 80% exceedance level in dry years during the driest months of July and August.

Groundwater discharge to the Crooked River contributes to streamflow downstream from Terrabonne. In excess of 1,000 cfs enters the Crooked River year-round through groundwater inputs between Osborne Canyon and Opal Springs Dam.

Groundwater

Basin Hydrogeology

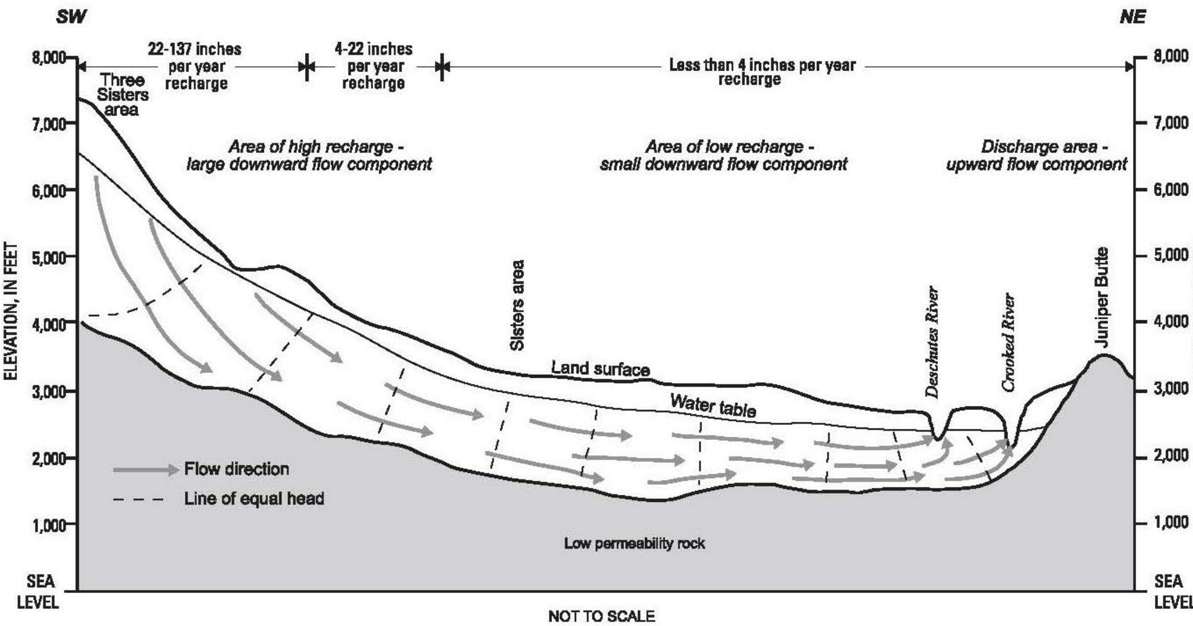
The permeable rock underlying the Deschutes River Basin, combined with the large annual precipitation in the Cascades, results in a substantially large aquifer system that is highly productive and a river system that is influenced by groundwater–surface water interactions. Due to the porous geology of the area, water can move relatively easily between the surface and groundwater systems depending on the relative elevations of the groundwater levels and stream channels and local hydrogeologic conditions.

The study area includes groundwater within the Upper Deschutes Basin, which is bound on the north by Jefferson Creek, the Metolius River, the Deschutes River, and Trout Creek; the east by the geological change between the Deschutes Formation and the much less permeable John Day Formation; on the south by the drainage divides between the Deschutes Basin and the Fort Rock and Klamath Basins; and on the west by the Cascade Mountain Range.

USGS, in conjunction with OWRD, published the study Groundwater Hydrology of the Upper Deschutes Basin in 2001 that documents the groundwater system and its interactions with the rivers in the upper basin (Gannett et al. 2001). An update of the original study that evaluates the groundwater level changes observed in the basin was published in 2013 (Gannett and Lite 2013). These studies define the hydrology and hydrogeologic interactions in the Deschutes Basin regional groundwater system that are summarized below.

The groundwater system and its interactions with the rivers in the Upper Deschutes Basin is primarily controlled by the distribution of recharge, the geology, and the location and elevation of streams relative to the groundwater table. Groundwater flows from the recharge areas in the Cascade Range and Newberry Volcano through the younger porous Cascade and Deschutes Formation deposits within the basin. Beneath these permeable deposits is the older, low permeability John Day Formation deposits. The top of the John Day Formation forms the bottom of the groundwater system (Figure 2).

Figure 2. Diagrammatic Section of Water Movement through the Groundwater System in the Upper Deschutes Basin (Source: Gannett et al. 2001: 62)

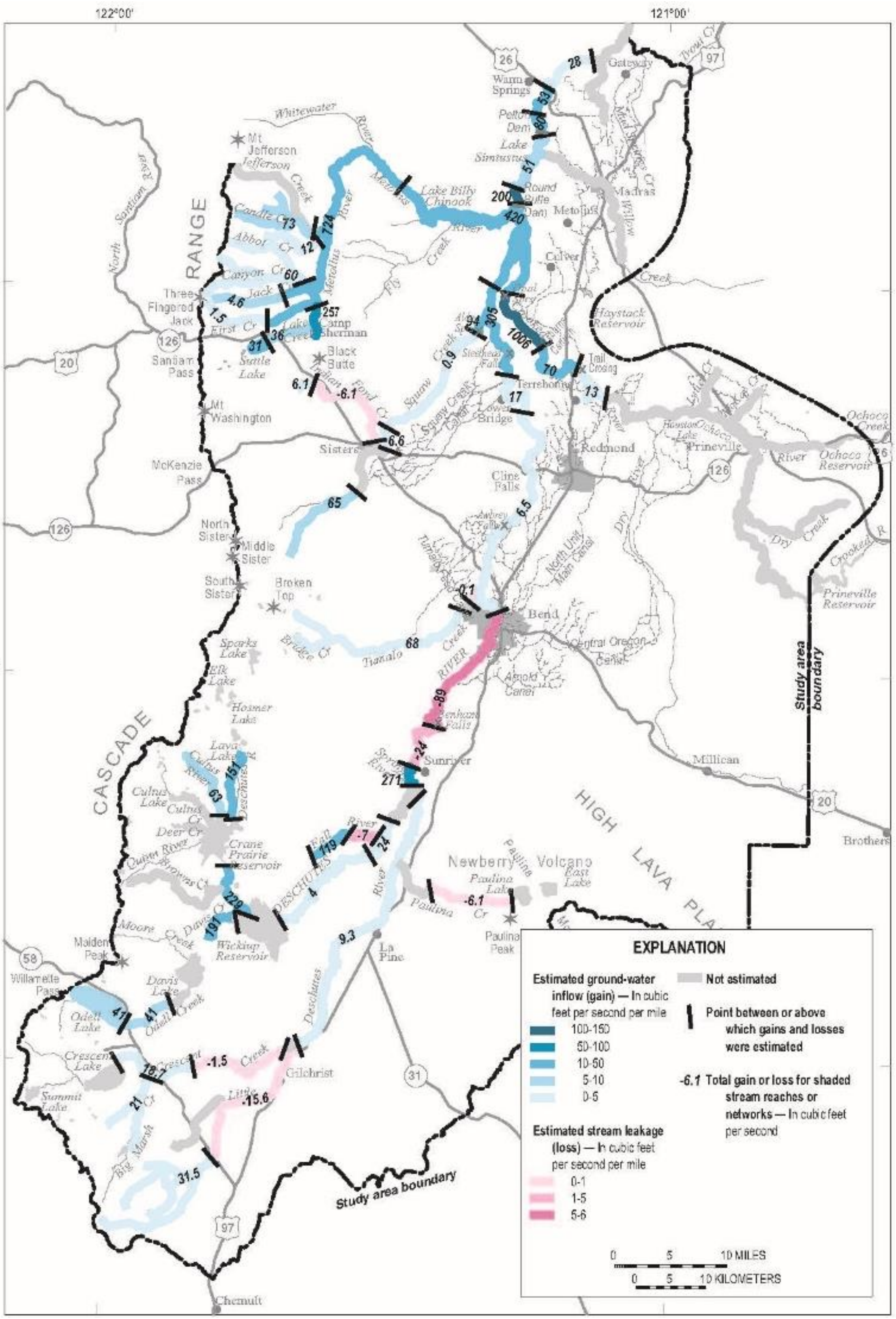


Water moves through the groundwater system toward the discharge areas along the margin of the Cascade Range and near the confluence of the Deschutes, Crooked, and Metolius Rivers. Approximately 10 to 15 miles upstream of the confluence of these rivers, the river canyons are sufficiently deep to intersect the groundwater table, and the groundwater system discharges into the rivers (Figure 2). The exposure of the older deposits in the bottom of the incised river canyons approximately 10 miles north of Lake Billy Chinook (near the Pelton Dam) marks the northern extent of the permeable groundwater system in the study area. There is no appreciable discharge of groundwater to the Deschutes River downstream of this point. Therefore, the groundwater system evaluation is limited to the Upper Deschutes Basin from the confluence of the Deschutes, Crooked, and Metolius Rivers.

Annual recharge to the groundwater system includes precipitation, inter-basin flows, and irrigation canal leakage. Precipitation in the Cascade Range provides an average of 3,800 cfs of recharge (2.45 billion gallons per day or approximately 2.7 million af per year) based on data from 1962 to 1997 (Gannett et al. 2001:22). Interbasin groundwater flows from outside the Upper Deschutes provide an additional 850 cfs of recharge. Canal leakage provides an additional approximately 490 cfs of recharge (1994 dataset) (Gannett et al. 2001:1 and 26), which has recently been reduced in localized areas by canal lining and piping projects. (Gannett and Lite 2013: 13). At the basin-scale, fluctuations in the groundwater levels generally follow the climate cycles, with periods of high groundwater levels generally corresponding to high precipitation, and lower water levels corresponding to low precipitation periods. This effect dampens going eastward and away from the recharge area.

Areas where groundwater discharges into surface waters through springs, increasing streamflow, are *gaining reaches*; areas where water leaks from a stream, recharging the groundwater system, are *losing reaches*. Figure 3 depicts average gains and losses across segments of the river systems and shows that within the Upper Deschutes Basin, the groundwater system is generally discharging water into the river systems with a few notable exceptions described below (Gannett et al. 2001:34-37).

Figure 3. Estimated Gains and Losses from Select Stream Reaches in the Upper Deschutes Basin (Source: Gannett et al. 2001:37)



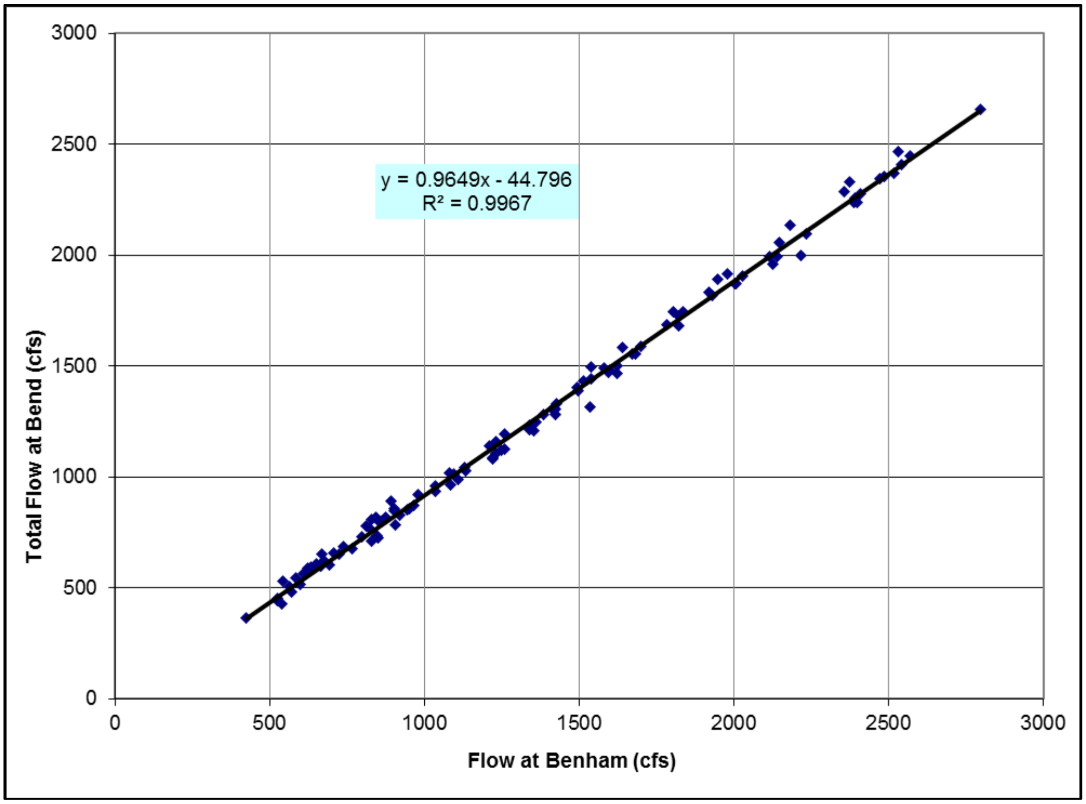
River–Groundwater System Interactions

In the upper portions of the Deschutes River and its tributaries, numerous springs supply water to the headwaters of the river systems and reservoirs along the edge of the Cascade Mountains. According to Gannett et al. (2001), seepage losses from Crane Prairie Reservoir to the groundwater system are dependent on reservoir stage, with the rate of loss increasing with higher reservoirs stages. On average the reservoir loses 60,000 af per year, or approximately 83 cfs based on 1939 through 1950 data (Gannett et al. 2001: 29). It is thought a large fraction of these losses are returned to the system through the springs located just below Crane Prairie Reservoir and along the edges of Wickiup Reservoir, and some of this likely contributes to the groundwater system recharge. Wickiup Reservoir is not as well understood, but generally has a net inflow of water through springs and rivers with some seepage occurring from periodic development of sinkholes.

In the LaPine area the groundwater table elevation is near land surface. Stream gains and losses along most of these reaches of the Deschutes and Little Deschutes Rivers area are small, indicating relatively little net exchange of water between the groundwater and river systems (Figure 3) (Gannett et al. 2017:12). The exception is the significant inflow to the Deschutes River from the Spring River area near Sunriver. There also is one notable area in this upper basin where the losing reach of stream on the Little Deschutes River and Crescent Creek is likely recharging the local groundwater system.

At approximately Sunriver and northwards the groundwater table elevation begins dropping below the land surface (and stream system) due to changes in the geologic deposits and faulting. The only significant losing reach along the Deschutes River occurs between Sunriver and Bend (Figure 2) where the river crosses a highly porous and recent lava flow losing approximately 113 cfs on average, up to 7% of river flow (Gannett et al. 2001: 73). Historical data indicate a correlation between seepage rate (water loss) and river flows, with higher river flows resulting in higher seepage rates. Figure 4 presents the relationship of flow between Benham Falls and Bend and OWRD's estimation of the relationship of the river losses to the flow (LaMarche pers. comm. [a, b]; Gannett et al. 2001: 38).

Figure 4. Relationship of Flow between Benham Falls and Bend and Resulting Relationship between River Flow and Channel Loss (Source: LaMarche pers. comm. [a, b]; Gannett 2001:38) (monthly data from 1932 to 1999; Lag-7 dataset)



From Bend to Lower Bridge (Figure 3) is considered a neutral reach where there is little net exchange of water between the groundwater and river systems. From Lower Bridge to the confluence of the Metolius, Deschutes, and Crooked Rivers, the groundwater system becomes exposed to the incising river canyons and begins discharging large volumes of groundwater to the river system (Gannett et al. 2001:44–46).

The Whychus Creek system is generally a gaining river system with the exception of the short segment just upstream of Sisters. This short segment of the creek flows through a braided stream restoration project just upstream of Sisters and loses approximately 10 cfs (LaMarche pers. comm. [a, b]), which appears to recharge the groundwater system and not discharge back to the creek locally. Groundwater discharges into the creek significantly increase near the Deschutes River confluence.

Based on the OWRD seepage run data from 2007, the Crooked River generally interacts with a shallow alluvial aquifer in the upper deposits of the valley and not with the regional groundwater system until downriver below Smith Rocks. The river gains small amounts of groundwater from the shallow alluvial aquifer throughout the Prineville valley until the incising river canyon intersects the regional groundwater table approximately 5 miles downstream of Smith Rocks State Park (LaMarche pers. comm. [a, b]). At this point, significant gains in flow result from the discharge of groundwater from the regional aquifer system, continuing down to the confluence of the Metolius, Deschutes, and Crooked Rivers.

Other Groundwater System Influences

Groundwater levels fluctuate within the Upper Deschutes Basin based on a number of factors with the degree of change based on the location, duration, and magnitude of the influencing factor. At the basin-scale, fluctuations in the groundwater levels mimic the larger-scale basin-wide/regional precipitation cycles, with periods of high groundwater level generally corresponding to high precipitation, and lower water levels corresponding to low precipitation periods. Water level measurements across the basin indicate the magnitude of these basin-scale stresses on the groundwater system within the study area are diminished (attenuated), delayed, and diffused with distance from the recharge source because of the highly permeable nature of the system combined with the size of the aquifer (Gannett et al. 2001:65). Similar attenuation effects on water levels can occur on a more local-scale as one moves farther away from a large agricultural or municipal well. Conversely, small-scale changes associated with variations in river stage at different flows result in only minor localized effects that are attenuated and absorbed by the local groundwater system and do not affect overall basin-wide groundwater levels.

The effects of canal leakage on the river system are documented in the historical hydrograph in the lower Crooked River, near the confluence with the Deschutes River, which shows an overall increase in groundwater discharge to the river of 400 to 500 cfs between 1918 and the early 1960s. This increase in groundwater discharge (baseflow) to the river is similar to the estimated annual mean canal losses of this same period, and the general rate of the increase in baseflow is similar to that of the estimated canal leakage in the study area (Gannett et al. 2001:52; Gannett and Lite 2013:4). Therefore, current groundwater discharges measured downstream of the canals near the confluence of the river systems have been artificially increased in an amount similar to the irrigation canals annual leakage rate.

The aquifers in the Upper Deschutes Basin have been affected by a general drying trend since the 1950s (Gannett and Lite 2013:2). Climate oscillations remain the largest influence on water level fluctuations (Gannett et al. 2001:2; Gannett and Lite 2013:1) with increases in groundwater pumping and decreases in recharge due to canal lining also contributing to declines within the central part of the Upper Deschutes Basin (between Benham Falls and Lower Bridge) (Gannett and Lite 2013:1). Groundwater levels in the central part of the groundwater system declined by approximately 5 to 14 feet between 1997 and 2008 (Gannett and Lite 2013:1), with 60 to 70% of the measured decline associated with climate cycles, 20 to 30% with increased groundwater pumping, and 10% with canal lining and piping. In general, water-level declines are dominated by climatic variability. Therefore, these basin-scale natural fluctuations in groundwater levels will largely mask small or minor changes in the study area groundwater levels caused by changes in river flows, while the central part of the basin is also susceptible to additional groundwater level fluctuations associated with increases in pumping and canal lining. (Gannett and Lite 2013:33).

Supporting Analysis for Environmental Consequences

Alternative 1: No Action

The values presented in the effects analysis are direct RiverWare model outputs (without rounding). They are not intended as exact predictions of future conditions, but and are used for purposes of comparing among alternatives.

Water Conservation Activities

Recent and reasonably foreseeable water conservation projects[4] will affect the study area hydrology over the analysis period by changing the timing and amount of water diverted, instream flow, and as seepage for irrigation networks.

Water saved as a result of water conservation projects can be protected instream under the State of Oregon's Allocation of Conserved Water (ACW) process[5] (Oregon Administrative Rule [OAR] 690-18), reduce demand for the entity completing the project (typically where available water supply is not meeting existing demand), or potentially increase water supply for another water user(s). The potential effects of these three scenarios are described further.

If water saved through conservation projects are protected instream through an ACW, water would be expected to be protected from the point of diversion to Lake Billy Chinook. Thus, for conservation projects for Deschutes River water supply, streamflow in the Middle Deschutes River would be higher during the irrigation season compared to existing conditions. If the saved water were used to reduce the demands of the entity completing the project or made available to another water user, saved water may change the amount and timing of water supply shortages and streamflow in the Upper Deschutes Basin. If the saved water were not protected instream during the irrigation season, the saved water would potentially provide managers with additional flexibility to meet fish and wildlife flow needs. For example, if less stored water is needed to meet irrigation needs during the irrigation season, more water could be released during the winter period to meet fish and wildlife needs. Water released during the storage season may be able to be legally protected instream.

Whether water saved through conservation is protected instream or used to reduce water supply deficits depends in part on State of Oregon rules and statutes governing the use and instream protection of water rights. Prior to the implementation of water conservation projects, the outcome of State of Oregon review of proposed water right transactions is not certain. The allocations by source and by season presented in Tumalo ID's watershed EA are estimates based on conserved water applications that were associated with similar, completed projects in TID that have already completed the State of Oregon's administrative process for the allocation of conserved water (see ORS 545.470). The allocations presented in the Plan-EA may change following a thorough review of the application by OWRD who may order a different allocation in attempt to avoid impacting other water users at either source. (Farmers Conservation Alliance 2018a).

Two water conservation projects are assumed under the no-action alternative: the Swalley ID Irrigation Modernization Project and the Tumalo ID Irrigation Modernization Project. Water saved through these projects would be protected instream under the ACW process, and would thereby increase instream flow below irrigation diversions in the Deschutes River, and Tumalo Creek as shown in Table 4. Flows would increase incrementally over the first 10 years of the analysis period as projects are completed. Table 4 also includes flows from the recent Tumalo ID piping project that is not reflected in the diversions assumed in the RiverWare model. These flow values are included

[4] RiverWare includes instream water rights at gages throughout the study area, including instream water rights originating from conserved water projects. Tumalo ID's Conserved Water Project 37 (CW-37) is currently in progress. RiverWare accounts for instream water rights at the TUMO gage through increment 3 of CW-37. Two additional increments have added to the instream water rights at the TUMO gage and will result in an increase in instream flows below Tumalo ID relative to the RiverWare model. It is anticipated that Tumalo ID will complete CW-37 within the next two years, then initiate a new conserved water project (or projects) to allocate water saved through piping of Tumalo ID's laterals. The projected streamflow impact of these conserved water projects is shown in Table 4.

[5] Under an ACW, water allocated to instream use would be protected under an instream water right with a priority date equivalent to or 1minute junior to that of the irrigation district rights used to divert water. OWRD must find that the ACW does not "harm" other water users.

under years 1 through 5. The flow increases are reflected in the streamflow analysis (Impact WR-4) in Alternatives 2 through 4 for the affected reaches.

Table 4. Instream Flow Increases during Peak Irrigation Season from Water Conservation Projects assumed under the No-Action Alternative

Irrigation District	Streamflow Impact - Years 1 through 5			Streamflow Impact - Years 6 through 10			Streamflow Impact - Years 11 through 5		
	DEBO	CULO[c]	TUMO	DEBO	CULO[c]	TUMO	DEBO	CULO[c]	TUMO
Tumalo ID[a]	0	12.35	12.35	0	19.83	19.83	0	30.91	30.91
Swalley ID[b]	7.6	7.6	0	15.2	15.2	0	0	0	0

Source: Farmers Conservation Alliance 2018a, 2018b

[a] Planned piping began in October 2018 and has an anticipated 12-year timeline. Flow values also reflect completion of conserved water 37 project.

[b] Piping is planned to begin in 2019 and has an 8- to 9-year timeline.

[c] The table shows all water gauged at TUMO and CULO would be saved through water conservation projects, but some of the water saved through piping may have discharged to surface water on the Deschutes River above the CULO gauge and below the DEBO and TUMO gauges.

Groundwater

This section provide supporting information on groundwater fluctuations due to conservation activities, climate change, future groundwater demands, and City of Prineville future groundwater pumping and associated mitigation. Based on the historical record, basin-scale groundwater levels will continue to fluctuate in response to precipitation cycles that affect the overall recharge to the system (Gannett and Lite 2013:2). The magnitude of water level changes will vary across the basin depending upon the distances from the basin's primary recharge source (the Cascade Range) as well as localized changes resulting from district water conservation projects (Tumalo ID and Swalley ID Irrigation Modernization Projects), groundwater pumping, and other conservation assumed under the no-action alternative. The basin-scale fluctuations in groundwater levels driven by precipitation cycles will likely mask any localized changes in water levels. The exception is groundwater levels in wells immediately adjacent to planned district water conservation projects, where declines in water levels may exceed the precipitation driven fluctuations.

Under the no-action alternative, it is anticipated there will be no change to the ongoing basin-scale groundwater level fluctuations over the 30-year analysis period. If climate change conditions significantly modify the annual precipitation to the region (beyond the current cycles) the basin groundwater levels could be affected. Therefore, there would be no effect on groundwater recharge under the no-action alternative with the exception of a negative effect on localized groundwater levels adjacent to planned piping projects.

The Deschutes Basin is administratively closed to new surface water appropriations and therefore the water needs of new development in the Upper Deschutes Basin are anticipated to be met using groundwater. Any new groundwater permit in the basin requires mitigation under the Deschutes Groundwater Mitigation Program rules established in 2002. The mitigation program created a system for developing and obtaining mitigation credits that is designed to offset the potential impacts of future groundwater withdrawals on surface water flows.

It is expected that during the permit term the City of Prineville will continue to grow and obtain additional water supply from groundwater production from the Prineville Valley. Because groundwater wells pull water radially from the aquifer, depending upon the locations of the well(s), impacts from pumping can range from a partial connection to the Crooked River, to a more delayed and attenuated impact on the surface water system.

The Deschutes Basin Groundwater Mitigation Rules (Oregon Administrative Rules 690-505-0600 through 690-505-0630) require that new groundwater rights in the vicinity of the City of Prineville be accompanied by mitigation to offset the impact on surface water from groundwater pumping. Therefore, as the City obtains new groundwater supply and water rights, the City must annually provide mitigation equal to the volume of the groundwater used consumptively (the quantity of water that is not returned to the river through municipal wastewater plants).

In December 2018, the City obtained a new authorization (water use permit) for use of the Prineville Valley aquifer. This new water use permit will likely be the majority of the City's additional groundwater supply through the permit period.[6] The required mitigation for this new water use permit is stored water released from Prineville Reservoir.

OWRD has assumed that the wells under the City's new permit are hydraulically connected to the Crooked River and that 40 percent of the annual volume of groundwater pumped will be consumed. As a result, OWRD has required up to 1,292 af of mitigation[7] in the Crooked River annually.[8]

Under the Crooked River Act, the City of Prineville secured 5,100 af of stored water from Prineville Reservoir for mitigation for future groundwater production, which is equivalent to an annual flow rate of approximately 7 cfs. However under the Crooked River Act, Reclamation, in consultation with the National Marine Fisheries Service and the U.S. Fish and Wildlife Service, can develop release schedules for the 5100 af of mitigation water that maximizes benefits to downstream fish and wildlife. Therefore, the City's likely additional groundwater pumping through the permit period, combined with the 5,100 af of stored water released annually for mitigation, is likely to result in a net positive benefit to streamflow.

Alternative 2: Proposed Action

Under the proposed action, the applicants would implement the Deschutes Basin HCP conservation strategy. The conservation strategy consists of a series of conservation measures to reduce the adverse effects of covered activities on the covered species. Proposed conservation measures

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[6] The City's *2018 Water Master Plan* (WMP) estimates that by 2037, the City will need a total of 5,303 gallons per minute (gpm) of production for a period of 18 hours a day. With current capacity of 3,765 gpm (prior to the new well field and water right), this means that an additional 1,538 gpm of new supply will be needed to meet the City's needs in 2037 (Anderson Perry 2018:2-21). Assuming the permit will extend to 2049 (for 30 years) the City's water supply needs in 2049 can be estimated from the existing data. Annualizing the 1,538 gpm per year of additional needs over the WMP's 20 year planning window indicates an annual increase of 76.9 gpm; therefore, the City will need approximately an additional 932 gpm by 2049 (76.9 x 12 years = 932 gpm). The City's total new water supply needs beyond the current supply is 1,538 gpm + 932 gpm = 2,461 gpm (pumping 18 hours per day). Required mitigation under OWRD's Deschutes Basin Groundwater Mitigation Rules for 2,461 gpm for 18 hour a day at a consumptive use rate of 40% is approximately 1,190 af of water, much less than the 5,100 af of stored water mitigation the City has already secured and is protected instream annually.

[7] Providing 1,292 af of mitigation assumes the City is pumping 2,000 gpm 24 hours a day all year long.

[8] The two separate 5-day aquifer tests on the City's recently installed wells under the new water use permit, which authorizes wells adjacent to the Crooked River, do not indicate an immediate direct connection to the river based on the low production capacity of each well (85 and 100 gpm) and the shape of the drawdown curves which after 5 days were not flat as would be expected with a direct connection to the river (Newton 2018: Appendix C). Additional macro-particulate analysis (MPA) testing results (collected at the end of each 5-day test) for the Oregon Health Authority indicates limited direct connection between the wells and the adjacent river, and water quality testing results from the end of each test show significant ammonia, and dissolved iron and manganese in the water suggesting reducing conditions, and not the oxygen rich conditions that would be associated with the river water. Although the new production is from groundwater that is hydraulically connected to the Crooked River, the current data indicates that the full impact from pumping may not be seen in an immediate corresponding decrease in the adjacent Crooked River flows, but the impact on streamflow will likely be spread out over a larger area.

include actions that would change the timing and volume of water released from covered reservoirs and streamflow in covered rivers and creeks.

The values presented in the effects analysis are direct RiverWare model outputs (without rounding). They are not intended as exact predictions of future conditions, but and are used for purposes of comparing among alternatives.

WR-1: Change Reservoir Storage

This section describes the impact and mechanism of impact for changes in reservoir water supply storage as a result of the proposed action.

Crane Prairie Reservoir

Measure CP-1 would adjust the range and timing of reservoir storage and drawdown rate for Crane Prairie Reservoir, and establish a recommended minimum instream flow of 75 cfs in the Deschutes River below the reservoir. This minimum instream flow requirement is the same as under the no-action alternative, however narrower limits on the range of surface elevations (water levels) in the reservoir under the proposed action would have a variable effect on water supply storage in Crane Prairie Reservoir. Storage would generally be higher from approximately late September through early May and lower from mid-May through mid-September compared to the no-action alternative (Table 5, Figure 6).

Because Crane Prairie is above Wickiup Reservoir, any water stored in Crane Prairie early in the storage season would otherwise be available to store in Wickiup. So although the timing of storage would be altered under the proposed action, that total combined storage in Crane Prairie and Wickiup Reservoirs is relatively unchanged in years 1 through 5 of the permit term (Figures 6 and 7), when winter releases from Wickiup Reservoir are the same as under the no-action alternative. Beginning in year 6 of the permit term, increased winter releases from Wickiup Reservoir would result in a reduction in combined storage. Given the high seepage loss from Crane Prairie Reservoir, as reservoir elevation increases, the increased September through May storage would likely result in an increased volume of seepage loss on an annual basis, compared to the no-action alternative, but the effect is relatively small (see WR-5).

Table 5. Modeled Crane Prairie Storage at the 20th, 50th, and 80th Percentiles in August and December under the No-Action Alternative and Proposed Action

		Crane Prairie Storage (af)				
	Water Year	No-Action Alternative	Proposed Action Years 1–5	Proposed Action Years 6–10	Proposed Action Years 11–20	Proposed Action Years 21–30
August (Reduction)	Dry	45,166	43,411	43,379	43,377	43,396
	Normal	46,813	43,637	43,653	43,637	43,637
	Wet	47,021	43,686	43,688	43,688	43,723
December (Increase)	Dry	35,000	42,694	42,694	42,694	42,694
	Normal	35,000	45,692	45,692	45,692	45,713
	Wet	35,000	47,546	47,546	47,546	47,546

af = acre-feet; cfs = cubic feet per second

Figure 5. Modeling Results Comparing Crane Prairie Reservoir Storage under the No-Action Alternative and Proposed Action in Years 1 through 5 of the Permit Term.

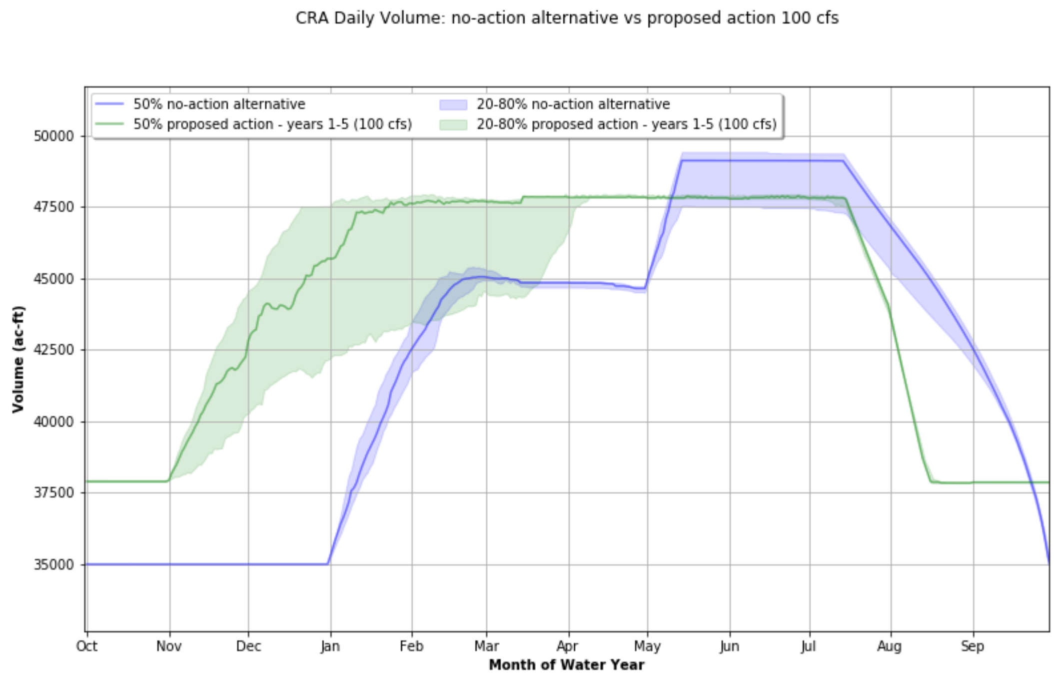
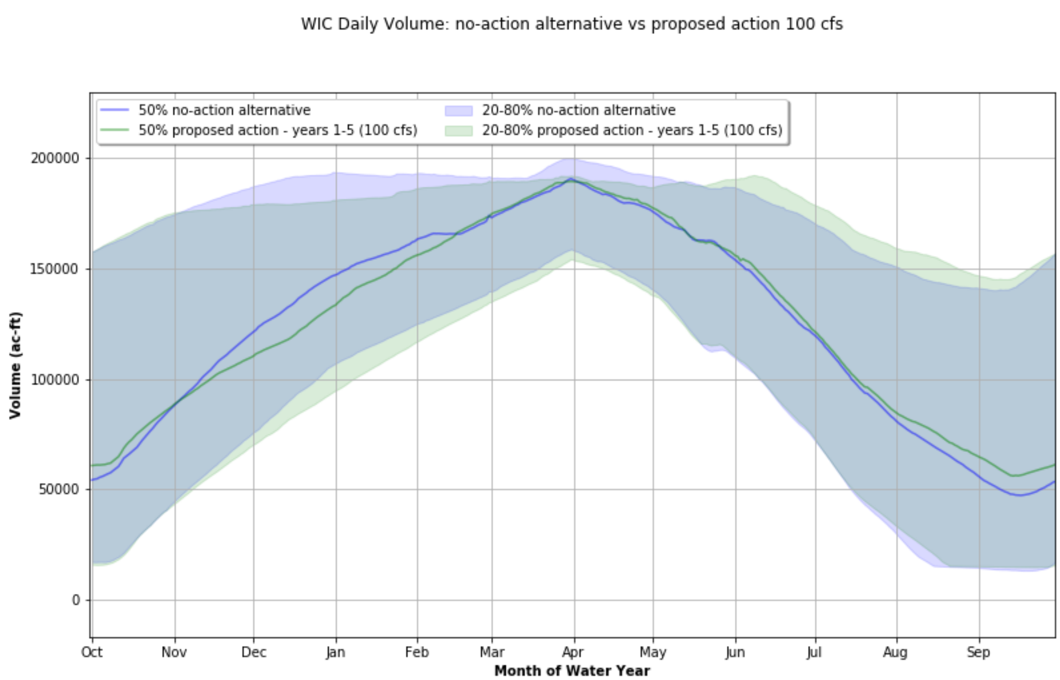


Figure 6. Modeling Results comparing Wickiup Reservoir Storage under the No-Action Alternative and Proposed Action in Years 1 through 5 of the Permit Term



Wickiup Reservoir

As winter flow releases from Wickiup begin to increase above the 100 cfs flow required under the no-action alternative, Wickiup Reservoir storage declines, with the greatest declines observed in years 21 through 30 of the permit term (Table 6; Figure 7). Compared to the no-action alternative, the reduction in maximum storage on or after April 1 is expected to occur in a normal year during years 21 through 30 of the permit term would be 52,278 af. The RiverWare model shows that for every 100 cfs increase in winter Wickiup Reservoir releases, the maximum Wickiup storage volume, after the beginning of the irrigation season on April 1, would decline by approximately 10,000 to 15,000 af with an average decline of 39,368 af in years 21 through 30 of the permit term. However, Wickiup Reservoir would still fill to over 175,000 af in more than one-quarter of years, when conditions are wet or very wet (Table 7). The frequency of filling Wickiup Reservoir to a maximum annual volume of at least 100,000 af—approximately half of the total capacity of Wickiup Reservoir—declines from 100 to 38% (Table 7), indicating that the effects of reduced reservoir storage would be concentrated in normal, dry, and very dry years.

Under the proposed action, reservoir releases may be reduced below what is required to ensure that adequate flows are maintained at the WICO gauge. Depending on how outflows are managed, this may lead to an increase in Wickiup Reservoir storage relative to the modeled storage levels shown in Tables 6 and 7, and Figure 7.

Table 6. Modeled Wickiup Reservoir Storage under the No-Action Alternative and Proposed Action

Water Year Conditions	No-Action Alternative (af)	Proposed Action (af)			
		Years 1–5	Years 6–10	Years 11–20	Years 21–30
Very Dry	97,654	99,025	85,968	63,509	35,013
Dry	109,445	111,279	94,005	70,920	46,204
Normal	126,096	123,582	105,845	83,922	73,318
Wet	191,249	190,740	190,185	190,157	190,157
Very Wet	200,976	201,178	201,178	201,178	201,178

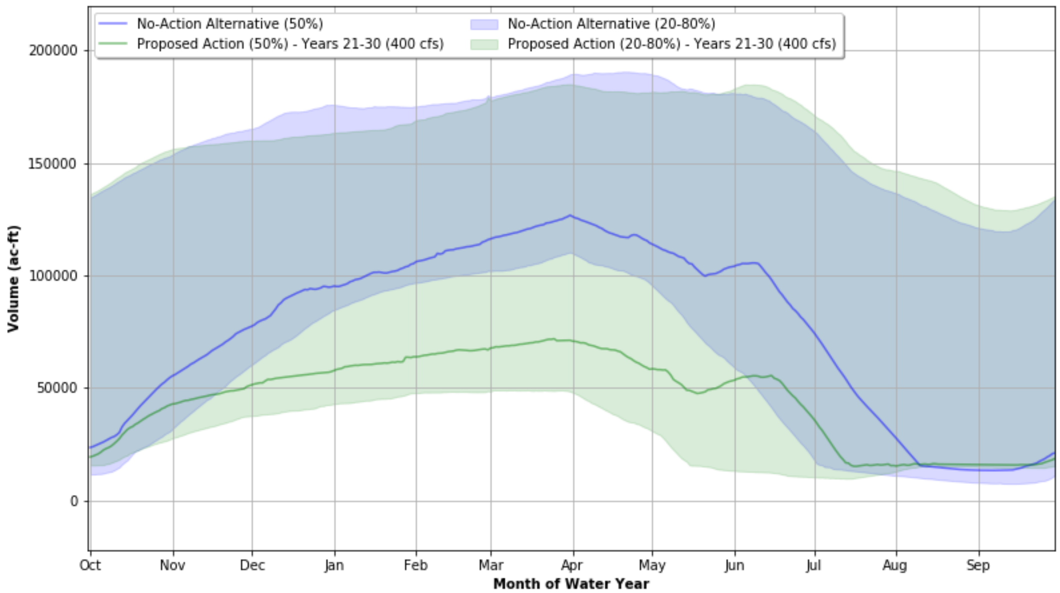
af = acre-feet; cfs = cubic feet per second

Table 7. Frequency of Wickiup Reservoir Fill under the No-Action Alternative and Proposed Action

Maximum Fill Volume April–August (af)	No-Action Alternative	Proposed Action			
		Years 1–5	Years 6–10	Years 11–20	Years 21–30
25,000	100%	100%	100%	100%	100%
50,000	100%	100%	100%	100%	72%
75,000	100%	100%	100%	69%	48%
100,000	97%	97%	62%	45%	38%
125,000	55%	48%	41%	38%	38%
150,000	38%	38%	38%	38%	38%
175,000	31%	31%	31%	28%	28%

af = acre-feet; cfs = cubic feet per second

Figure 7. Modeling Results Comparing Wickiup Reservoir Storage under the No-Action Alternative and Proposed Action in Years 21 through 30 of the Permit Term



Crescent Lake Reservoir

The proposed action would reduce minimum flows downstream from Crescent Lake Dam as compared to the no-action alternative. Under the no-action alternative the minimum flow below Crescent Lake Dam would be 30 cfs from March 15 through November 30 and 20 cfs during the rest of the year. Under the proposed action the minimum flow would be 20 cfs from October 1 through June 30. Because TID is typically releasing 50 cfs from July through September anyway to meet irrigation demands, the primary impact of the proposed action would be to reduce minimum outflows during the storage season. As a result, the proposed action would generally result in an increase in Crescent Lake storage (Figure 8).

In years 1 through 5 of the permit term, the maximum storage volume attained between April and August would stay approximately the same in a normal year or very dry year, and would increase in dry, wet, and very wet years (Table 8). As winter releases from Wickiup increase to 400 cfs during years 21 through 30 of the permit term, the increase in Crescent Lake storage compared to the no action declines by 1,000 af or more compared to the proposed action at 100 cfs of Wickiup releases, reflecting the increasing frequency of regulatory calls on junior water rights. Tumalo ID holds two water rights for storage in Crescent Reservoir, certificate 76683 for storage of 35,000 af with a March 20, 1911, priority, and certificate 76637 for storage of 51,050 af with a 1961 priority. Because certificate 76637 is junior to North Unit ID's 1913 live flow water right, under rare circumstances, it may be subject to regulatory calls when North Unit ID experiences shortages.

Tumalo ID's water right to store water in Crescent Lake Reservoir beyond 35,000 af per year is junior to live flow water rights on the main stem Deschutes, including North Unit ID's 1913 live flow water rights. Additionally, the RiverWare model anticipates increased regulation of Tumalo ID's 1905 live flow priority date on the main stem Deschutes River, which may lead to further reliance on Crescent Lake storage releases to make up for the reduced availability of live flow, and a commensurate reduction in storage. In years 21 through 30, reductions in maximum Crescent storage may not reflect reductions in end of year storage, as maximum storage may be reduced through mid-July by regulation of Deschutes natural flow water rights to maintain Crane Prairie elevations, but TID's storage account may be rebalanced with Crane Prairie storage accounts later in the year.

Figure 8. Modeling results Comparing Crescent Lake Reservoir Storage under the No-Action Alternative and Proposed Action in Years 1 through 5 of the Permit Term

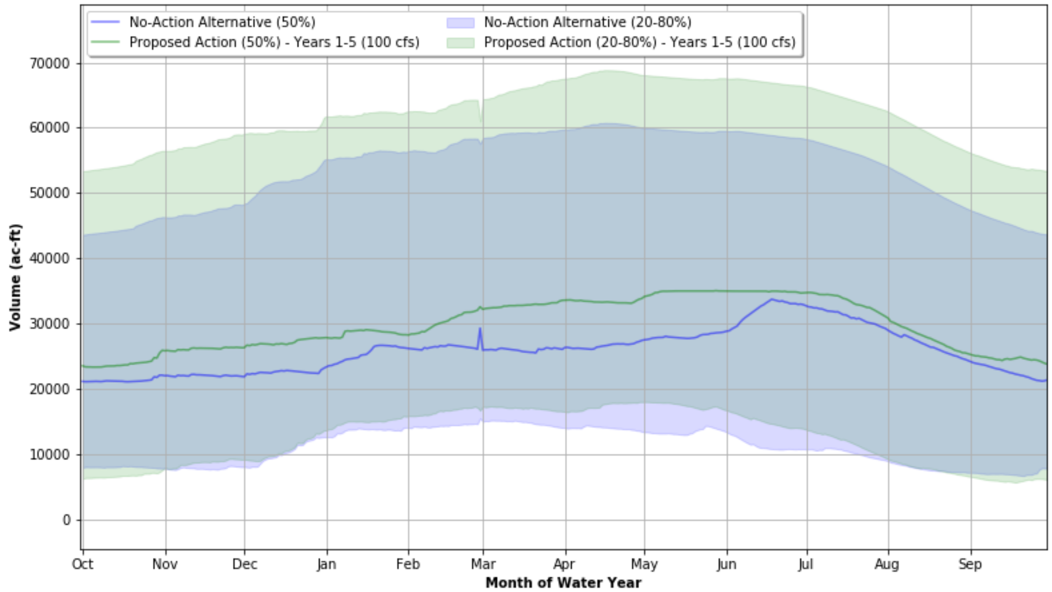


Table 8. Change in Crescent Lake Storage under the No-Action Alternative and Proposed Action

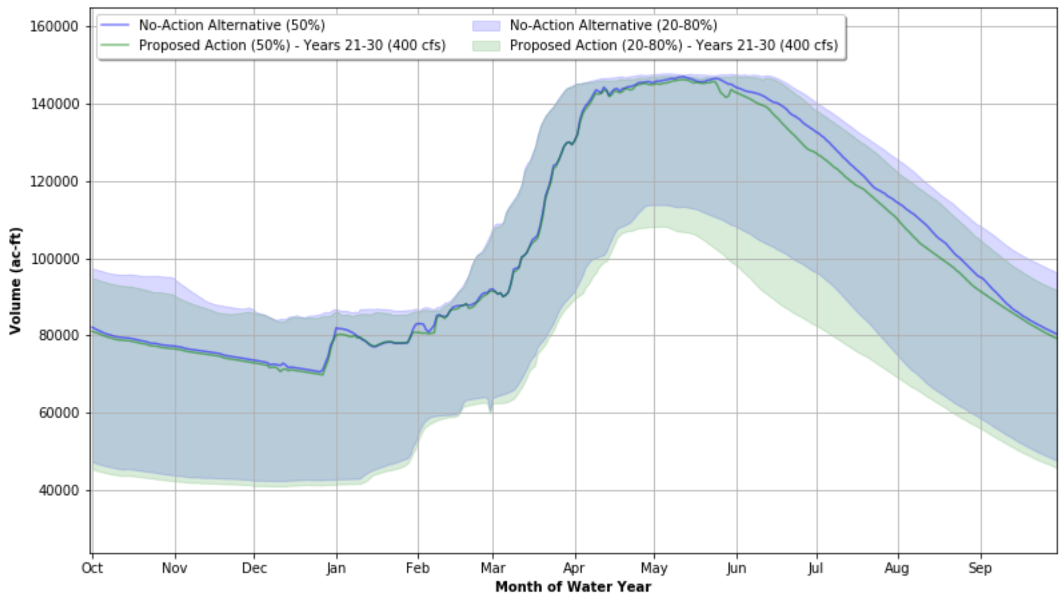
Water Year Conditions	No-Action Alternative	Proposed Action Years 1–5	Proposed Action Years 6–10	Proposed Action Years 11–20	Proposed Action Years 21–30
Very Dry	7,020	7,288	7,278	7,274	7,237
Dry	14,681	18,883	18,616	17,790	17,785
Normal	34,956	35,020	35,020	35,020	35,020
Wet	58,872	65,342	65,144	62,439	64,230
Very Wet	76,631	77,652	77,503	78,006	78,006

af = acre-feet; cfs = cubic feet per second

Prineville Reservoir

North Unit ID is expected to increase use of its Crooked River Pumping Station to address the declining reliability of stored water supply from Wickiup Reservoir storage as described above. North Unit uses the Crooked River Pumping Station to divert both Crooked River live flow and up to 10,000 af of stored water from Prineville Reservoir. Additionally, increased winter minimum flows in the Crooked River lead to reduced storage in Prineville Reservoir in dry and very dry years. Under the proposed action, increased use of the Crooked River by North Unit ID and increased winter minimum flows in the Crooked River would reduce Prineville Reservoir storage in most years. The RiverWare model shows that the proposed action would generally result in a reduction of Prineville Reservoir storage compared to the no-action alternative under all water year types, with changes ranging from an increase of 170 af in wet years to a reduction of 9,533 af (very dry year). Although the reduction in Prineville storage is high during dry and very dry years, the change in storage in a normal year is a reduction of 757 af, which is equivalent to less than 1 percent of total storage. Figure 9 shows the impacts of the proposed action on Prineville Reservoir storage during years 21 through 30 of the permit term.

Figure 9. Modeling Results Comparing Prineville Reservoir Storage under the No-Action Alternative and Proposed Action during Years 21 through 30 of the Permit Term

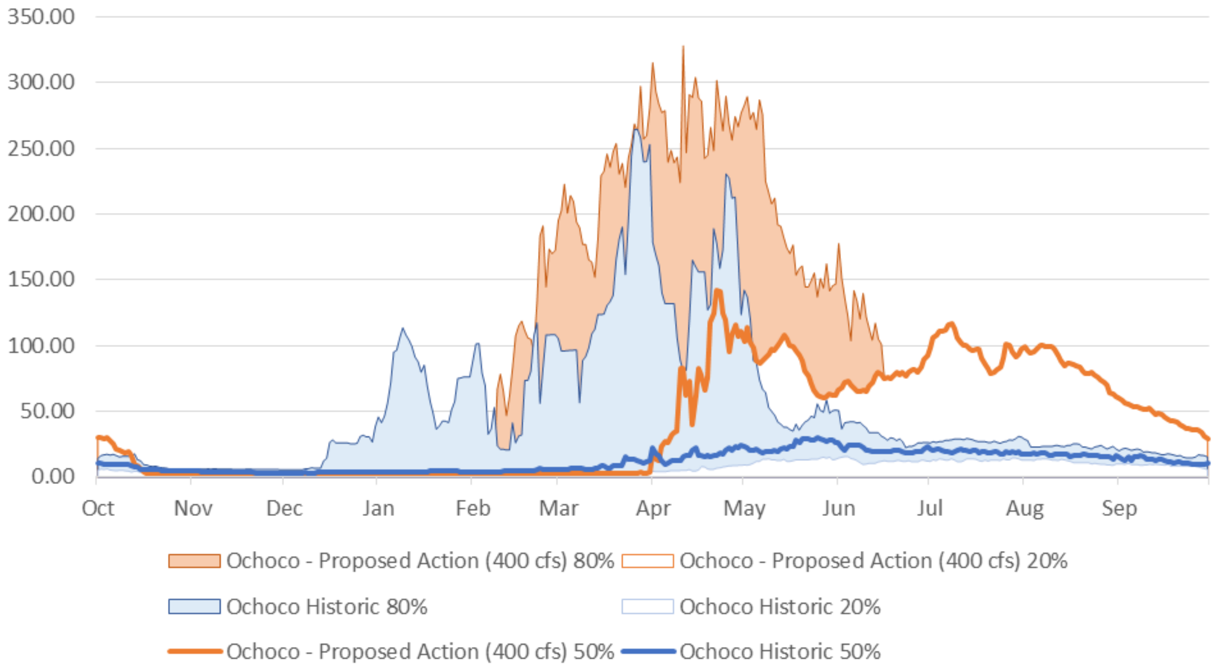


Ochoco Reservoir

The proposed action (Conservation Measure CR-2) provides for release of additional flow from the Ochoco Main Canal downstream of Ochoco Reservoir to contribute to flow increases in Ochoco Creek during the irrigation season and non-irrigation season, subject to limitations (Figure 10). Historically, flows at gauge 14085300 below Ochoco Reservoir have regularly dropped below 3.0 cfs. Maintaining a flow of 3.0 cfs during the non-irrigation season and 5.0 cfs during the irrigation season would likely reduce water supply storage 0 af to 1,516 af compared to historical conditions.[9] This analysis did not consider the effect of bypassing additional flows associated with instream water rights (regardless of priority date as compared to Ochoco ID storage) originating above Ochoco Reservoir, but such measures would be expected to further reduce Ochoco Reservoir storage compared to the historical baseline.

[9] This analysis assumes that a minimum flow of 3.0 cfs would be maintained below Ochoco Reservoir from October through April and a minimum flow of 5.0 cfs would be maintained from May through September.

Figure 10. Gauged Flow at OCHO Gauge (14085300) compared to RiverWare Output at 100 cfs Flow below Wickiup



Measure CR-3 provides for minimum flows in McKay Creek during the active irrigation season, to be achieved through bypass or release of water into McKay Creek, as needed. Similar to measure CR-2, historical data suggests that bypass flows will not be sufficient to maintain the identified flow in McKay Creek, requiring Ochoco ID to release additional flow into McKay Creek to maintain the specified minimum flows. During times when some part of Ochoco ID's water supply comes from Prineville or Ochoco Reservoir, water released into McKay Creek will be at least partly made up of stored water. Compared to the historical baseline, measure CR-3 would likely have an effect on Ochoco Reservoir water supply storage because Ochoco ID would need to release and divert more stored water to maintain minimum flows on McKay Creek.

Measure CR-4 provides funding for the Crooked River Conservation Fund to support conservation measures and benefit covered species in the Crooked River Subbasin. Possible uses of the Crooked River conservation fund include temporary instream leasing of secondary irrigation rights supplied by stored water in Prineville and Ochoco Reservoirs. Measure CR-4 specifies that such water rights may be released at any time from February 1 through November 30, which may result in a reduction of Prineville and Ochoco Reservoir storage, depending upon the timing of water releases and how instream leases are administered and accounted for.

The results of the RiverWare model show that Ochoco Reservoir storage does not change under the proposed action. However, RiverWare assumed that Ochoco Creek minimum flows proposed under measure CR-2 would be met under the no-action alternative. When compared to the historical baseline, measures CR-2, CR-3, and CR-4 are expected to have a small impact on Ochoco Reservoir water supply storage.

WR-2: Change in Water Supply for Irrigation Districts and Other Water Supply Users

Changes in stored water supply described under impact WR-1 have direct and indirect effects on water supply for irrigation districts and other surface water users. Modeling results show that as stored water supplies decrease, the frequency and duration of regulatory calls on live flow water rights and of water shortages for water users with water rights junior to Central Oregon ID's October 31, 1900, priority date increase.[10] Changes in annual and monthly diversions for irrigation districts under the proposed action indicate that supply shortages would tend to be concentrated during June through September rather than evenly distributed throughout the irrigation season. This analysis considers water supply shortfalls on the basis of reduced irrigation district diversions during the full irrigation season of April through October and peak irrigation season of June through September.[11]

Figures 11 through 15 compare irrigation season diversions under the proposed action (years 1–5 and years 21–30) in normal, dry, and very dry years as a percentage of the diversion under the no-action alternative. North Unit, Central Oregon, Arnold, Lone Pine, and Ochoco IDs are expected to experience reductions in diversions as a result of the proposed action. Tumalo, and Three Sisters IDs are not shown and are discussed in greater detail below. Swalley ID is not affected by the proposed action.

Figures 16 and 17 compare diversions in normal, dry, and very dry years between the no-action alternative and the proposed action (in years 1 through 5 and years 21 through 30 of the permit term) from April through October as volumes. Supply shortages under the proposed action from June through September are more pronounced than for the entirety of the irrigation season.

The analysis shown in the figures does not capture changes expected to occur under the no-action alternative during the permit term.

The impacts of the proposed action on the water supply of the applicants and other water users is described below.

North Unit Irrigation District

As described under WR-1, the proposed action will reduce Wickiup Reservoir storage. North Unit ID is dependent on Wickiup Reservoir storage when live flow in the Deschutes River is insufficient to meet North Unit ID demands under their February 28, 1913 water right certificates (72279, 72280, 80936, 94079). This will reduce water supply available to North Unit ID (Figures 11 and 16) and increase the frequency that North Unit ID would make regulatory calls for Deschutes River live flow. While there have been regulatory calls on water rights junior to North Unit ID in previous years (Giffin pers. comm. [a, b]), the declining likelihood of filling Wickiup Reservoir (Table 7) and increased value of entering the storage season with more water in Wickiup Reservoir mean that regulatory calls on Upper Deschutes River water rights junior to 1913 would be expected to occur with much greater frequency.

By year 21 under the proposed action, when the required fall/winter flow at WICO is 400 cfs, North Unit ID diversion would be reduced by over 28,000 af in a normal year compared to the no-action

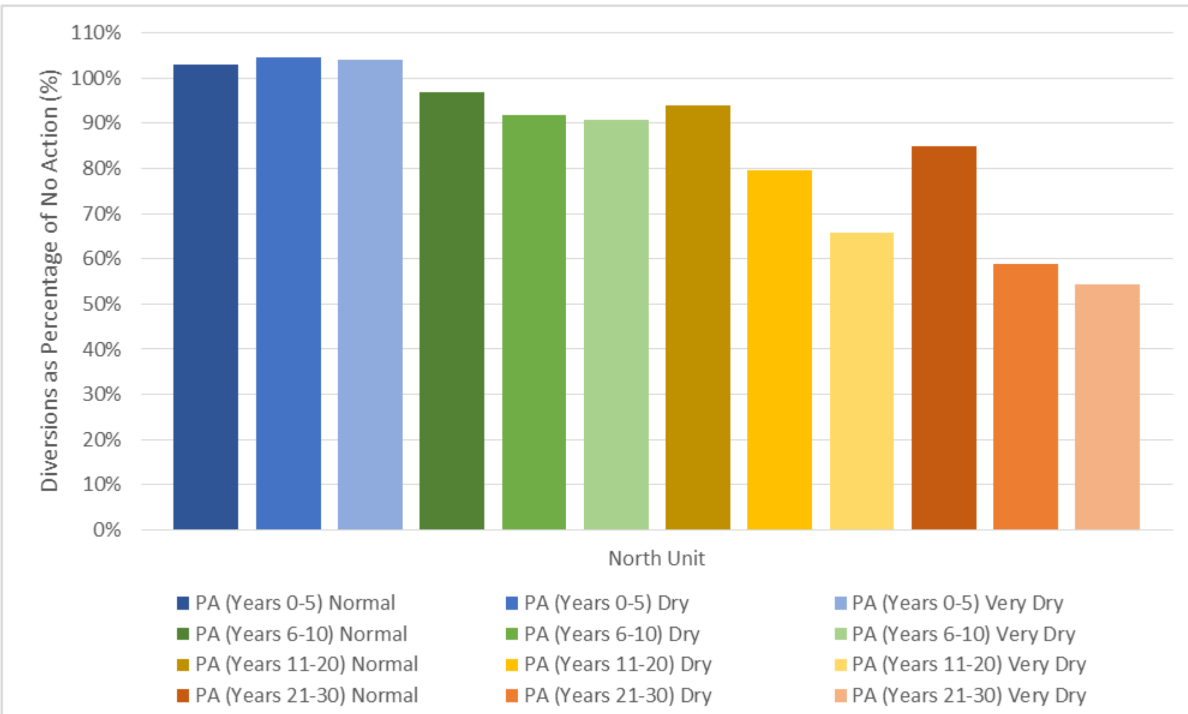
[10] Lone Pine ID's water right certificate (72197) also has a priority date of October 31, 1900, but it is junior to Central Oregon ID's October 31, 1900 under certificate 83571.

[11] This metric is intended to capture substantial water supply shortfalls caused by a lack of water available under a district's water rights for live flow or supplemental stored water.

alternative (Figures 11 and 16).[12] In a dry year, North Unit ID diversions would be reduced by over 54,000 af. In wet and very wet years, there would be no reduction in North Unit ID diversions.

In general, the RiverWare model shows that North Unit ID would increase use of its Crooked River pumping plant to offset some of the loss of Deschutes River water supply. Under the proposed action, during years 21 through 30 of the permit term, North Unit ID would increase use of the Crooked River pumping plant in one out of every two years, with an average of 5,679 af per year. However, in very dry years (e.g., 1992) RiverWare shows that North Unit ID pumping from the Crooked River would decline by approximately 2,000 af, further exacerbating Deschutes River water supply shortages. The decline in the utilization of the Crooked River pumping plant in a very dry year is attributable to increased winter releases from Prineville Reservoir under the proposed action, which would cause a decrease in Prineville Reservoir storage and Crooked River water supply for North Unit ID.

Figure 11. North Unit Irrigation District Diversions (April through October) under the Proposed Action as a Percentage of Diversions under the No-Action Alternative



Arnold, Lone Pine, and Central Oregon Irrigation Districts

The proposed action would reduce water supply available to the entities with water rights to Crane Prairie Storage: Arnold ID, Lone Pine ID, and Central Oregon ID. Crane Prairie's active storage would be effectively reduced 5,000 af; from approximately 15,000 af under the no-action alternative to 10,000 af under the proposed action. Furthermore, because Crane Prairie must be held above 46,800 af through July 15 (Conservation Measure CP-1A), supply shortages prior to July 15 cannot be addressed by release of Crane Prairie stored water. As described above under Water uses and

[12] In general, the model results show that North Unit ID will increase use of its Crooked River pumping plant to offset some of the loss of Deschutes River water supply. However, in a very dry year (1992), the model shows that water available from the Crooked River declined by approximately 2,000 af, exacerbating Deschutes River water supply shortages.

Water Rights Administration, under Oregon Law, when there is insufficient water to meet the needs of all water users, OWRD can regulate water rights by relative priority. As a result of this regulatory framework, RiverWare modeling indicates that the frequency of regulatory calls on live flow water rights and of water shortages for water users with water rights junior to Central Oregon ID's October 31, 1900, priority date, including Arnold and Lone Pine ID, and other water users shown in Table 2, would increase (Figures 13 and 14).[13] It is important to note that the reason for the curtailment shown in Figures 13 and 14 is that the modeling results anticipate that senior water right holders, including Central Oregon ID, would make regulatory calls on more junior water right holders, and that OWRD would validate that call. If no senior water right holder makes a valid, regulatory call affecting live flow water rights with more junior priority dates, even during very dry years, Arnold ID, Central Oregon ID, and Lone Pine ID may instead share demand shortfalls during summer low flow periods.

In years where Crane Prairie storage would not be available, a comparison of demand and diversion for Arnold ID, Lone Pine ID, and Central Oregon ID in RiverWare anticipates regulation of water right priority dates as senior as 1900. Using Lone Pine ID as an example, RiverWare model output for a very dry year (2005) shows that Lone Pine's water right will be regulated with greater frequency, and for longer durations during years 21 through 30 of the permit term, when minimum winters flow releases from Wickiup are 400 cfs. Under the no-action alternative, modeling results do not show any regulation of Lone Pine ID's water right until late July. Under the proposed action, during years 21 through 30 of the permit term, Lone Pine ID's live flow water right is regulated throughout the year, including from mid-June through mid-July. Therefore, Conservation Measure CP-1 results in more frequent water shortages prior to July 15 for Lone Pine ID and all other water users with rights junior to Lone Pine ID.[14] Figure 15 shows regulation of Lone Pine ID's water right as a reduction in Lone Pine ID's diversion under the no-action alternative and the proposed action (during years 21 through 30 of the permit term). As described above, in the absence of a regulatory call affecting Lone Pine ID's water rights, and cessation of deliveries to Lone Pine ID through the Central Oregon ID distribution system, demand shortfalls may be shared amongst Lone Pine ID, Central Oregon ID, and Arnold ID. Additionally, it should be noted that reductions in available live flow that RiverWare simulates for Lone Pine ID and Arnold ID are small compared to Central Oregon ID's total diversion.

[13] Lone Pine ID's water right certificate (72197) also has a priority date of October 31, 1900, but it is junior to Central Oregon ID's October 31, 1900 priority date under certificate 83571.

[14] It is important to note that the reason for the curtailment shown is that the modeling results anticipate that senior water right holders, including Central Oregon ID, will make a regulatory call on junior water right holders, and that OWRD will validate that call.

Figure 12. Central Oregon Irrigation District Diversions (April through October) under the Proposed Action as a Percentage of Diversions under the No-Action Alternative

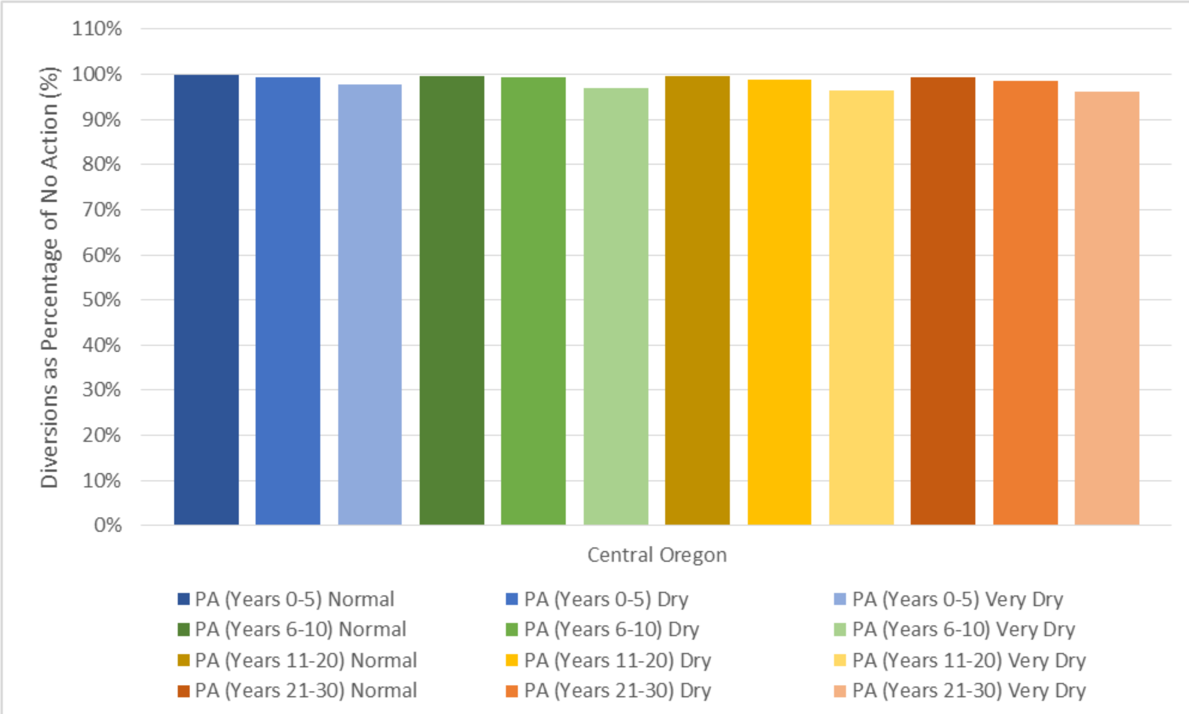


Figure 13. Arnold Irrigation District Diversions (April through October) under the Proposed Action as a Percentage of Diversions under the No-Action Alternative

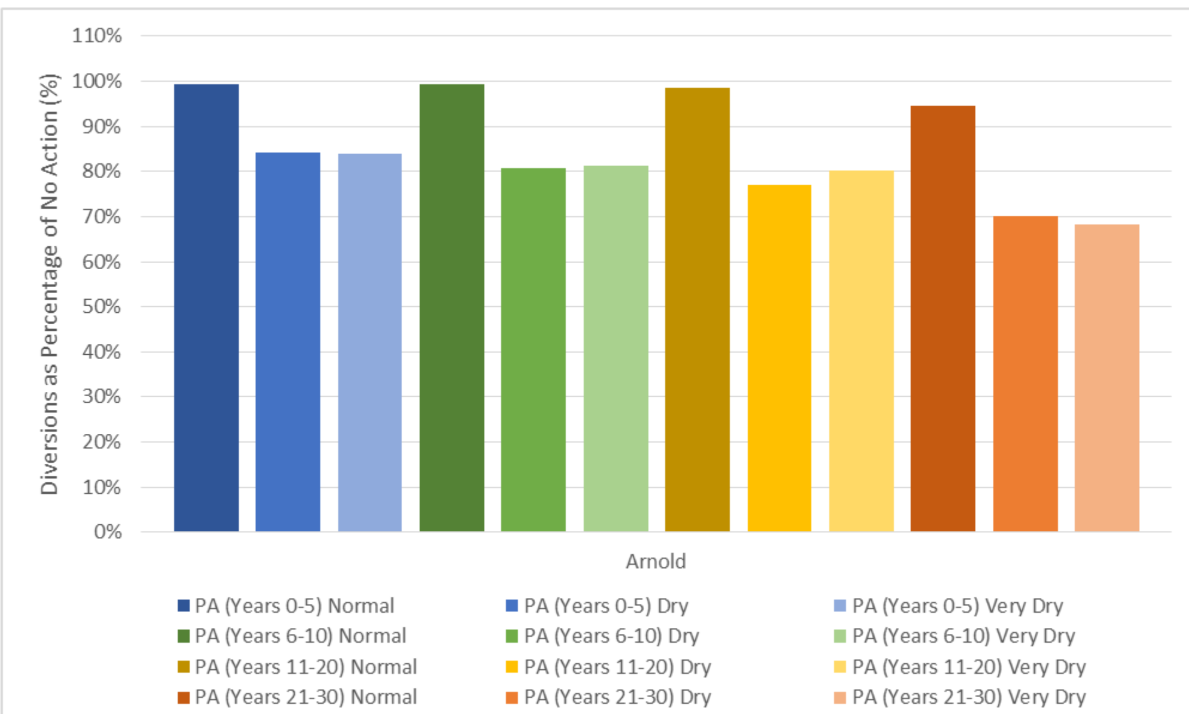


Figure 14. Lone Pine Irrigation District Diversions (April through October) under the Proposed Action as a Percentage of Diversions under the No-Action Alternative

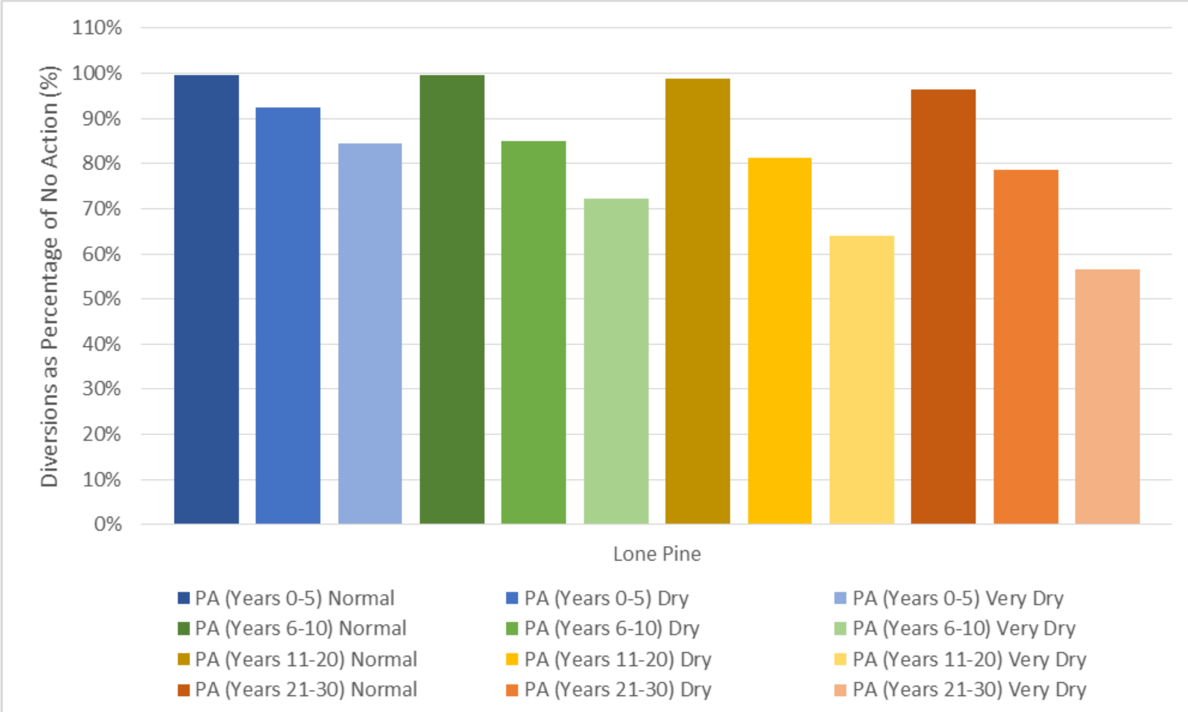


Figure 15. Comparison of Regulation of Lone Pine Irrigation District's Water Rights under the No-Action Alternative and Proposed Action in a Very Dry Water Year during Years 21 through 30 of the Permit Term

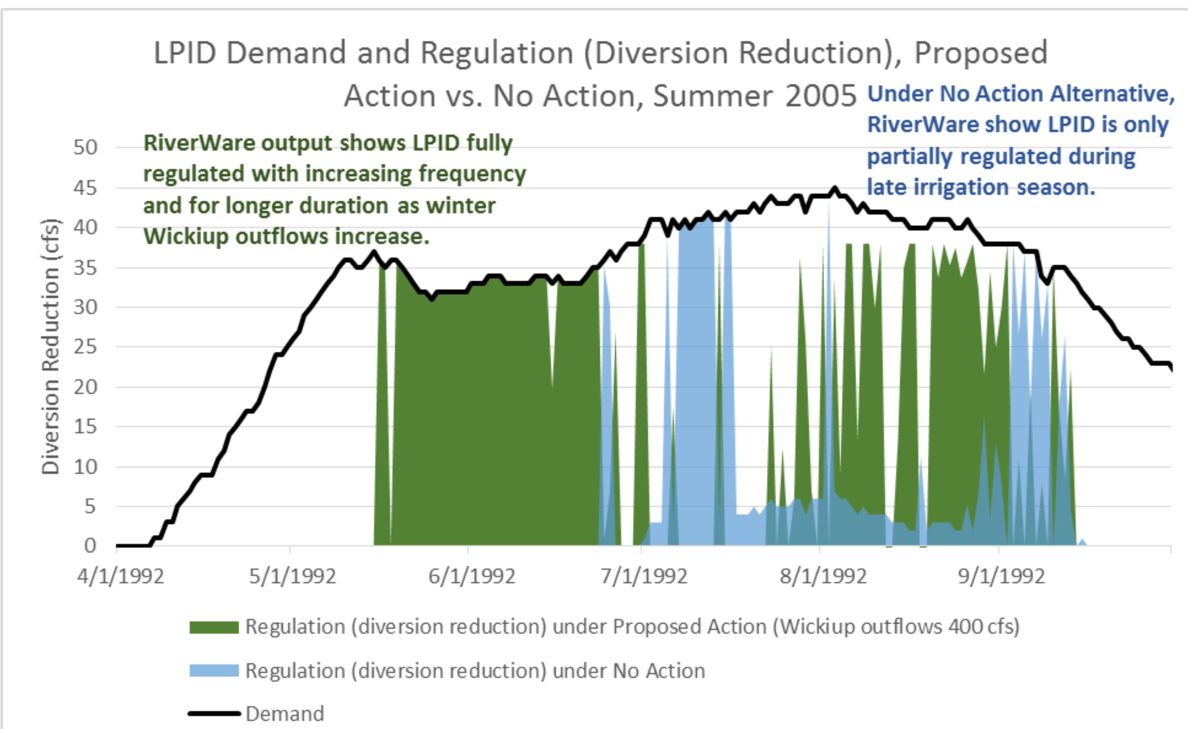


Figure 16. Central Oregon and North Unit Irrigation District Diversions (April through October)—No-Action Alternative and Proposed Action during Years 1 through 5 (100 cfs) and 21 through 30 (400 cfs) of the Permit Term

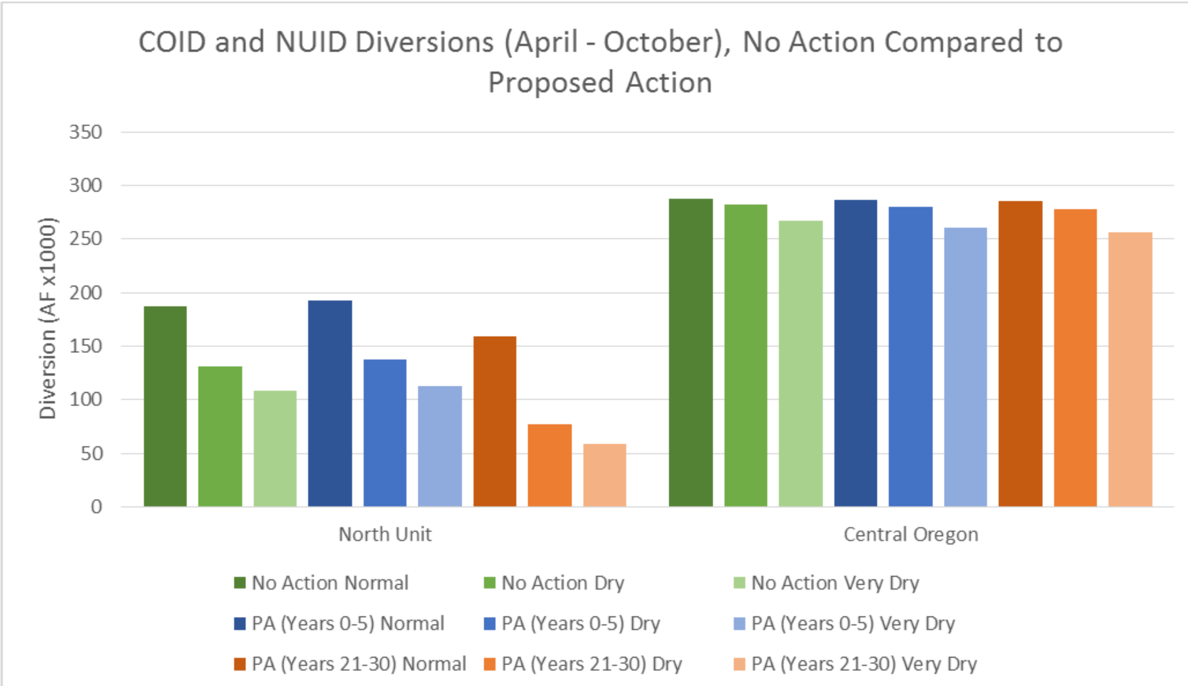
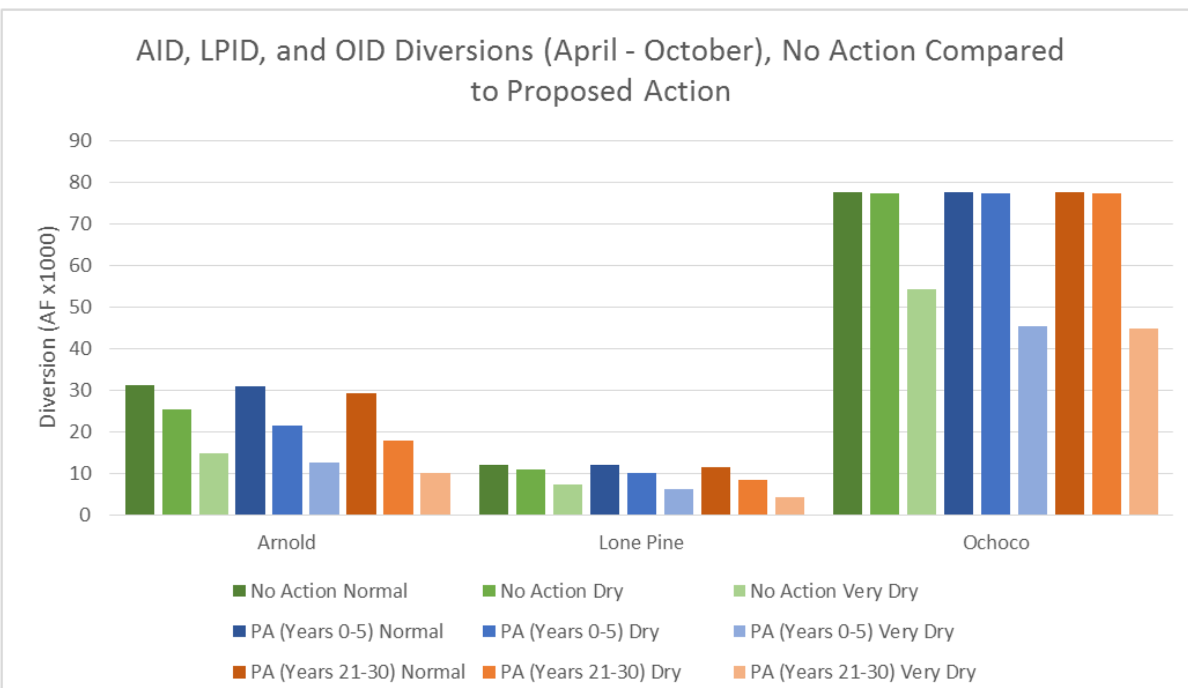


Figure 17. Arnold, Lone Pine, and Ochoco Irrigation District Diversions (April through October)—No-Action Alternative and Proposed Action during Years 1 through 5 (100 cfs) and 21 through 30 (400 cfs) of the Permit Term



Ochoco Irrigation District

Modeling results show that under the proposed action, increased winter releases from Prineville Reservoir, combined with North Unit ID's increased utilization of the Crooked River would result in a reduction of approximately 9,300 af of irrigation water supply for Ochoco ID in a very dry year scenario (Figure 17).

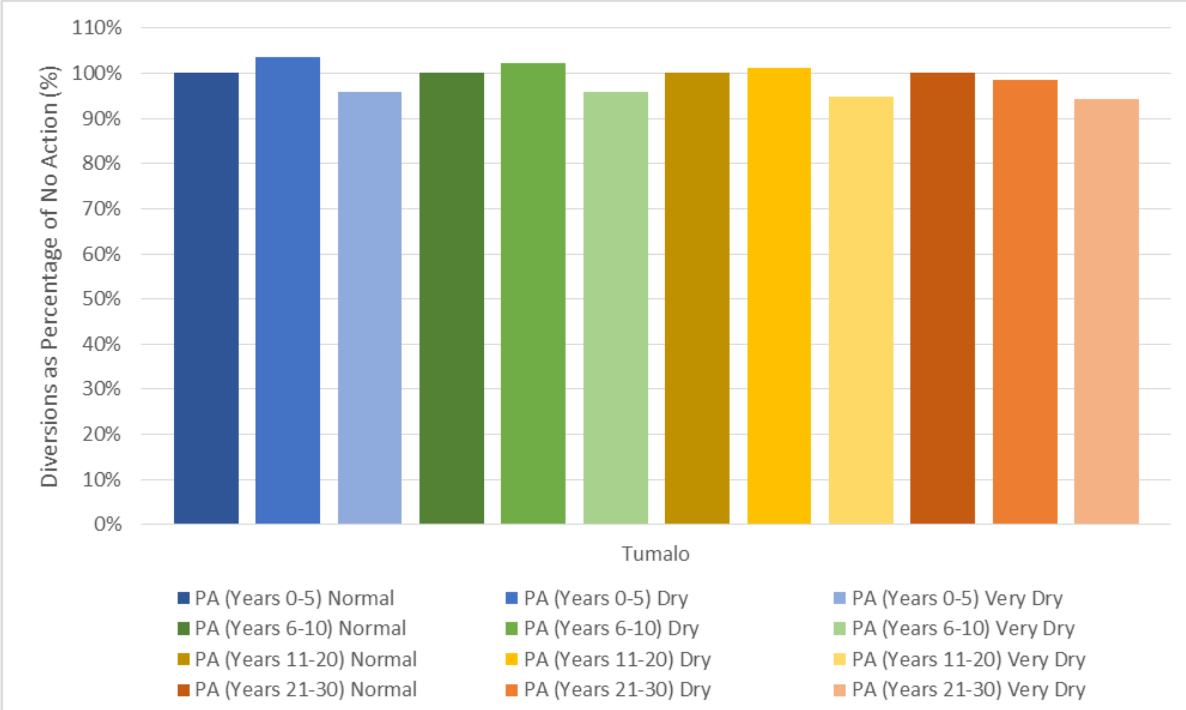
Historical data suggests that bypass flows in Ochoco Creek and McKay Creek under the proposed action could not be maintained without release and spill of additional supply. During times when some part of Ochoco ID's water supply comes from Prineville or Ochoco Reservoir, water released into McKay Creek would at least partly be made up of stored water.

The proposed action also specifies that water protected under temporary instream leases by Ochoco ID patrons with water rights for supplemental stored water in Prineville and Ochoco Reservoirs may be released at any time from February 1 through November 30. This could result in a decline of Prineville and Ochoco Reservoir storage, depending upon the timing of water releases and how instream leases are administered and accounted for. As a result, the proposed action could result in a decline in water supply available to Ochoco ID and other water users.

Tumalo Irrigation District

Overall, the proposed action would increase water supply available to Tumalo ID as a result of decreased minimum winter flows below Crescent Reservoir. Winter releases from Crescent Lake would be reduced from 30 cfs to 20 cfs, increasing Crescent Lake storage and Tumalo ID's supplemental water supply. However, RiverWare generally does not show any increase in Tumalo ID diversions. As described under the no-action alternative, RiverWare does not reflect recent and planned conservation projects that have reduced TID's demand. Although all water conserved through these projects was protected instream through an allocation of conserved water, improvements in operational flexibility are anticipated to alleviate short-term water supply challenges. On average, RiverWare shows Tumalo ID's April through October diversion would increase by up to 1,200 af, except in very dry years, when it would decrease by less than 1,000 af. Over the modeling period, TID's diversion increased in 6 years and decreased in 10 years. Figure 18 shows Tumalo ID diversions under the proposed action (100 through 400 cfs) in normal, dry, and very dry years as a percentage of the diversion under the no-action alternative.

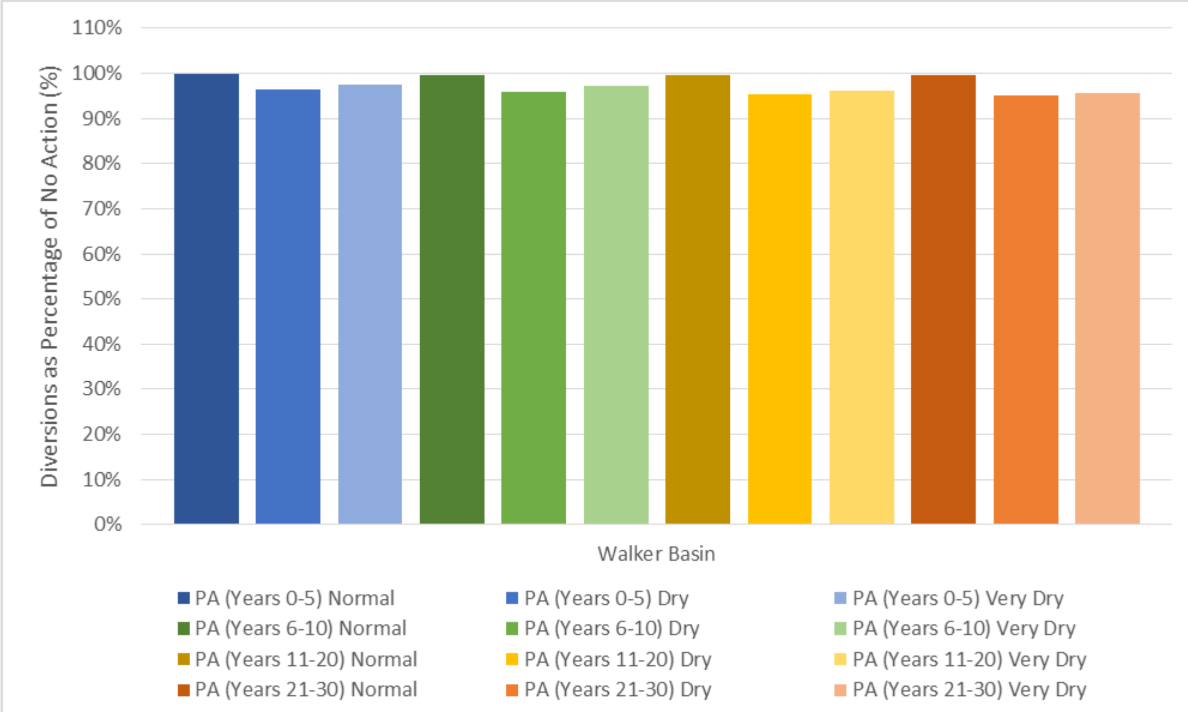
Figure 18. Tumalo Irrigation District Diversions (April through October) under the Proposed Action as a Percentage of Diversions under the No-Action Alternative



Other Deschutes Water Users

RiverWare indicates that the proposed action would result in more frequent regulatory calls on live flow water rights in the Upper Deschutes Basin beginning in year 6, when winter flows below Wickiup Reservoir begin to increase above 100 cfs due to release of stored water. With the reduction in Crane Prairie Reservoir supply for Arnold ID, Lone Pine ID, and Central Oregon ID, it is anticipated that there would be spillover effects on other water users who have historically benefited indirectly from Arnold ID's, Lone Pine ID's, and Central Oregon ID's supply of stored water during dry years. Table 2 shows water rights in the Deschutes Basin above the BENO gauge with priority dates junior to October 31, 1900, who may experience a reduction in water supply due to increased regulatory calls. RiverWare includes modeled diversions for the Walker Basin ditch (also known as La Pine Cooperative Water Association diversion), which has water rights with priorities of 1897, 1900, and 1902. Figure 19 shows diversions under the proposed action (100 through 400 cfs) in normal, dry, and very dry years as a percentage of the diversion under the no-action alternative for the Walker Basin diversion. The proposed action begins to affect Walker Basin diversions beginning in year 6 of the permit term. Due to recent reductions in the acreage irrigated through the Walker Basin diversions, it is unclear whether Walker Basin water supplies will actually be affected.

Figure 19. Walker Basin Diversions (April through October) under the Proposed Action as a Percentage of Diversions under the No-Action Alternative



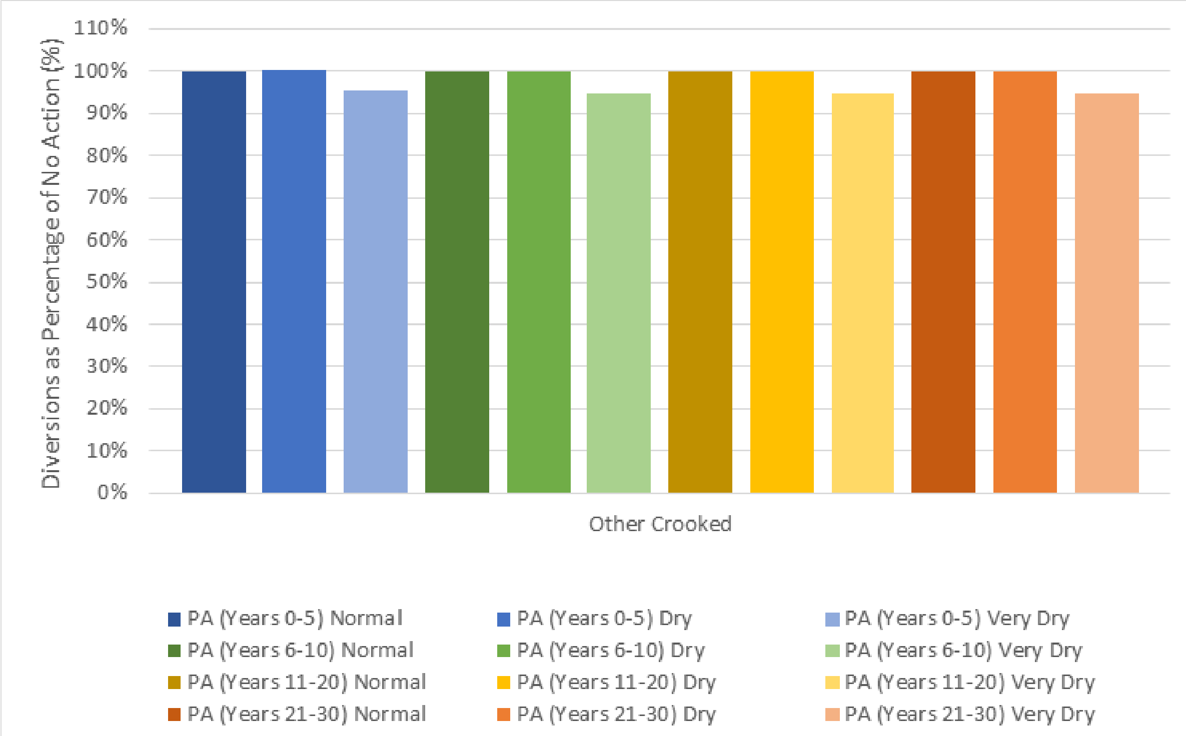
Similarly, while there have been regulatory calls on water rights junior to North Unit ID in previous years, the proposed action would be expected to increase the frequency of regulatory calls, resulting in a reduction in water supply for junior water users in the Upper Deschutes Basin.

Other Crooked River Water Users

Similar to Ochoco ID, increased winter storage releases on the Crooked River and North Unit ID's increased use of the Crooked River, Crooked River water users other than Ochoco ID, including small irrigation districts, private irrigators using shared conveyance systems, and private irrigators with individual diversions,[15] could experience reduced supply in dry or very dry years beginning in year 6 of the permit term. Table 3 lists major diversions between Prineville Reservoir and the North Unit ID Crooked River Pumping Plant. Figure 20 shows diversions under the proposed action (100 through 400 cfs) in normal, dry, and very dry years as a percentage of the diversion under the no-action alternative for of Crooked River water users listed in Table 3, excluding Ochoco and North Unit IDs. The figure shows the change from the no-action alternative to the proposed action in years 1 through 5 of the permit term (to show effects of Conservation Measure CR-1) and years 21 through 30 of the permit term (to show effects of Conservation Measures CR-1 and WR-1 combined) below the WICO gauge. In the worst year for water supply (1992), the effect on Crooked River water users would be a reduction in supply of approximately 5%. RiverWare did not model the impacts on all irrigators, and others with more junior water rights may also be affected by the proposed action.

[15] RiverWare includes modeled diversions for Crooked River irrigators above the Crooked River Feed Canal, Lowline Irrigation District, People's Irrigation District, the Rice Baldwin ditch, and Crooked River Central ditch.

Figure 20. Other Crooked River Irrigator Diversions (April through October) under the Proposed Action as a Percentage of Diversions under the No-Action Alternative



WR-3: Changes in Reservoir Water Surface Elevations and Flood Storage Capacity

This section describes changes in reservoir water surface elevation as it relates to flood storage capacity under the proposed action. Changes in reservoir flood storage capacity are likely to occur in response to reservoir management intended to improve study area habitat for Oregon spotted frog and other species. Modeled reservoir storage volumes and associated water surface elevations for Crane Prairie, Wickiup, Crescent Lake, Prineville, and Ochoco Reservoirs were compared to the 90% total storage capacity of each reservoir (Table 9) during the October through June period (when rain-on-snow and spring runoff floods typically occur) to compare the number of days when the reservoir storage would exceed 90% of flood storage capacity. Modeled data include the median and maximum daily water surface elevations. Exceedance of 90% of reservoir storage capacity was set as the threshold for effect on flood storage capacity. Only Prineville and Ochoco reservoirs have Congressionally-mandated flood control operations. Managers may operate Crane Prairie, Wickiup, and Crescent Lake reservoirs to reduce downstream flood risk, but these reservoirs are not Congressionally-authorized flood control facilities. Although the aforementioned reservoirs are not flood control facilities, changes to reservoir flood storage capacity is reviewed in the context of potential proposed action effects on flood storage.

Table 9. Total and 90% Reservoir Storage Volumes and Elevations for the Covered Reservoirs

	Crane Prairie Reservoir	Wickiup Reservoir	Crescent Lake Reservoir	Prineville Reservoir[1]	Ochoco Reservoir[2]
Total Reservoir Storage Volume (af)	55,300	200,000	86,500	148,633	44,248
Total Reservoir Storage Water Surface Elevation[3](ft)	4,445.00	4,337.65	4,845.43	3,234.80	3,130.70
90% Storage Volume (af)	49,770	180,000	77,850	133,770	39,823
90% Storage Water Surface Elevation (ft)	4,443.86	4,335.79	4,843.21	3,234.80	3,126.41

1 An incomplete station capacity curve is available for Prineville Reservoir. An elevation of 3,234.80 ft is the normal water surface elevation when the outlet works are at capacity.

2 Data provided by Ochoco Irrigation District (B. Scanlon, Ochoco Irrigation District, personal communication, February 5, 2019).

3 Elevations taken from station storage capacity curves posted to OWRD station webpages (OWRD 2018a, 2018b, 2018c, 2018d, 2018e).

af = acre-feet; ft = feet

Crane Prairie Reservoir

By Congressional authorization, Crane Prairie Dam and Reservoir are operated solely for storage of irrigation water. The dam may be operated informally for flood storage in anticipation of abnormally high inflow according to operating rules developed by Reclamation, but only to the extent that flood control does not compromise the storage of irrigation water. There is also a state-imposed minimum instream flow water right of 30 cfs downstream of Crane Prairie Dam.

Crane Prairie Reservoir median water surface elevations over the permit term would be higher during the storage season (November 1 through March 31) and lower through most of the irrigation season (April 1 through October 31) (Figure 21). Increased winter storage would start in October to meet Oregon spotted frog overwintering habitat targets (Conservation Measure CP-1). In contrast to median water surface elevations, maximum water surface elevations would be lower except from September through November, when reservoir storage would be prioritized for Oregon spotted frog overwintering habitat (Figure 22). Average median and maximum water surface elevations would be approximately 0.5 feet higher and 0.5 feet lower, respectively, over the permit term.

Figure 21. Comparison of Monthly Median Water Surface Elevations for Crane Prairie Reservoir (The reference elevation associated with 90% flood storage capacity is 4,443.86 ft [red line]. The 90% flood storage capacity is based on a total reservoir capacity of 55,300 af.)

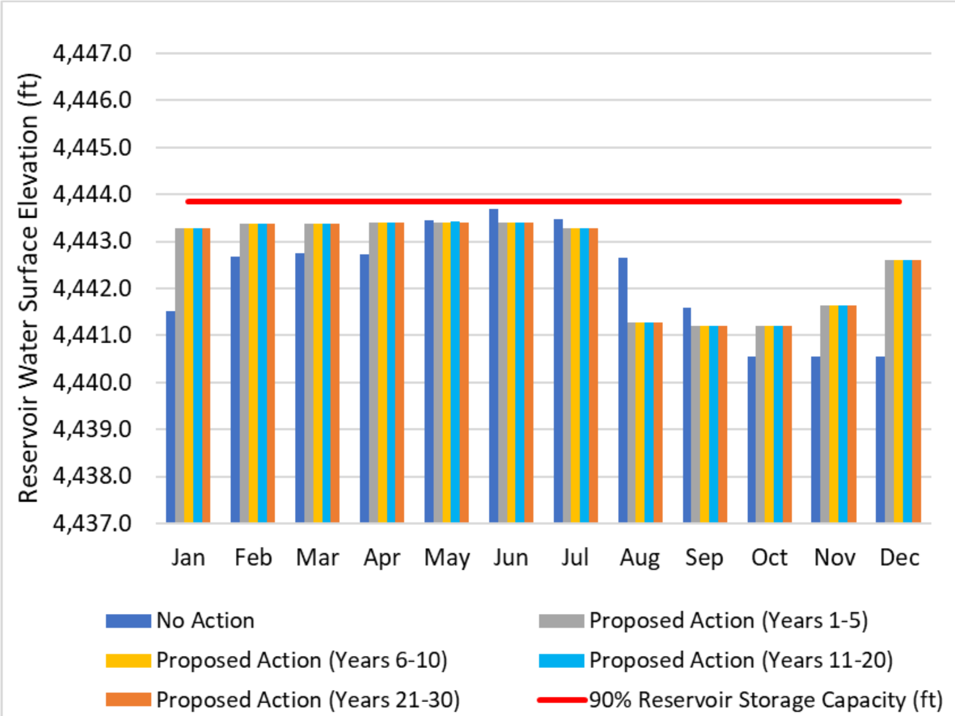
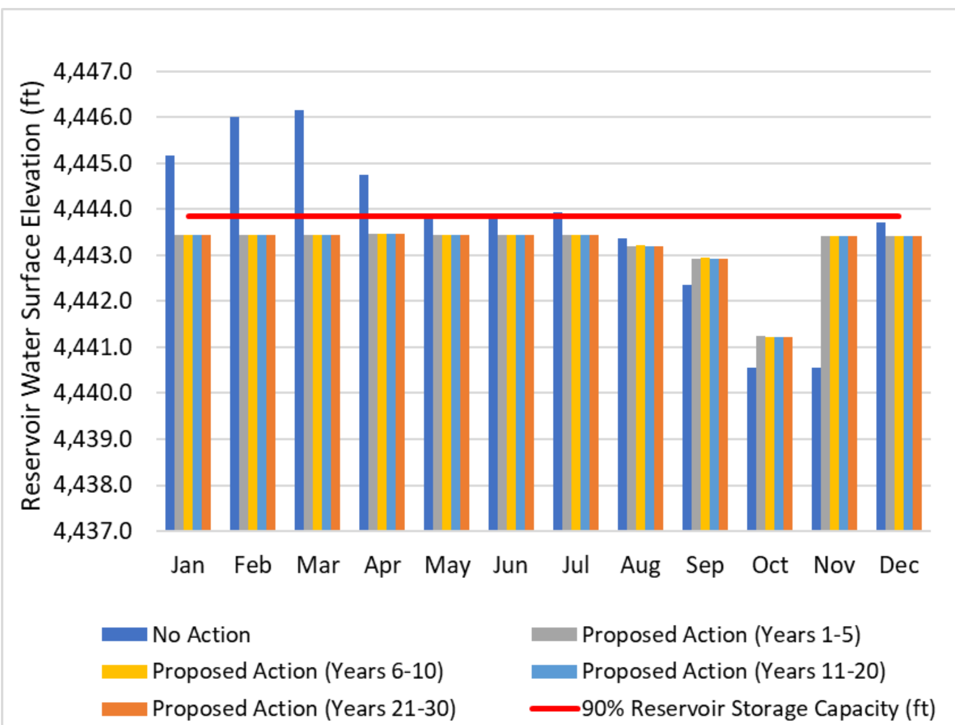


Figure 22. Comparison of Monthly Maximum Water Surface Elevations for Crane Prairie Reservoir (The reference elevation associated with 90% flood storage capacity is 4,443.86 ft [red line]. The 90% flood storage capacity is based on a total reservoir capacity of 55,300 af.)



Wickiup Reservoir

By Congressional authorization, Wickiup Reservoir is operated solely for storage of irrigation water. The dam may be operated informally for flood storage in anticipation of abnormally high inflow according to operating rules developed by Reclamation, but only to the extent that flood control does not compromise the storage of irrigation water.

Wickiup Reservoir would experience the greatest change from increased prioritization of Crane Prairie Reservoir water levels and increased minimum winter instream downstream from Wickiup Dam (Conservation Measures CP-1 and WR-1). These measures would result in Wickiup Reservoir median water surface elevations becoming more variable, especially in years 21 through 30 as less water would be stored year-round compared to earlier periods of the permit term (Figure 23). Median reservoir water surface elevations would, on average, be 16.6 feet lower during the storage season and 20.8 feet lower during the irrigation season. Maximum reservoir water surface elevations are similar with minor water surface elevation increases during July and August (Figure 24).

Figure 23. Comparison of Monthly Median Water Surface Elevations for Wickiup Reservoir (The reference elevation associated with 90% flood storage capacity is 4,335.79 ft [red line]. The 90% flood storage capacity is based on a total reservoir capacity of 200,000 af.)

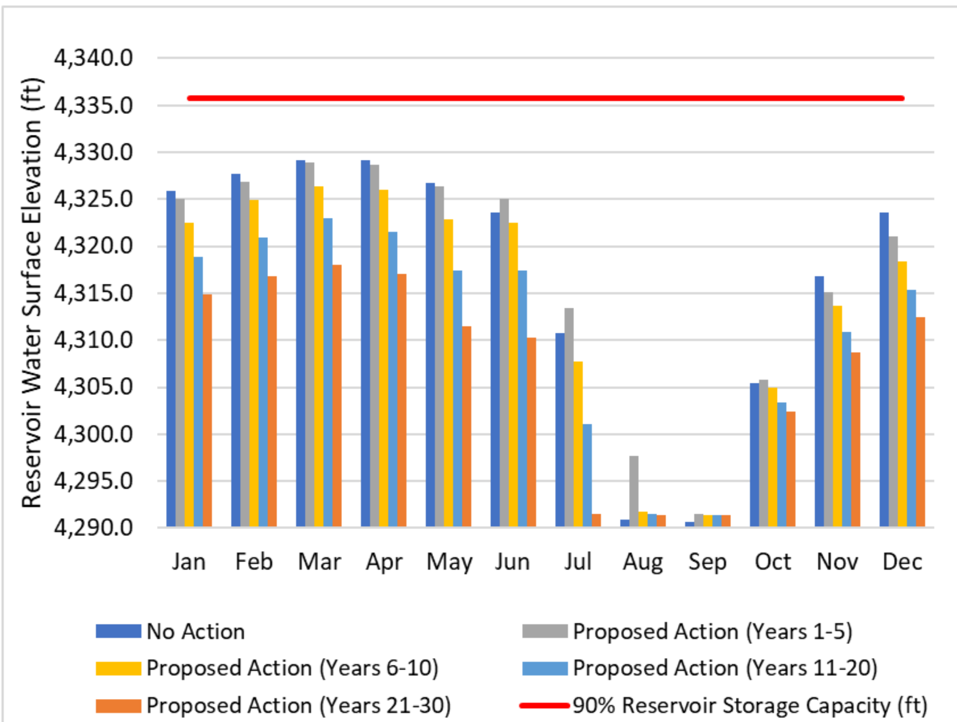
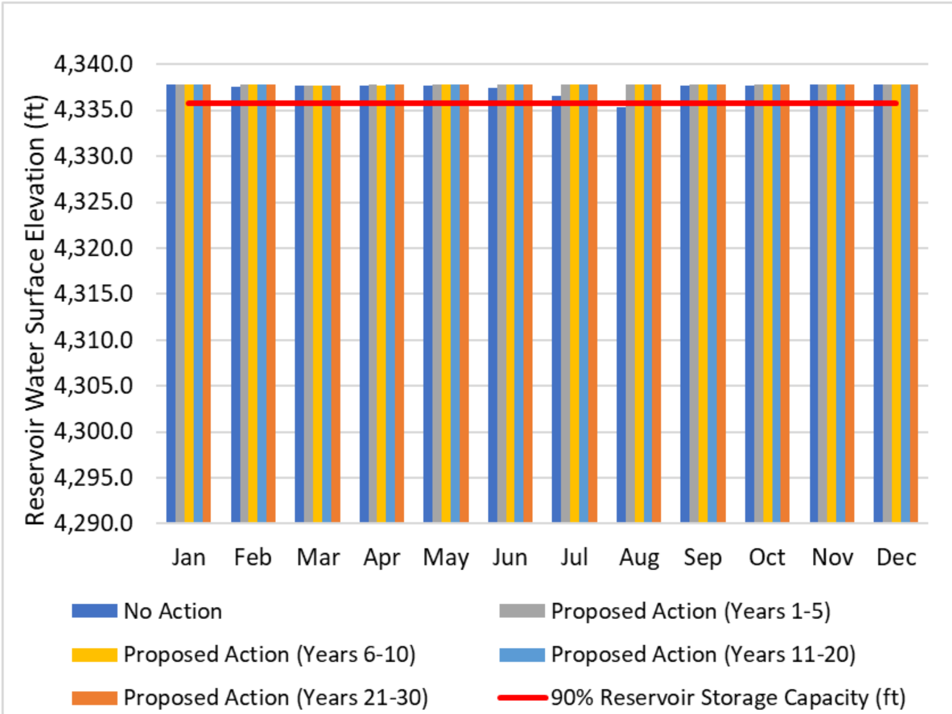


Figure 24. Comparison of Monthly Maximum Water Surface Elevations for Wickiup Reservoir (The reference elevation associated with 90% flood storage capacity is 4,335.79 ft [red line]. The 90% flood storage capacity is based on a total reservoir capacity of 200,000 af)



Crescent Lake Reservoir

Crescent Lake Reservoir would experience higher median water surface elevations due to lower minimum flows downstream from Crescent Lake Dam from March 15 through November 30 (Conservation Measure CC-1) (Figure 25). Water surface elevation differences relative to the no-action alternative would be greatest during the storage season, and least during irrigation season when water is released to meet irrigation demand. There would be minor differences in median water surface elevations over the permit term. Maximum water surface elevations follow a similar pattern to median water surface elevations, although maximum water surface elevation differences between the no-action and proposed action would be less (Figure 26). Average median and maximum water surface elevations would be approximately 0.7 feet higher and 0.5 feet higher, respectively, over the permit term.

Figure 25. Comparison of Monthly Median Water Surface Elevations for Crescent Lake Reservoir (The reference elevation associated with 90% flood storage capacity is 4,843.21 ft [red line]. The 90% flood storage capacity is based on a total reservoir capacity of 86,500 af.)

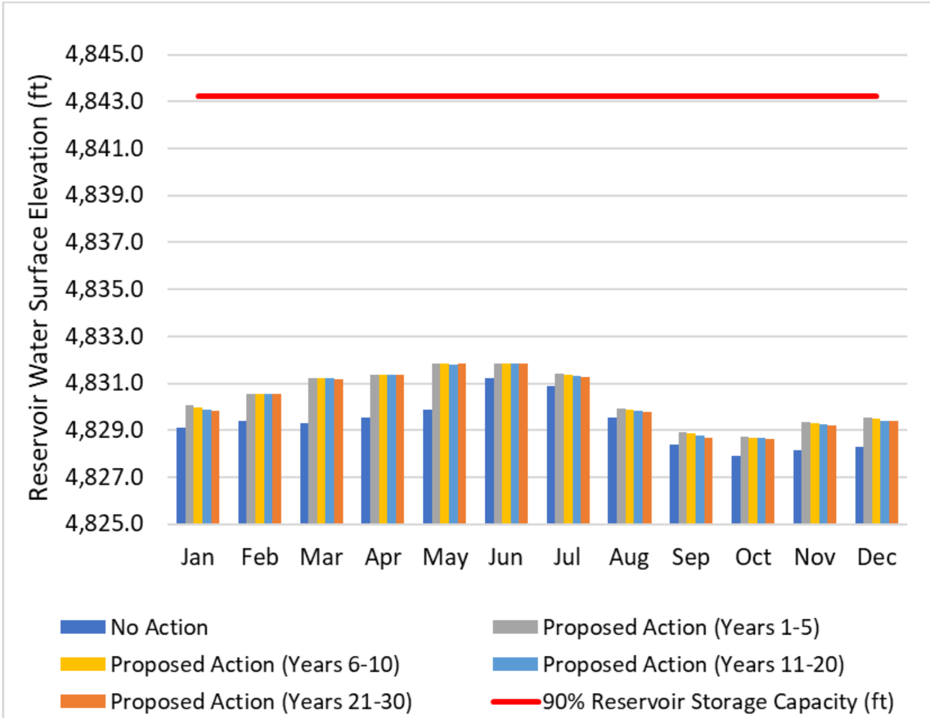
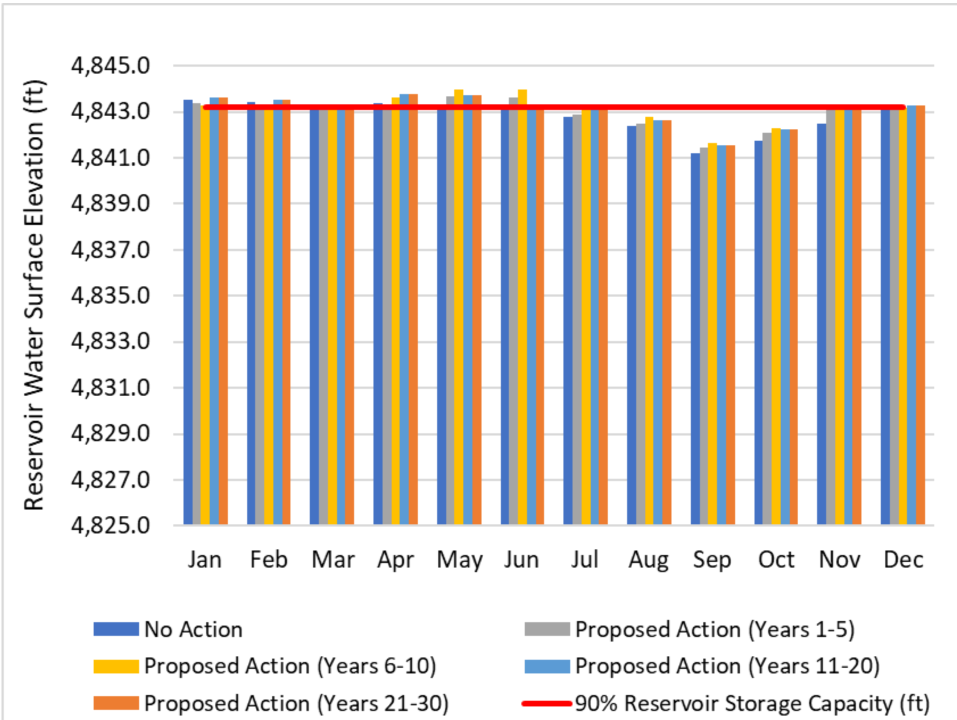


Figure 26. Comparison of Monthly Maximum Water Surface Elevations for Crescent Lake Reservoir (The reference elevation associated with 90% flood storage capacity is 4,843.21 ft [red line]. The 90% flood storage capacity is based on a total reservoir capacity of 86,500 af.)



Prineville Reservoir

Ochoco Reservoir and Prineville Reservoir are managed jointly for irrigation and flood control. Reservoir filling is based on Reclamation runoff forecasts and guided by USACE's rule curves to balance demands for irrigation and flood control. At least 16,500 af of evacuated space (flood storage capacity) are retained in Ochoco Reservoir from November 15 through January 31, and at least 60,000 af of flood storage capacity are retained in Prineville Reservoir from November 15 through February 15. After these dates, additional storage occurs according to established rule curves to limit flood flows to 3,000 cfs downstream from Prineville Reservoir and 1,100 cfs downstream from Ochoco Reservoir. Both reservoirs typically reach annual maximum storage elevations during April or May (Deschutes Basin Board of Control and City of Prineville 2019).

Prineville Reservoir would experience similar median water surface elevations late in winter storage (January through March), but lower median water surface elevations would occur through irrigation season and early in winter storage (Figure 27). Lower median reservoir water surface elevations primarily beginning in year 11 of the permit term, would result from releasing stored water to meet North Unit ID's water needs and meeting minimum instream flow requirements downstream from Prineville Reservoir (Conservation Measure CR-1). Maximum reservoir water surface elevations would be similar except in late winter, when the proposed action water surface elevations would be lowered to meet minimum flow requirements downstream from Bowman Dam (Figure 28). Average median and maximum water surface elevations would be approximately 0.6 feet lower and 0.1 feet lower, respectively, over the permit term.

Figure 27. Comparison of Monthly Median Water Surface Elevations for Prineville Reservoir (The reference elevation associated with the outlet works is 3,234.80 ft [red line]. The 90% flood storage capacity is based on a total reservoir capacity of 148,633 af.)

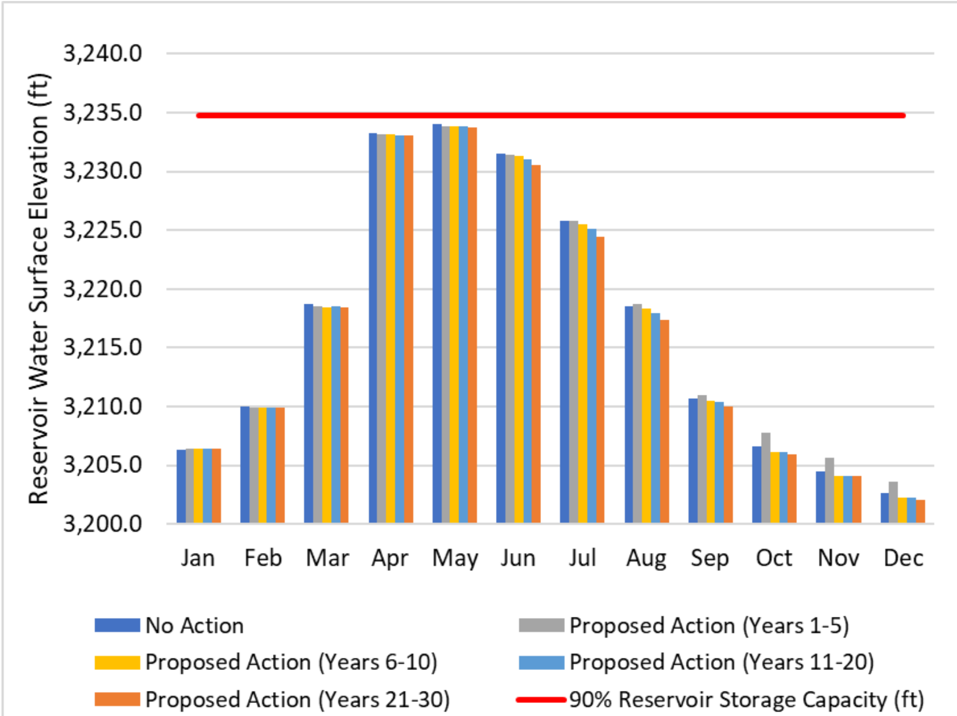
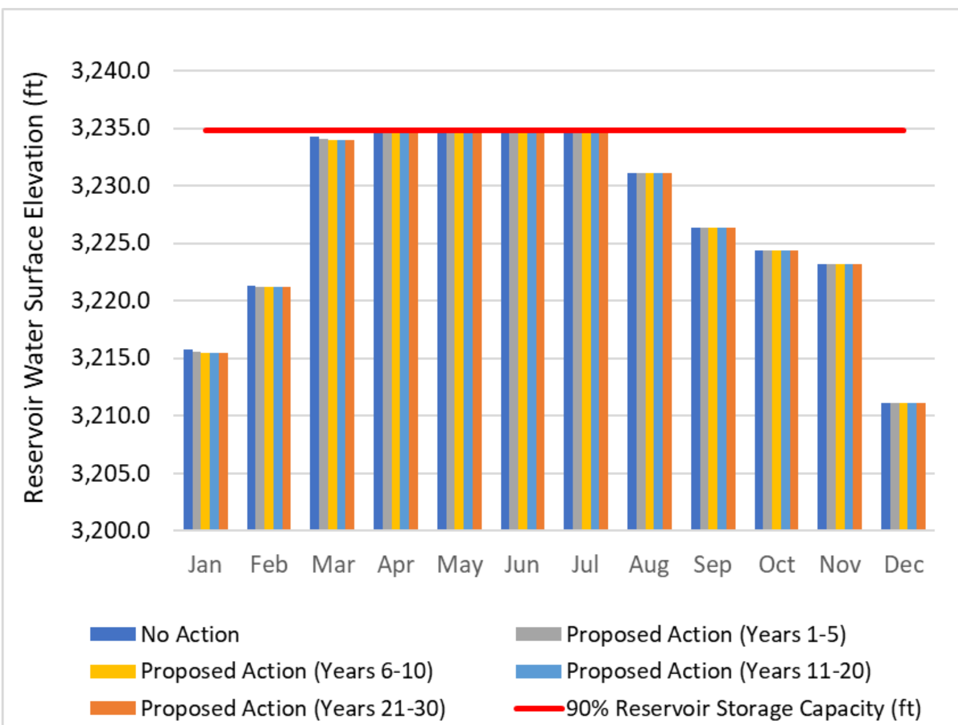


Figure 28. Comparison of Monthly Maximum Water Surface Elevations for Prineville Reservoir. (The reference elevation associated with the outlet works is 3,234.80 ft [red line]. The 90% flood storage capacity is based on a total reservoir capacity of 148,633 af.)



Ochoco Reservoir

Ochoco Reservoir median and maximum water surface elevations would be similar to the no-action alternative over the permit term. Conservation Measures CR-2, CR-3, and CR-4 would have minimal influence over median (Figure 29) and maximum (Figure 30) reservoir water surface elevations. Modeling results suggest there would be no difference in the proposed action's average median and maximum water surface elevations over the permit term.

Figure 29. Comparison of Monthly Median Water Surface Elevations for Ochoco Reservoir (The reference elevation associated with the outlet works is 3,130.06 ft [red line]. The 90% flood storage capacity is based on a total reservoir capacity of 44,248 af.)

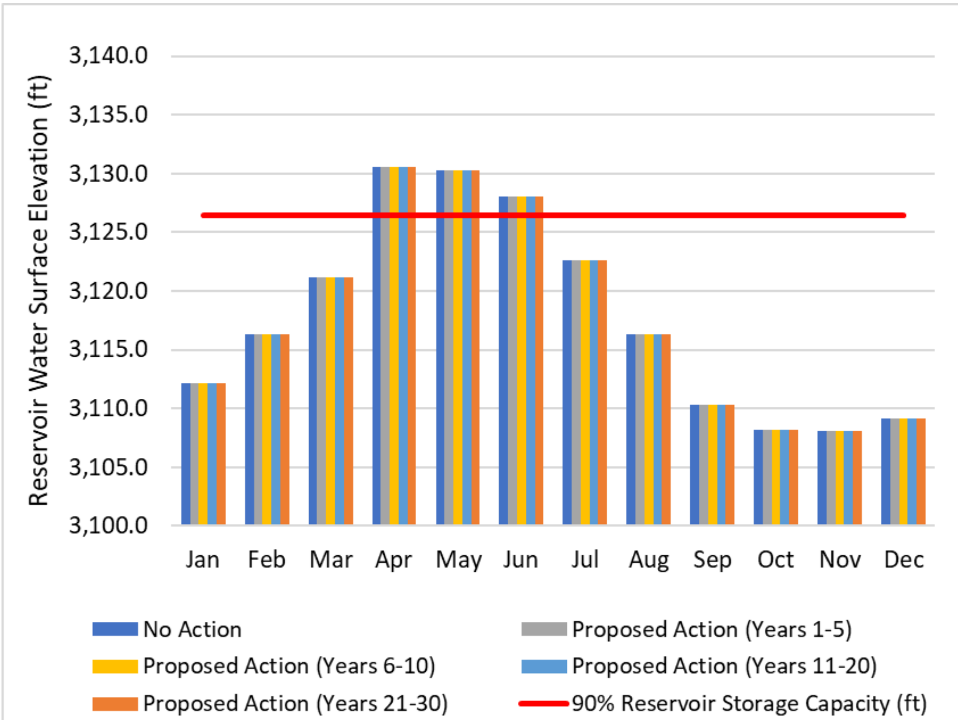
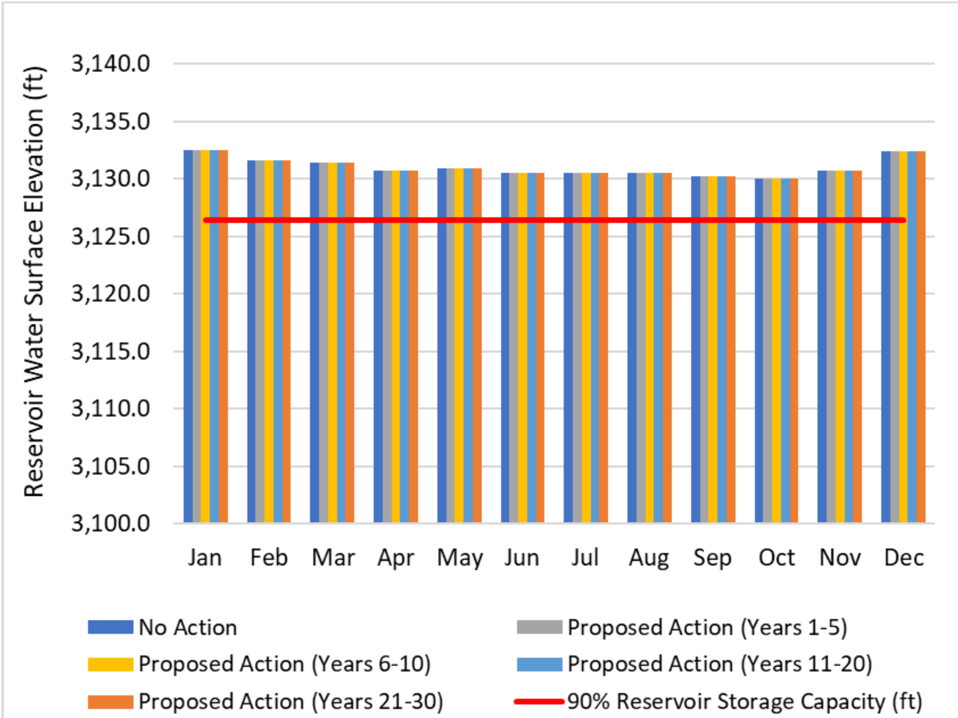


Figure 30. Comparison of Monthly Maximum Water Surface Elevations for Ochoco Reservoir (The reference elevation associated with the outlet works is 3,130.06 ft [red line]. The 90% flood storage capacity is based on a total reservoir capacity of 44,248 af.)



WR-4: Changes in Seasonal River and Creek Flow

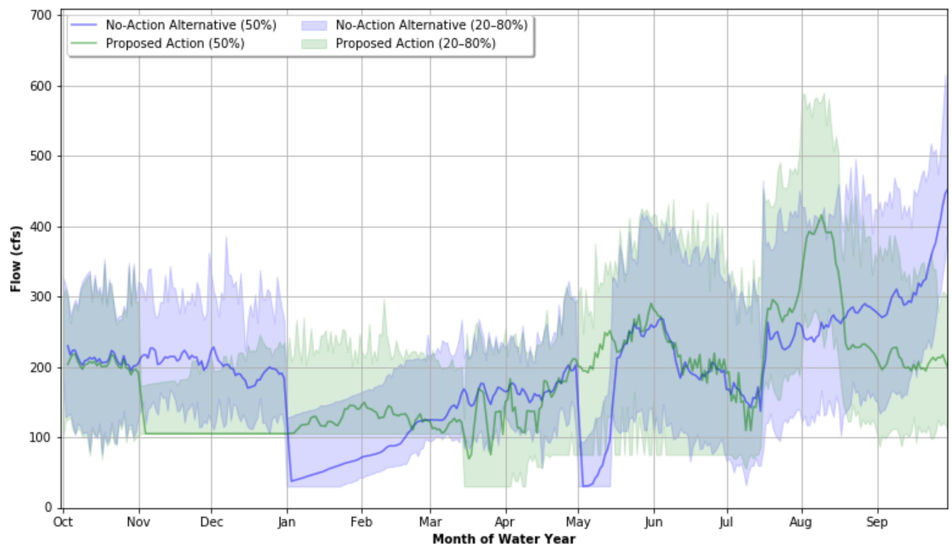
Seasonal river and creek flows in the study area would generally respond to changes in the proposed action's water management regime. Anticipated changes include higher winter flows on the Upper Deschutes River and Crooked River in response to higher minimum winter flows in both rivers. Conversely, irrigation period flows will decrease due to the reduction in reservoir storage associated with the increasing minimum flows in winter. Although the analysis includes wet, normal, an dry years, additional evaluation was completed for normal and dry years since these are periods when water availability may be limited.

Deschutes River from Crane Prairie Reservoir to Wickiup Reservoir

Implementation of Conservation Measures CP-1 and WR-1 would cause a more variable flow regime in this reach. Conservation Measure CP-1 would establish a minimum year-round instream flows that are subordinate in priority to maintaining consistent storage in Crane Prairie Reservoir. The minimum instream flow target of 75 cfs is less than the no-action alternative target of 100 cfs (January through August) and the same as the 75 cfs target established for September through December under the no-action alternative.

Generally, flows at the CRAO gauge downstream from Crane Prairie Reservoir would be higher during five months of the year (January through February, the first half of May, and then mid-July through mid-August), lower during six months of the year (November through December, mid-March through mid-April, and mid-August through the end of September), and similar during three months of the year (October and mid-May to mid-July) (Figure 31). Minimum flow requirements for the Deschutes River downstream from Wickiup Reservoir would not affect flow levels in this reach since water surface elevations in Crane Prairie Reservoir are prioritized for Oregon spotted frog habitat.

Figure 31. The Deschutes River Hydrograph for Years 1–5 (upper) and Years 21–30 (lower) of the Proposed Action Based on Modeled Flows at the CRAO Gauge between Crane Prairie Reservoir and Wickiup Reservoir (Figures show the median flow and 20 to 80% flow range for the no-action alternative and proposed action.)



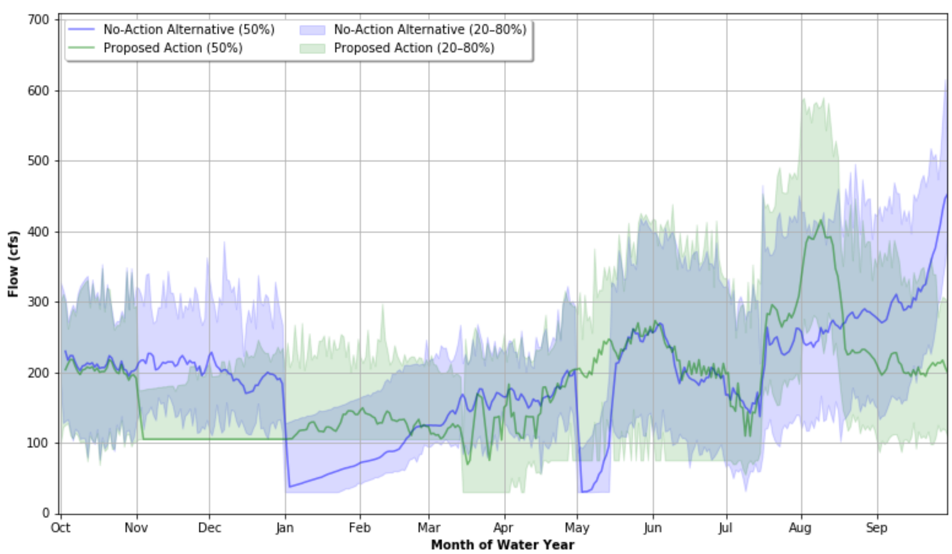


Table 10 includes a comparison of seasonal differences in minimum and maximum median flows for the permit term based on RiverWare output for the CRAO gauge. The proposed action has higher minimum and lower maximum median flows during the winter and irrigation periods. Minimum and flows remain consistent through the permit term. The proposed action's narrower range between minimum and maximum flows suggests less variable outflows from Crane Prairie Reservoir since reservoir storage would be managed to meet Oregon spotted frog habitat goals.

Table 10. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Deschutes River between Crane Prairie Reservoir and Wickiup Reservoir by Season for the No-Action Alternative and Proposed Action over the Permit Term

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	Minimum (cfs)	Maximum (cfs)	Minimum (cfs)	Maximum (cfs)
No-Action	60.0	212.7	130.7	335.3
Proposed Action (Years 1–5)	105.0	133.4	171.3	304.9
Proposed Action (Years 6–10)	105.0	133.4	171.3	304.9
Proposed Action (Years 11–20)	105.0	133.4	173.3	303.9
Proposed Action (Years 21–30)	105.0	133.4	171.7	303.9

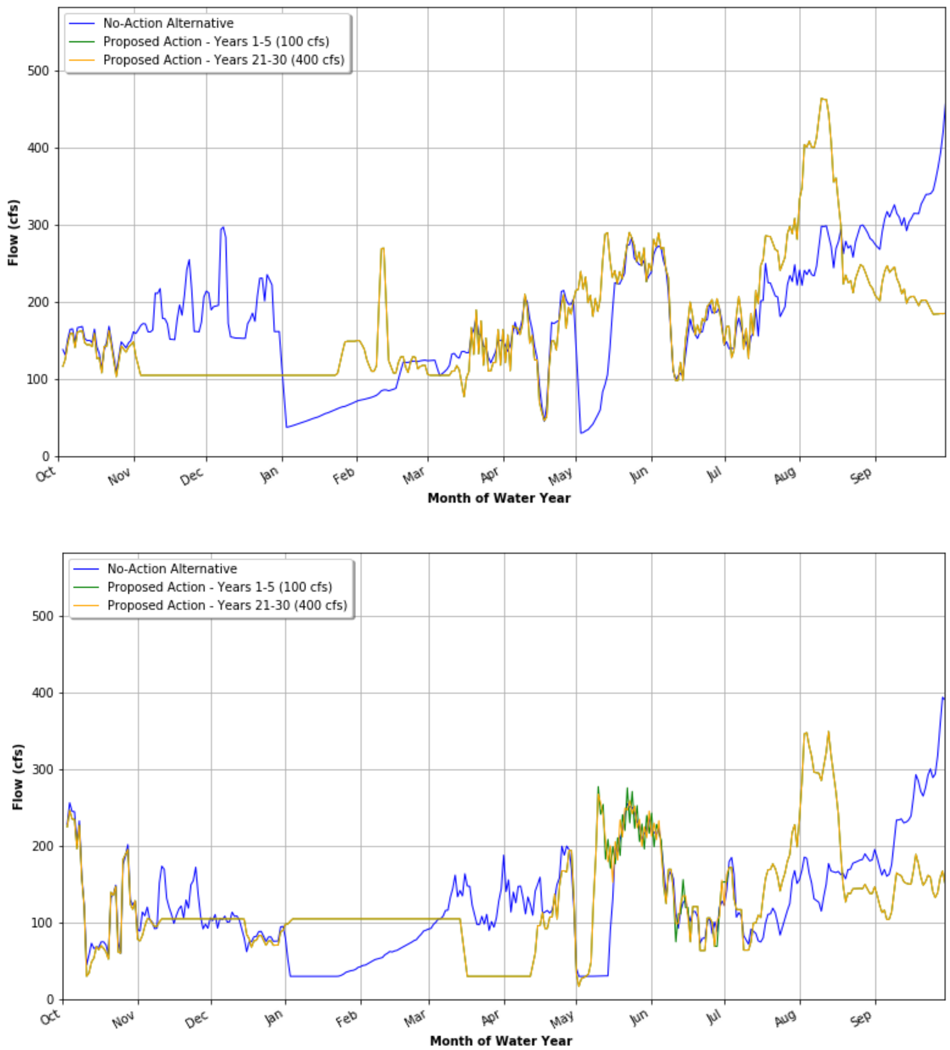
Total monthly streamflow volume (af) for representative wet, normal, and dry years was evaluated to assess changes in seasonal streamflow. Proposed action results are presented as the percent difference from the no-action alternative (Table 11). Total streamflow volume decreases from 2% to 5% from a wet year to a dry year in years 21 through 30 compared to the no-action alternative. Winter storage period flows are variable, decreasing by 9% for wet and dry years, and decreasing by 17% in a normal year. Irrigation period flows are 2% and 3% greater in wet and normal years, respectively in years 21 through 30 of the permit term, but are 3% lower in dry years. Dry year flows are least variable while wet year flows are the most variable. Flow differences remain the same over the permit term for each of the water year types.

Table 11. Percent Differences in Streamflow Volume between the No-Action Alternative and Proposed Action for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Normal and Dry Years at the CRAO Gauge

		Proposed Action			
Water Year Type	Time Period	Years 1–5	Years 6–10	Years 11–20	Years 21–30
Wet	Irrigation Period	2%	2%	2%	2%
	Winter/Storage Period	-9%	-9%	-9%	-9%
	Annual	-2%	-2%	-2%	-2%
	1 SD	21%	21%	21%	21%
Normal	Irrigation Period	3%	3%	3%	3%
	Winter/Storage Period	-17%	-17%	-17%	-17%
	Annual	-3%	-3%	-3%	-3%
	1 SD	-6%	-6%	-6%	-6%
Dry	Irrigation Period	-3%	-3%	-3%	-3%
	Winter/Storage Period	-9%	-9%	-9%	-9%
	Annual	-5%	-5%	-5%	-5%
	1 SD	-28%	-28%	-28%	-28%

Figure 32 includes the representative normal and dry year hydrographs for the CRAO gauge under the proposed action in years 21 through 30 of the permit term. Proposed action flows increase from mid-July through mid-August and then decrease as Crane Prairie Reservoir filling begins in mid-August. In a dry year, the proposed action reaches minimum flow levels between mid-March and mid-May, likely in response to low reservoir elevations and the need to minimize reservoir fluctuations. Increasing flows beginning in mid-July take place after the Oregon spotted frog reservoir water surface prioritization time period for Crane Prairie Reservoir, and to meet downstream irrigation demand. Flows less than 100 cfs in the dry year hydrograph indicate the reservoir volume is below fill targets and therefore, less flow is released from Crane Prairie Reservoir. Anticipated normal year peak flows exceed the 400 cfs maximum flow criterion for a short period in early August.

Figure 32. The Deschutes River Hydrograph for the No-Action Alternative and Proposed Action in Years 1–5 and Years 21–30 in Representative Normal (upper) and Dry (lower) Years at the CRAO Gauge

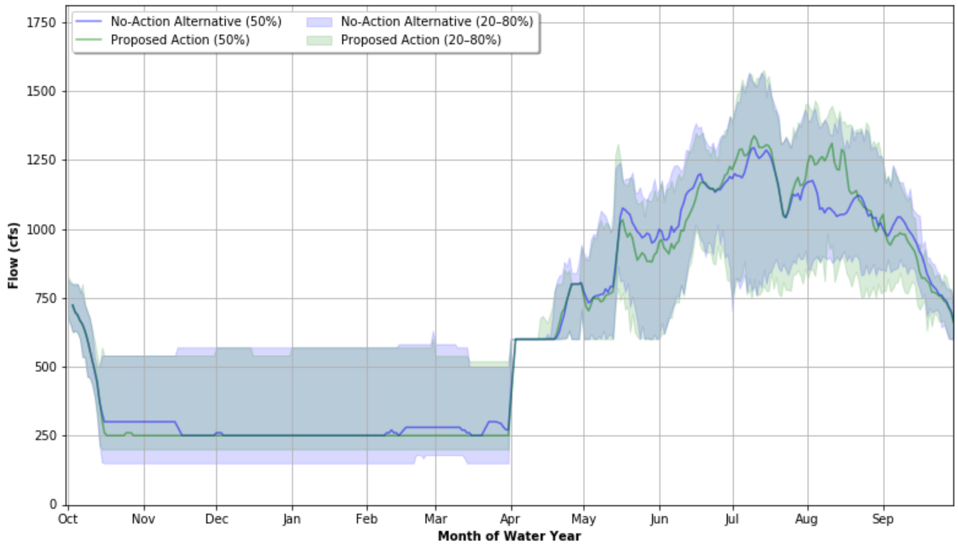


Deschutes River from Wickiup Dam to the Little Deschutes River

Conservation measures for the Deschutes River downstream from Wickiup Dam (Conservation Measure WR-1) are intended to increase minimum winter and spring flows downstream from the dam. The no-action alternative and proposed action in years 1 through 5 of the permit term would have a similar influence on flow levels at the WICO gauge downstream from Wickiup Dam. Increasing minimum flows to 400 cfs in years 21 through 30 of the permit term, would increase flows during the winter storage season and decrease instream flows during the irrigation season (Figure 33). In years 21 through 30, there would be higher median flows from mid-October through

April, and lower median flows during the irrigation season due to less stored water availability due to higher winter minimum flows.

Figure 33. The Deschutes River Hydrograph for Years 1–5 (upper) and Years 21–30 (lower) of the No-Action Alternative and Proposed Action Based on Modeled Flows at the WICO Gauge Downstream from Wickiup Reservoir (Figures show the median flow and 20 to 80% flow range for the alternatives.)



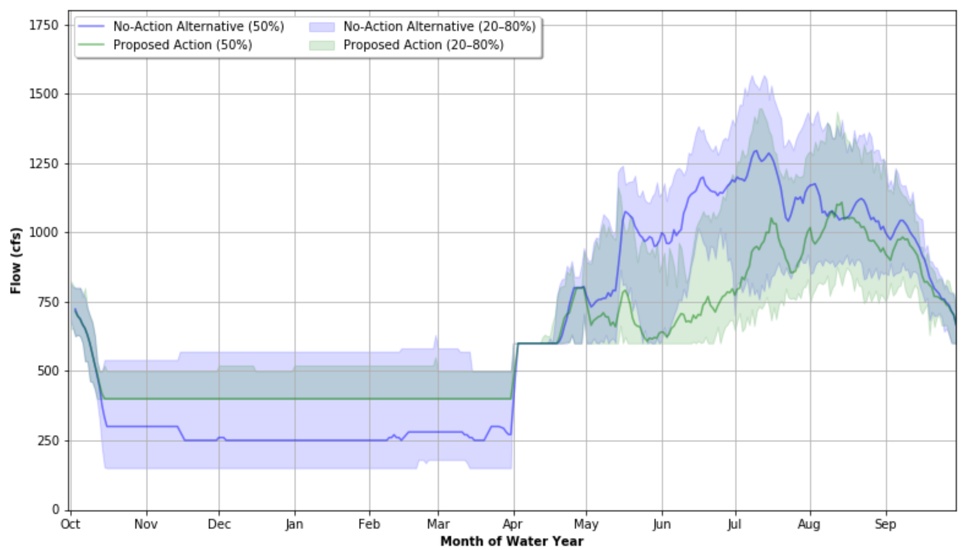


Table 12 includes a comparison of seasonal differences in minimum and maximum median flows based on WICO gauge data. The proposed action beginning in year 6 would have higher minimum and maximum median flows during winter as minimum flows increase over the permit term. Conversely, maximum irrigation period flows decrease over the permit term in response to reduced reservoir storage due to the higher winter flow releases from Wickiup Reservoir.

Table 12. Comparison of Minimum And Maximum Median (50%) Daily Flows on the Deschutes River Downstream from Wickiup Reservoir by Season for the No-Action Alternative and Proposed Action over the Permit Term

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	Minimum (cfs)	Maximum (cfs)	Minimum (cfs)	Maximum (cfs)
No-Action	250.0	280.0	500.0	1,181.4
Proposed Action (Years 1–5)	250.0	250.0	500.0	1,212.4
Proposed Action (Years 6–10)	300.0	300.0	500.0	1,112.8
Proposed Action (Years 11–20)	350.0	350.0	500.0	1,034.6
Proposed Action (Years 21–30)	400.0	400.0	500.0	1,005.2

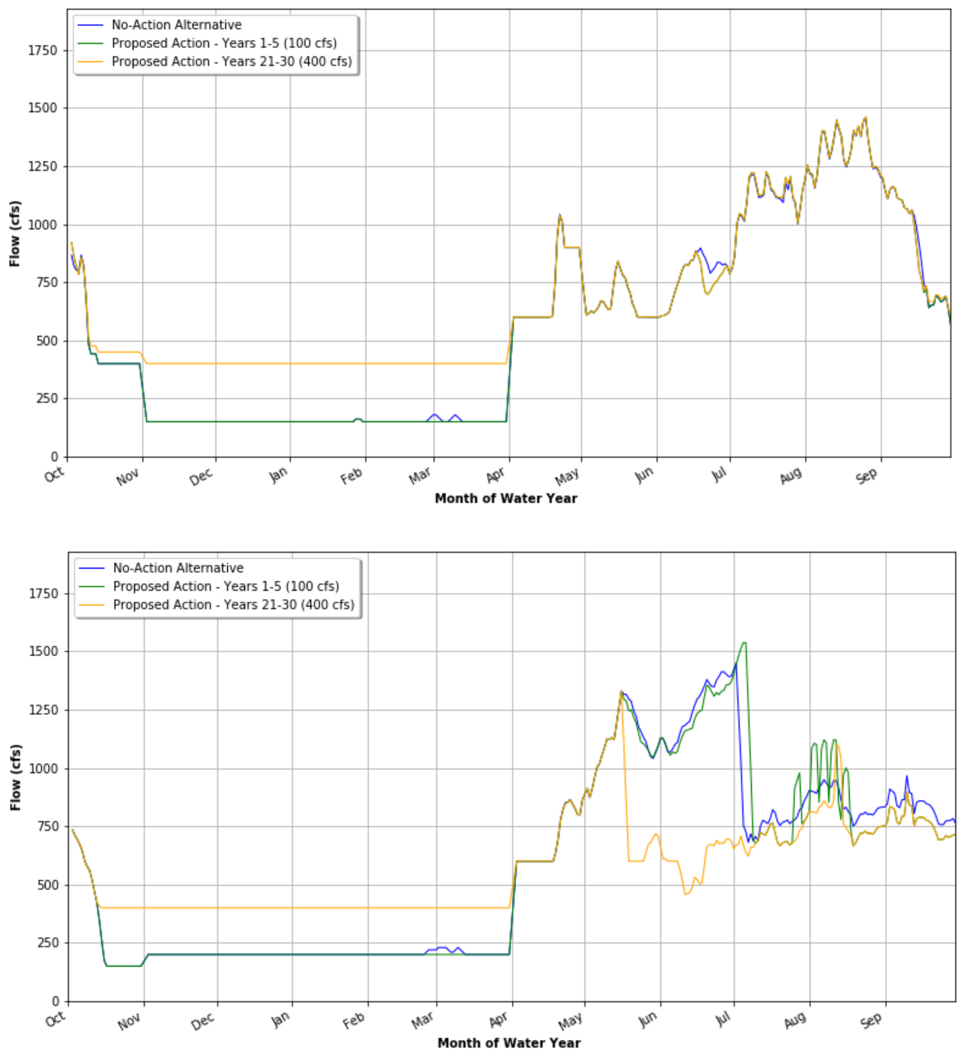
Total monthly streamflow volume (af) for representative wet, normal, and dry years was evaluated to assess changes in seasonal streamflow. Proposed action results are presented as the percent difference from the no-action alternative (Table 13). Total streamflow volume is 4% greater in wet and normal years, relative to the no-action alternative, and the same in a dry year. Streamflow during the winter storage period in a wet year and normal year is 20% and 26% greater, respectively, compared to the no-action alternative. In a dry year, winter storage flows increase substantially over the permit term and in years 21 through 30, flows are 120% greater than the no-action alternative winter storage flows. Irrigation period flows have a contrasting trend to the winter storage flows, with irrigation period flows ranging from a 1% decrease over the no-action in a wet year, to a 17% decrease in a dry year. Minimum winter flow releases have the greatest effect on dry year irrigation period releases. Monthly flows are also less variable under the proposed action with decreasing variability from a wet year to a dry year.

Table 13. Percent Differences in Streamflow Volume between the No-Action Alternative and Proposed Action for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years at the WICO Gauge

Water Year Type	Time Period	Proposed Action			
		Years 1–5	Years 6–10	Years 11–20	Years 21–30
Wet	Irrigation Period	-8%	-1%	-1%	-1%
	Winter/Storage Period	-10%	10%	15%	20%
	Annual	-9%	2%	3%	4%
	1 SD	2%	-6%	-9%	-11%
Normal	Irrigation Period	-2%	-2%	-1%	-2%
	Winter/Storage Period	3%	7%	14%	26%
	Annual	-1%	0%	2%	4%
	1 SD	0%	-7%	-11%	-16%
Dry	Irrigation Period	0%	-5%	-13%	-17%
	Winter/Storage Period	10%	37%	81%	120%
	Annual	1%	1%	0%	0%
	1 SD	-3%	-15%	-35%	-54%

Figure 34 includes the representative normal and dry year hydrographs for the WICO gauge under the proposed action in years 21 through 30 of the permit term. Hydrographs for representative normal and dry years have similar patterns with the proposed action daily flows higher from mid-October through March 31, similar from April 1 through mid-May, and then lower from mid-May through mid-July. The dry year hydrograph shows a similar pattern but a greater difference compared to the no-action during the irrigation season. In the dry year hydrograph, flows drop below 800 cfs in mid-May as inflows and storage in Wickiup Reservoir are insufficient to maintain a 800 cfs flow downstream of Wickiup Dam.

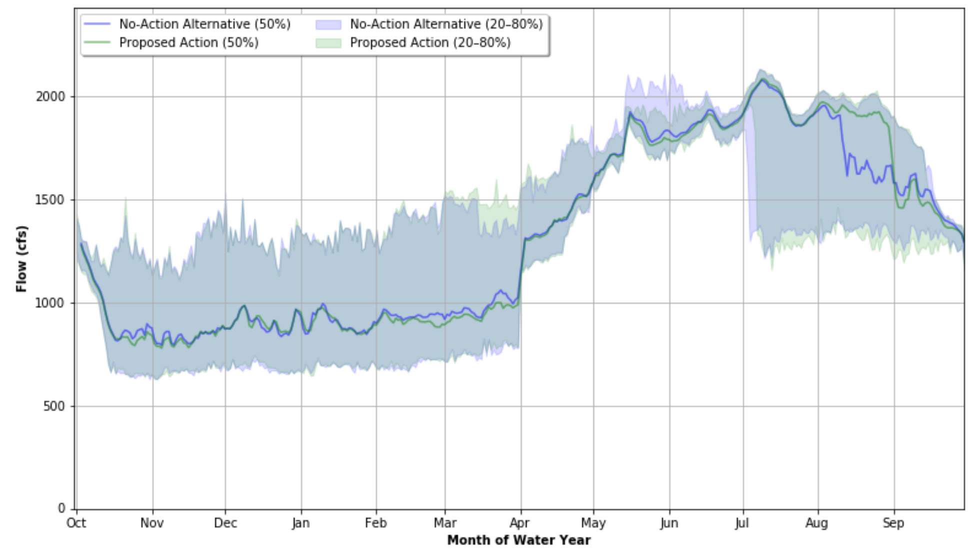
Figure 34. The Deschutes River Hydrograph for the No-Action Alternative and Proposed Action in Years 1–5 and Years 21–30 in Representative Normal (upper) and Dry (lower) Years at the WICO Gauge



Deschutes River from the Little Deschutes River to Benham Falls

Implementation of Conservation Measures WR-1 influences flows in the Little Deschutes River to Benham Falls reach. Generally, flows are similar between the proposed action in years 1 through 5, and the no-action alternative as the reservoir management rules are similar (Figure 35). In later periods of the permit term, streamflow at the BENO gauge illustrates the effects of higher minimum winter storage flows. Although this trend is apparent through the permit term periods, the winter minimum flow effects are most prominent in years 21 through 30. Irrigation period difference are most apparent from mid-May through mid-September as stored water in upstream reservoirs is depleted.

Figure 35. The Deschutes River Hydrograph for Years 1–5 (upper) and Years 21–30 (lower) of the No-Action Alternative and Proposed Action Based on Modeled Flows at the BENO Gauge (Figures show the median flow and 20 to 80% flow range for the alternatives.)



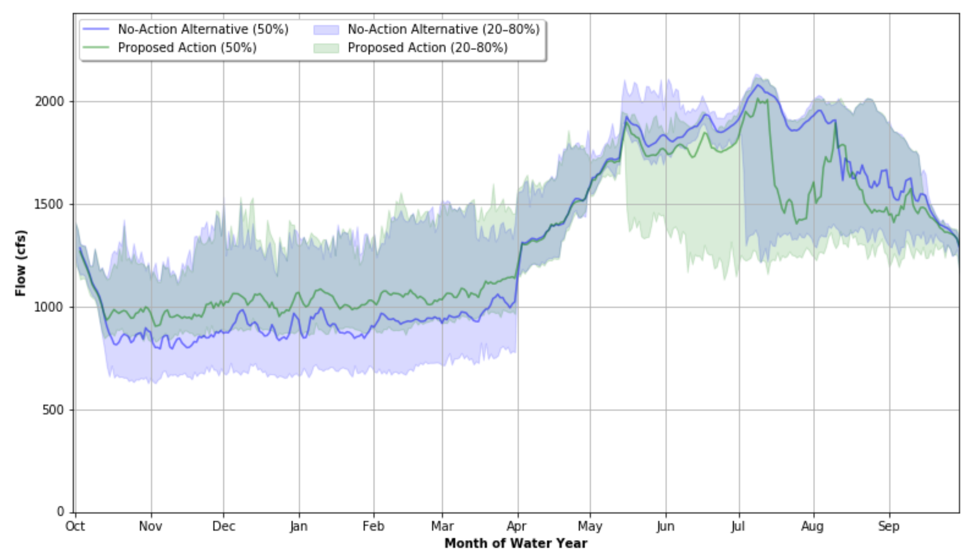


Table 14 includes a comparison of seasonal differences in minimum and maximum median flows for the permit term based on RiverWare output for the BENO gauge. The flow data show the increasing minimum and maximum median flows that would occur during the winter storage period over the permit term related to the implementation of Conservation Measure WR-1. Due to the increasing winter minimum flows, irrigation period flows experience an inverse relationship with decreasing maximum median flows especially beginning in years 6 through 10 when minimum winter flows on the Upper Deschutes River are set at 200 cfs.

Table 14. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Deschutes River at the BENO Gauge by Season for the No-Action Alternative and Proposed Action

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	Minimum (cfs)	Maximum (cfs)	Minimum (cfs)	Maximum (cfs)
No-Action	824.2	976.0	1,078.0	1,922.2
Proposed Action (Years 1–5)	820.3	949.3	1,066.7	1,931.6
Proposed Action (Years 6–10)	859.0	998.3	1,065.1	1,905.0
Proposed Action (Years 11–20)	903.7	1,049.6	1,066.6	1,873.9
Proposed Action (Years 21–30)	957.1	1,109.0	1,065.1	1,764.0

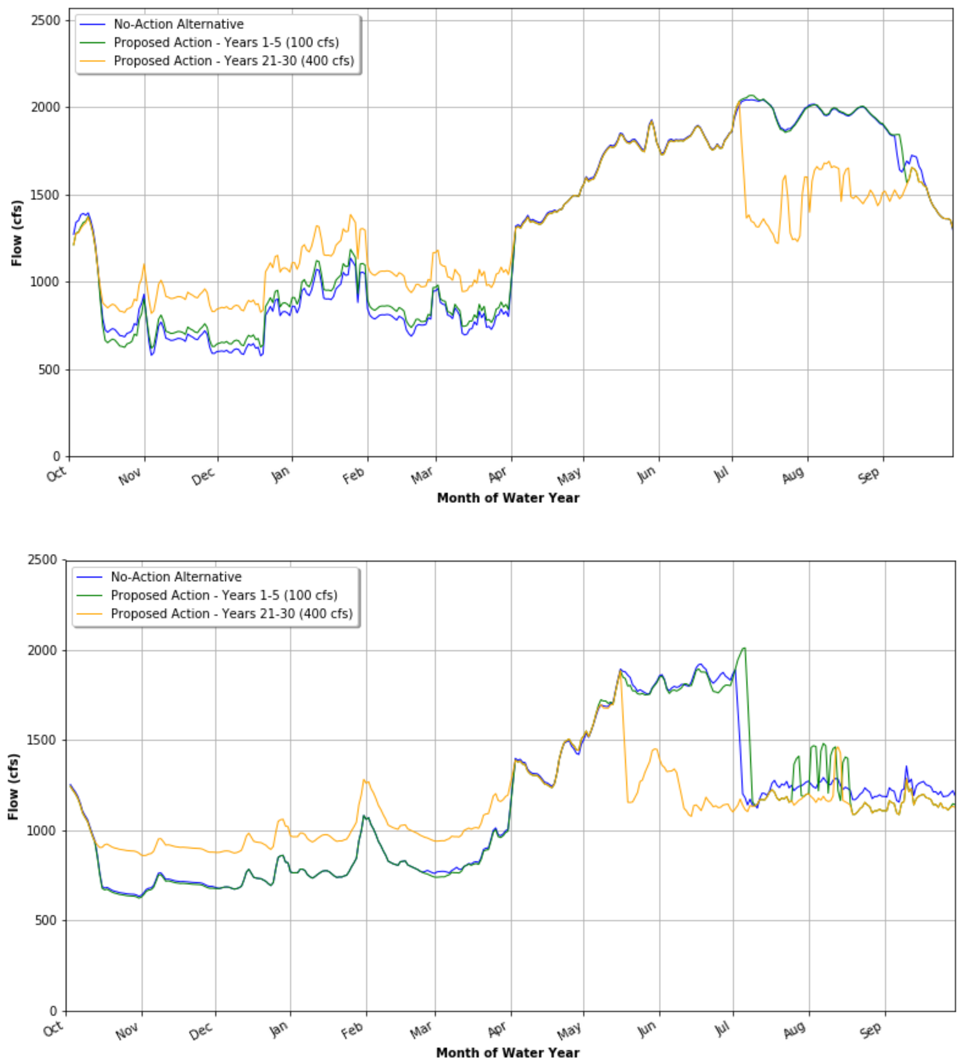
Total monthly streamflow volume (af) for representative wet, normal, and dry years were evaluated to assess changes in seasonal streamflow. Proposed action results were compared to the no-action alternative and proposed action results are reported as the percent difference from the no-action alternative (Table 15). Although annual flows would experience minimal change over the water year types, winter storage and irrigation period flows differ by water year type and over the periods of the permit term. From a wet year to a dry year, there would be winter storage period flow changes ranging from a decrease of 3% in a wet year, to an increase of 29% in a dry year. Similarly, there would be a reduction in irrigation period flows of between 8% and 11% for a normal year and dry year, respectively. Irrigation period flow reductions (-11%) are greatest in years 21 through 30 in a dry year.

Table 15. Percent Differences between the No-Action Alternative and Proposed Action for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years for the BENO Gauge

		Proposed Action			
Water Year Type	Time Period	Years 1–5	Years 6–10	Years 11–20	Years 21–30
Wet	Irrigation Period	2%	1%	1%	1%
	Winter/Storage Period	-1%	-3%	-3%	-3%
	Annual	1%	0%	0%	0%
	1 SD	-3%	-1%	-1%	-1%
Normal	Irrigation Period	-1%	-2%	-4%	-8%
	Winter/Storage Period	-6%	6%	12%	21%
	Annual	-3%	0%	0%	0%
	1 SD	1%	-10%	-20%	-38%
Dry	Irrigation Period	5%	-3%	-8%	-11%
	Winter/Storage Period	-11%	9%	19%	29%
	Annual	0%	1%	0%	0%
	1 SD	21%	-13%	-33%	-53%

Figure 36 includes the representative normal and dry year hydrographs for the BENO gauge under the proposed action in years 21 through 30 of the permit term. Hydrographs for representative normal and dry years have similar patterns with the proposed action daily flows being higher from mid-October to April 1, similar from April 1 to mid-May (dry year) and early July (normal year), and lower through the remainder of the irrigation season. Flow declines occur about a month and half earlier in a dry year compared to a normal year.

Figure 36. The Deschutes River Hydrograph for the No-Action Alternative and Proposed Action in Years 1–5 and Years 21 through 30 in Representative Normal (upper) and Dry (lower) Years at the BENO Gauge



Deschutes River from Benham Falls to Bend

Surface water diversions located between Lava Island and the DEBO gauge, and streamflow losses to groundwater, influence the amount of water remaining in the Deschutes River at the DEBO gauge (#14070500). Like the WICO and BENO gauges, the no-action and proposed action in years 1 through 5 yield similar median flows over the hydrograph (Figure 37). Flow variability marked by the 20 to 80% flow range is similar for both alternatives. In years 21 through 30, higher winter flows are related to minimum releases from Wickiup Reservoir. Irrigation period flows are similar to the no-action alternative except for lower flows from mid-May to early June.

Figure 37. The Deschutes River Hydrograph for Years 1–5 (upper) and Years 21–30 (lower) for the No-Action Alternative and Proposed Action Modeled Flows at the DEBO Gauge (Figures show the median flow and 20 to 80% flow range for the alternatives.)

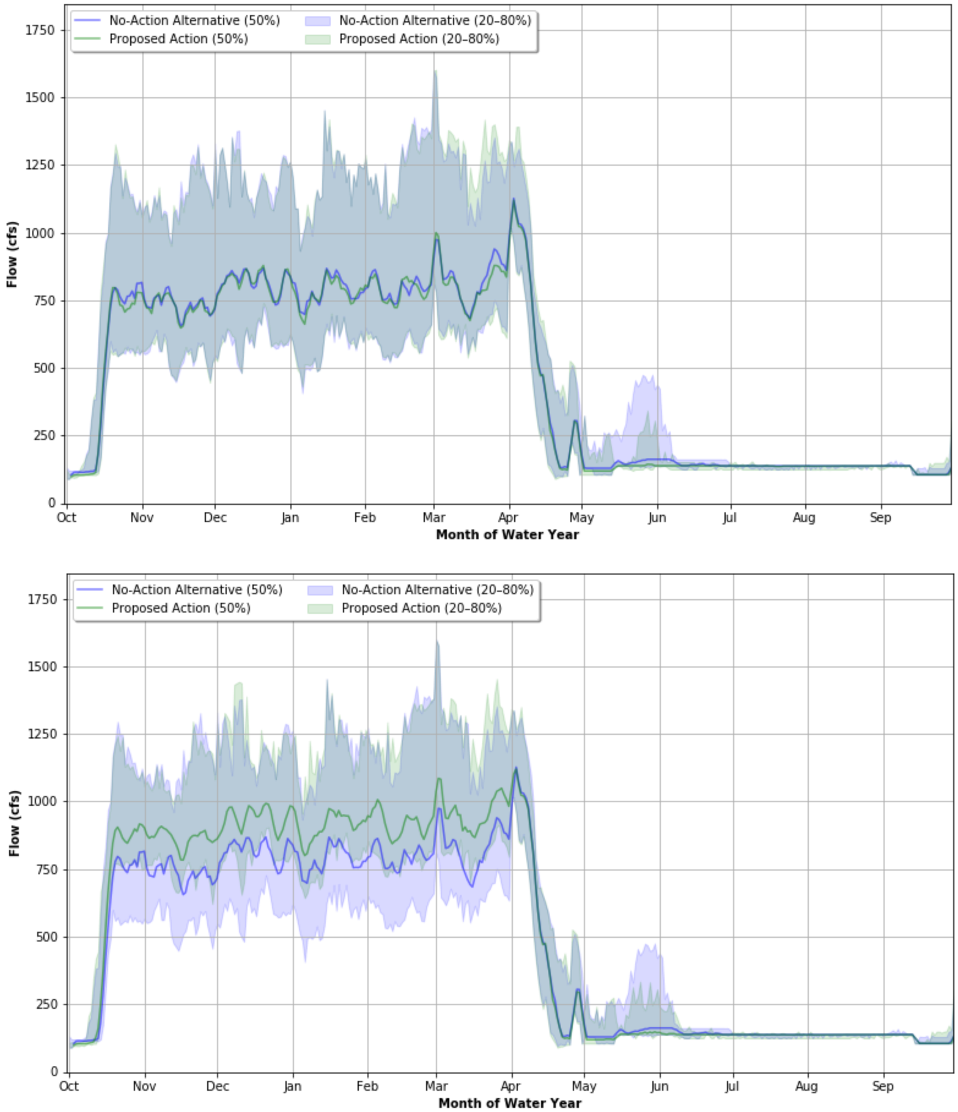


Table 16 includes a comparison of seasonal differences in minimum and maximum median flows based on DEBO gauge data. The proposed action in years 21 through 30 has the highest minimum and maximum median flows during winter due to the higher minimum flow target included in Conservation Measure WR-1. The irrigation period maximum flows included in Table 16 include the month of October when surface water diversions begin to shut down for the winter. If October is excluded from the calculations, the maximum median daily flows for the irrigation period flows would be very similar to the minimum median daily flows. Conservation measures approved for Tumalo ID and Swalley ID will increase diversion network efficiency. However, instream flow benefits associated with these improvements were not included in the RiverWare model logic. Conservation measures are anticipated to result in additional instream flow of 7.5 cfs in years 1 through 5, and 15.2 cfs in years 6 through 10 during the irrigation season at the DEBO gauge.

Table 16. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Deschutes River at the DEBO Gauge by Season for the No-Action Alternative and Proposed Action over the Permit Term[1]

	Winter (Nov 1–Mar 31)		Irrigation Season 3 (May 15–Sep 15)[2]	
Alternative	Minimum (cfs)	Maximum (cfs)	Minimum (cfs)	Maximum (cfs)
No-Action	726.0	834.9	130.3	508.2
Proposed Action (Years 1–5)	719.7	819.3	131.9	530.5
Proposed Action (Years 6–10)	761.8	866.1	130.3	572.2
Proposed Action (Years 11–20)	814.3	911.3	133.2	617.0
Proposed Action (Years 21–30)	871.3	972.3	130.3	667.5

1 Tumalo ID and Swalley ID water conservation projects would result in an additional 7.6 cfs of instream water during the irrigation season in years 1 through 5 and 15.2 cfs in years 6 through 30 under the no-action alternative and proposed action that were not modeled in RiverWare.

2 Minimum instream flow based on conserved water and instream leasing is 125.8 cfs.

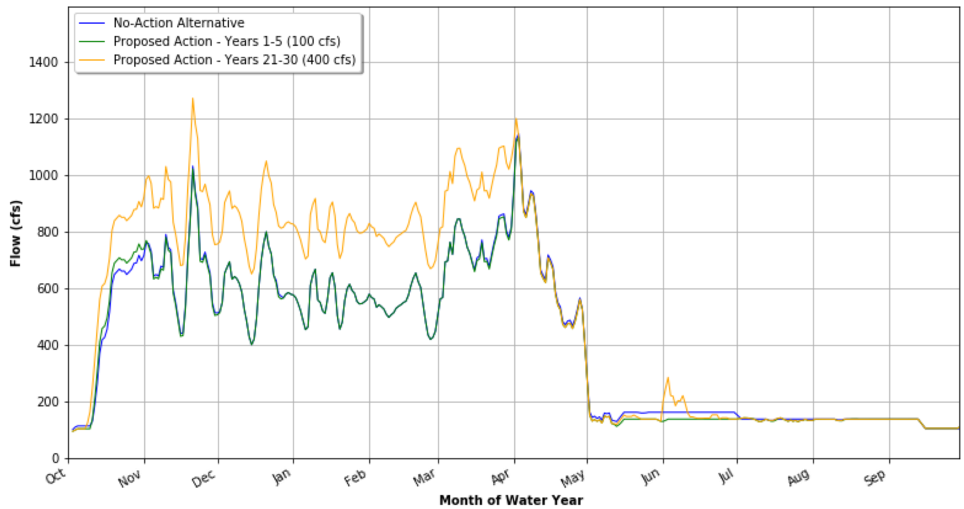
Total monthly streamflow volume (af) for representative wet, normal, and dry years was evaluated to assess changes in seasonal streamflow. Proposed action results were compared to the no-action alternative and proposed action results are reported as the percent difference from the no-action alternative (Table 17). Annual flow at the DEBO gauge would increase by up to 30% under normal and dry years, as more flow is released during the winter. Higher winter storage period flows are reflected in the 29% and 38% increases under normal and dry years, respectively. Irrigation period flows range from a decrease of 4% under a wet year, to increases of 7% and 15% under normal and dry years, respectively.

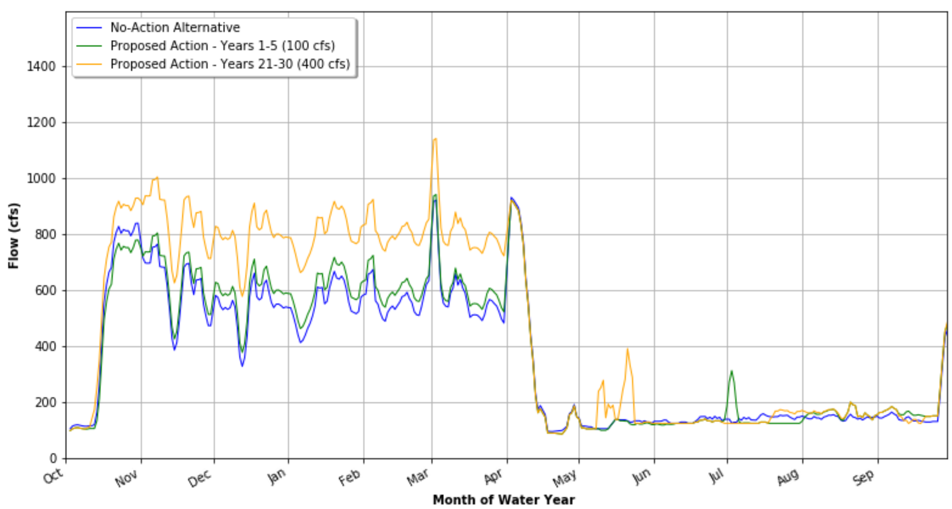
Table 17. Percent Differences between the No-Action Alternative and Proposed Action for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years for the DEBO Gauge

Water Year Type	Time Period	Proposed Action			
		Years 1–5	Years 6–10	Years 11–20	Years 21–30
Wet	Irrigation Period	-13%	-4%	-4%	-4%
	Winter/Storage Period	1%	-1%	-1%	-1%
	Annual	-3%	-1%	-1%	-1%
	1 SD	4%	-1%	-1%	-1%
Normal	Irrigation Period	-18%	0%	1%	7%
	Winter/Storage Period	-14%	9%	16%	29%
	Annual	-16%	5%	11%	21%
	1 SD	-5%	9%	17%	29%
Dry	Irrigation Period	-24%	5%	13%	15%
	Winter/Storage Period	-13%	12%	29%	38%
	Annual	-17%	10%	24%	30%
	1 SD	-4%	15%	35%	47%

Figure 38 includes the representative normal and dry year hydrographs for the DEBO gauge under the proposed action in years 21 through 30 of the permit term. Hydrographs for representative normal and dry years have similar patterns with the proposed action daily flows higher from mid-October to April 1, similar from April 1 to mid-May and lower through the irrigation season. In a dry year, proposed action flows decrease rapidly as flows are diverted by diversions upstream of the DEBO gauge.

Figure 38. The Deschutes River Hydrograph for the No-Action Alternative and Proposed Action in Years 1–5 and Years 21- 30 in Representative Normal (upper) and Dry (lower) Years at the DEBO Gauge

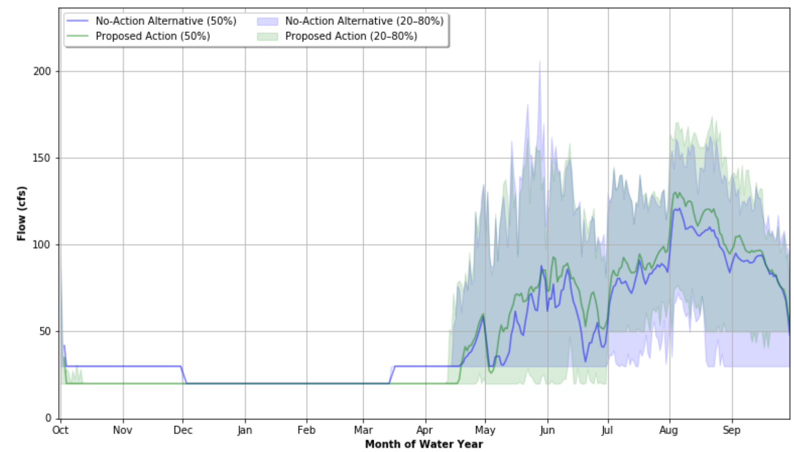




Crescent Creek from Crescent Lake to the Little Deschutes River

Crescent Creek conservation measures maintain minimum instream flows (CC-1), and address reservoir ramping rates (CC-2) and drawdown timing (CC-3). The RiverWare model only accounts for CC-1 andCC-3, ramping rates are not included in the RiverWare model. Relative to the no-action alternative, the proposed action over the permit term has similar seasonal flows. The proposed action calls for a minimum instream flow of 20 cfs, compared to the 20 cfs to 30 cfs minimum specified in the no-action alternative. Median flows for the proposed action are less than or the same as the no-action flows (Figure 39). The proposed action median flows are slightly greater than the no-action median flow during the irrigation season.

Figure 39. The Crescent Creek Hydrograph for Years 1–5 (upper) and Years 21–30 (lower) of the No-Action Alternative and Proposed Action Based on Modeled Flows at the CREO Gauge Downstream from Crescent Lake Reservoir



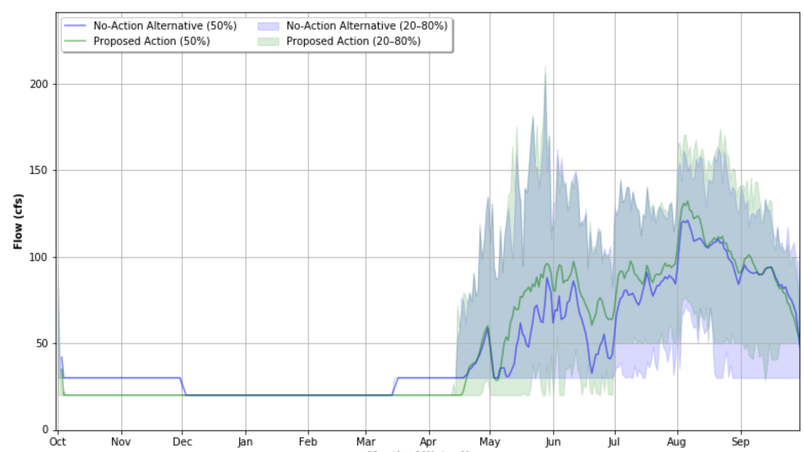


Table 18 includes a comparison of seasonal differences in minimum and maximum median flows based on CREO gauge data. Proposed action winter flows are limited to 20 cfs. Irrigation period flows are similar for the proposed action although the minimum flow of 20 cfs is also less than the no-action minimum.

Table 18. Comparison of Minimum and Maximum Median (50%) Daily Flows on Crescent Creek Downstream from Crescent Lake Reservoir by Season for the No-Action Alternative and Proposed Action over the Permit Term

Alternative	Winter (Nov 1–Mar 31) Minimum (cfs)	Winter (Nov 1–Mar 31) Maximum (cfs)	Irrigation (Apr 1–Oct 31) Minimum (cfs)	Irrigation (Apr 1–Oct 31) Maximum (cfs)
No-Action	20.0	30.0	30.0	107.9
Proposed Action (Years 1–5)	20.0	20.0	20.0	116.0
Proposed Action (Years 6–10)	20.0	20.0	20.0	113.2
Proposed Action (Years 11–20)	20.0	20.0	20.0	113.3
Proposed Action (Years 21–30)	20.0	20.0	20.0	110.5

Total monthly streamflow volume (af) for representative wet, normal, and dry years was evaluated to assess changes in seasonal streamflow. Proposed action results are presented as the percent difference in streamflow from the no-action alternative (Table 19). Total streamflow volume varies from 1% less during a dry year, to a 9% increase in a normal year in years 21 through 30 compared to the no-action alternative. In a dry year, there is a 1% reduction in total streamflow. Winter storage period flows are 13% to 15% less than the no-action alternative as less water is released from Crescent Lake Reservoir in the winter. Irrigation period flows experience 6% and 15% increases in wet and normal years, respectively, and an increase of 2% in a dry year in years 21 through 30 of the permit term. Flows are more variable under each water year type relative to the no-action alternative, due to the lower winter flows and higher irrigation period flows.

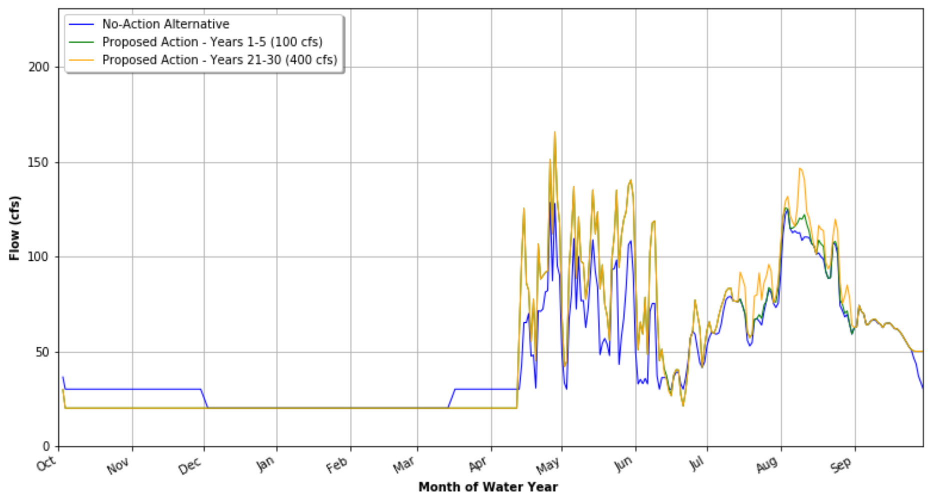
Table 19. Percent Differences in Streamflow Volume between the No-Action Alternative and Proposed Action for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years for the CREO Gauge

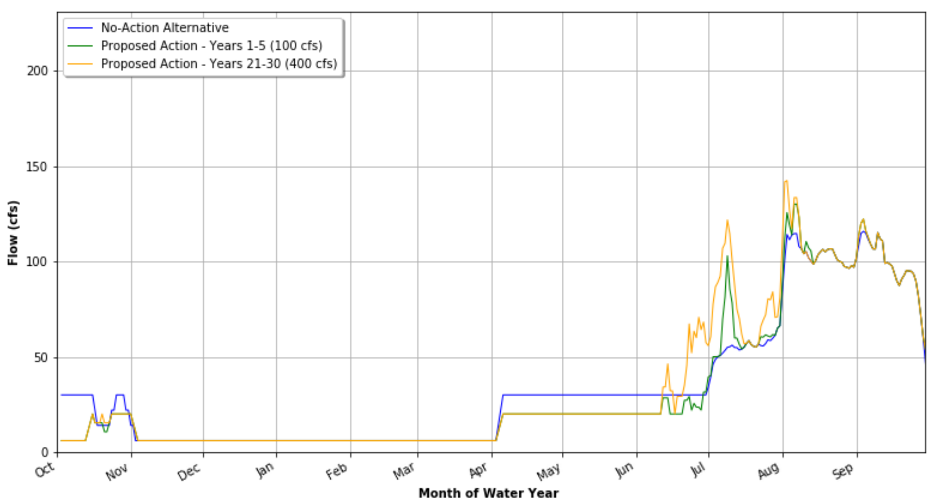
Water Year Type	Time Period	Proposed Action Years 1–5	Proposed Action Years 6–10	Proposed Action Years 11–20	Proposed Action Years 21–30
Wet	Irrigation Period	5%	5%	4%	6%
	Winter/Storage Period	-13%	-13%	-13%	-13%
	Annual	2%	2%	2%	3%
	1 SD	16%	16%	16%	17%
Normal	Irrigation Period	7%	12%	13%	15%
	Winter/Storage Period	-13%	-13%	-13%	-13%
	Annual	3%	7%	8%	9%
	1 SD	19%	27%	29%	32%
Dry	Irrigation Period	-2%	-5%	-4%	2%
	Winter/Storage Period	-15%	-15%	-15%	-15%
	Annual	-4%	-6%	-6%	-1%
	1 SD	4%	10%	10%	12%

Figure 40 includes the representative normal and dry year hydrographs for the CREO gauge under the proposed action in years 21 through 30 of the permit term. The representative normal year hydrograph illustrates the lower minimum winter flows and higher irrigation period flows from mid-April through August. Flows are similar through July while there are increased flows in August to satisfy downstream water demand. Flows are similar through September as flow from Crescent Lake Reservoir is ramped down to begin winter storage (Conservation Measure CC-3).

In a dry year, proposed action minimum flows are less than the 20 cfs minimum flow target, and streamflow is held at minimum levels until mid-June. Releases ramp up through the end of June and a peak release occurs in early July and a second release occurs in early August. In short, Crescent Creek flows increase later in the irrigation season under a dry year scenario in order to meet later season irrigation demand with Crescent Lake Reservoir stored water.

Figure 40. The Crescent Creek Hydrograph for the No-Action Alternative and Proposed Action in Years 1–5 and Years 21–30 Representative Normal (top) and Dry (bottom) Years at the CREO Gauge





Little Deschutes River from Crescent Creek Confluence to the Deschutes River

While there are no conservation measures outlined for the Little Deschutes River, Crescent Creek conservation measures influence Little Deschutes River flows. Median flows for the proposed action are slightly greater than the no-action alternative flows during the irrigation season as Crescent Lake Reservoir water is released to meet water user demand. Median proposed action flows are slightly less during winter due to lower proposed action minimum flows from Crescent Lake

Reservoir (Figure 41). Since flows change very little under the proposed action between years 1 through 5 and years 21 through 30, only the hydrograph for years 21 through 30 is presented.

Figure 41. The Little Deschutes River Hydrograph Based on Modeled Flows at the LAPO Gauge (The figure represents flows associated with the no-action alternative and the proposed action in years 21–30.)

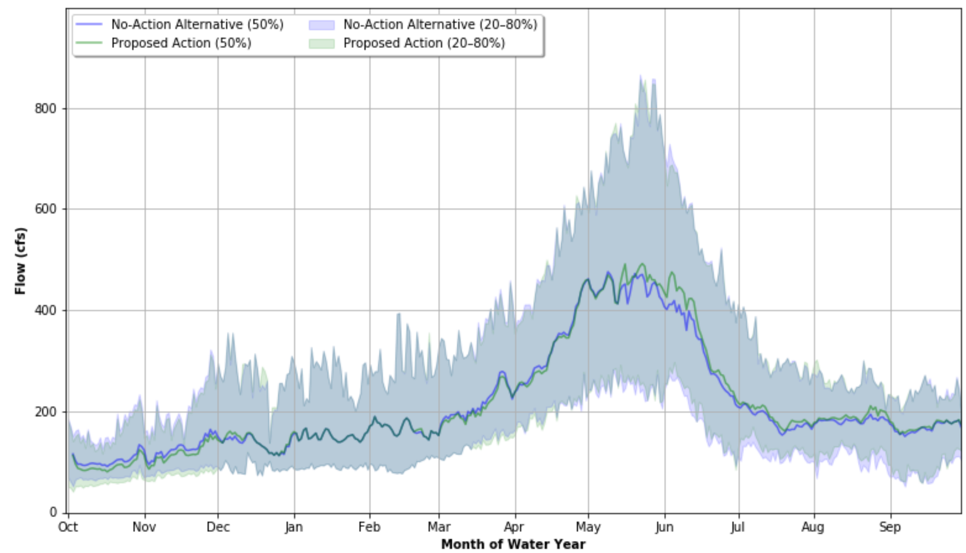


Table 20 includes a comparison of seasonal differences in minimum and maximum median flows based on LAPO gauge data. Proposed action minimum winter and irrigation period flows are influenced by the lower minimum flow releases (20 cfs instead of 30 cfs) from Crescent Lake Reservoir. Maximum flows during both periods are similar to the no-action alternative.

Table 20. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Little Deschutes River by Season for the No-Action Alternative and Proposed Action over the Permit Term

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	Minimum (cfs)	Maximum (cfs)	Minimum (cfs)	Maximum (cfs)
No-Action	126.2	213.2	103.1	445.4
Proposed Action (Years 1–5)	116.6	205.7	93.2	454.7
Proposed Action (Years 6–10)	116.6	203.2	93.2	451.9
Proposed Action (Years 11–20)	116.6	202.4	93.1	449.4
Proposed Action (Years 21–30)	116.6	202.4	93.1	450.1

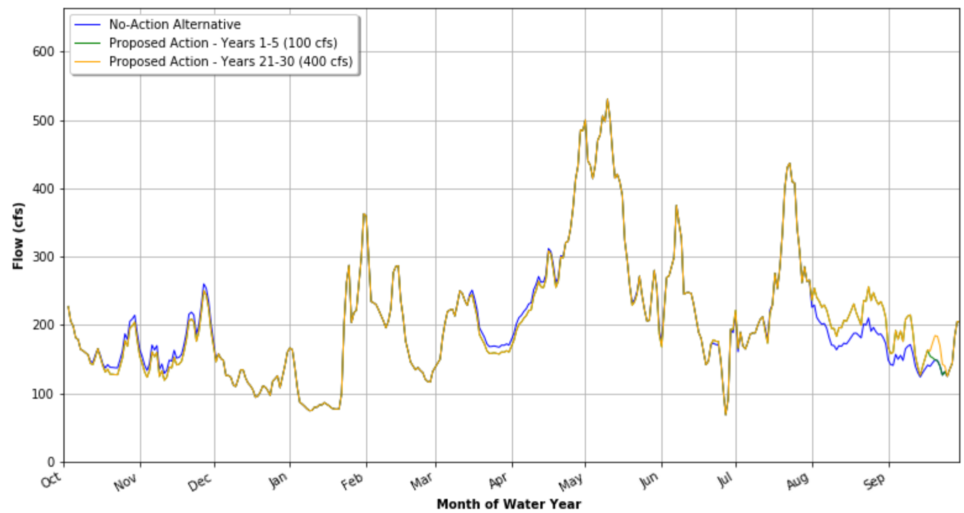
There are minimal differences in streamflow on the Little Deschutes River over the water year types, over the permit term periods, and over the seasonal periods (Table 21). Annual flows differ slightly from wet year (-1%) to normal year (1%). Winter storage period flows will experience decreases of 1% to 2% due to lower minimum outflows from Crescent Lake Reservoir. Irrigation period flows increase 2% in normal and dry years to meet downstream Tumalo ID water demands.

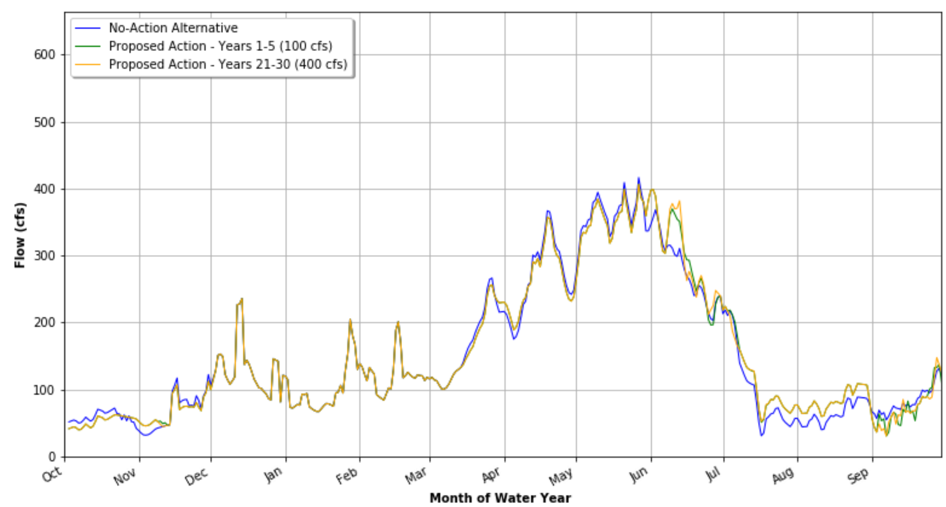
Table 21. Percent Differences in Streamflow Volume between the No-Action Alternative and Proposed Action for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years for the LAPO Gauge

Water Year Type	Time Period	Proposed Action			
		Years 1–5	Years 6–10	Years 11–20	Years 21–30
Wet	Irrigation Period	0%	0%	0%	0%
	Winter/Storage Period	-1%	-1%	-1%	-1%
	Annual	-1%	-1%	-1%	-1%
	1 SD	0%	0%	0%	0%
Normal	Irrigation Period	2%	2%	2%	2%
	Winter/Storage Period	-2%	-2%	-2%	-2%
	Annual	1%	1%	1%	1%
	1 SD	2%	2%	2%	2%
Dry	Irrigation Period	2%	2%	2%	2%
	Winter/Storage Period	-2%	-2%	-2%	-2%
	Annual	0%	0%	0%	0%
	1 SD	2%	1%	1%	1%

Figure 42 includes the representative normal and dry year hydrographs for the LAPO gauge under the proposed action in years 1 through 5 and years 21 through 30 of the permit term. Proposed action winter storage flows are slightly less as minimum outflows from Crescent Lake Reservoir are reduced under Conservation Measure CC-1. Flows from December through mid-April are similar to the no-action alternative in both normal and dry years. Proposed action flows are slightly greater than the no-action alternative through the balance of irrigation season, with higher flow releases from mid-July through August and lower flows through September in a dry year. The lower September flows in a dry year suggest the effects of reduced Crescent Lake Reservoir outflows as the reservoir storage period begins on September 1.

Figure 42. The Little Deschutes River Hydrograph for the No-Action Alternative and Proposed Action in Years 1–5 and Years 21–30 in Representative Normal (upper) and Dry (lower) Years at the LAPO Gauge

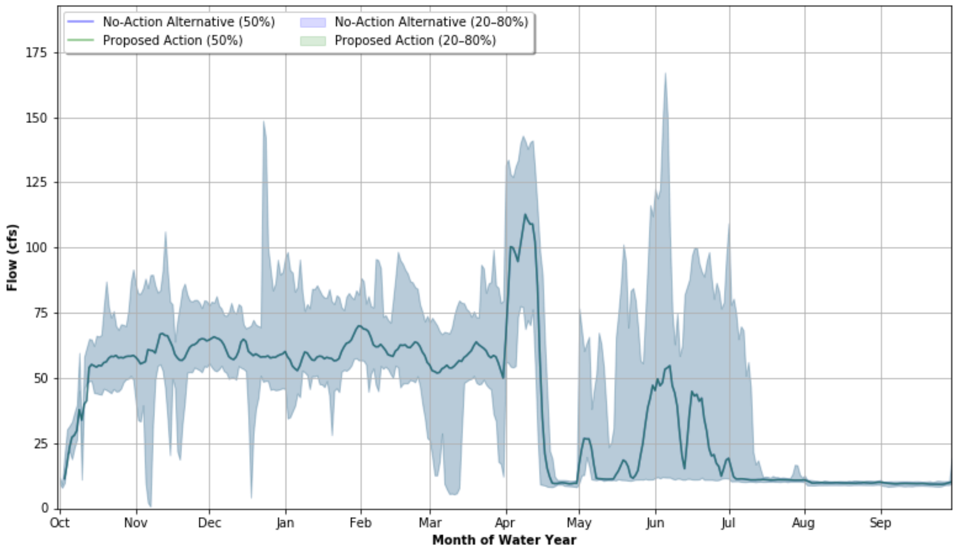




Tumalo Creek

The no-action alternative and proposed action yield the same flow results for Tumalo Creek based on the hydrograph developed for the TUMO gauge, located at river mile 2.8 on Tumalo Creek (Figure 43). Since flows change very little under the proposed action between years 1 through 5 and years 21 through 30, only the hydrograph for years 21 through 30 is presented.

Figure 43. The Tumalo Creek Hydrograph Based on Modeled Flows at the TUMO Gauge (Figure represents flows associated with the no-action alternative and the proposed action in years 21–30.)

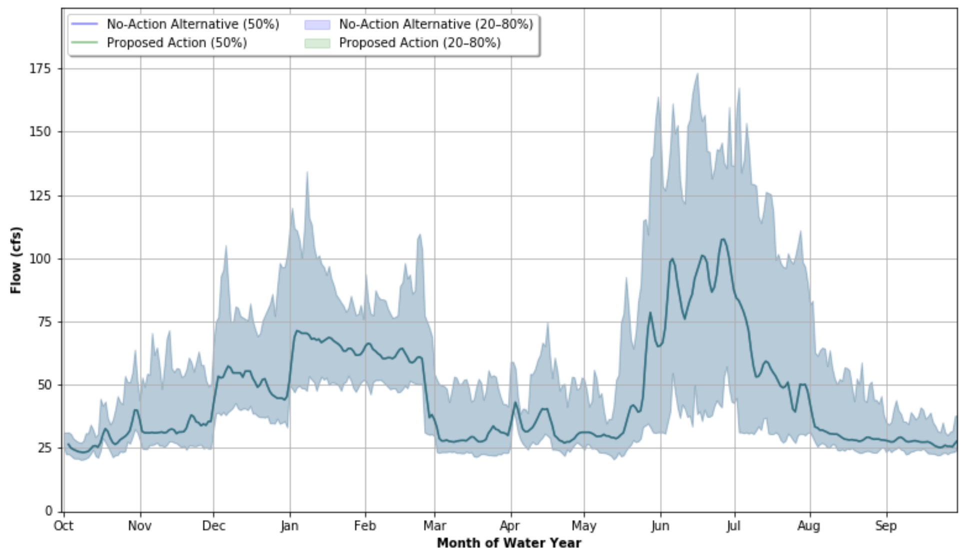


There were no differences in seasonal streamflow for the TUMO gauge over the permit term or between the no-action alternative and proposed action. Conservation measures approved for Tumalo ID will increase diversion network efficiency. However, instream flow benefits associated with these improvements were not included in the RiverWare model logic. Conservation measures are anticipated to result in additional instream flow in Tumalo Creek of 12.35 cfs in years 1 through 5, 19.83 cfs in years 6 through 10, and 30.91 cfs in years 11 through 30 during the irrigation season at the TUMO gauge.

Whychus Creek

Since there are no water management differences between the no-action alternative and the proposed action in the RiverWare model, there are no flow differences at the SQSO gauge (Figure 44).

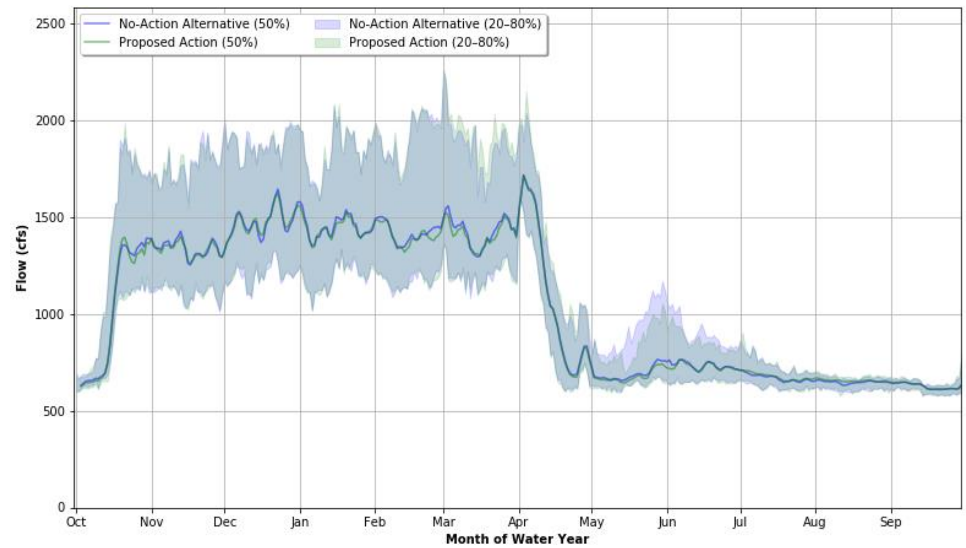
Figure 44. The Whychus Creek Hydrograph Based on Modeled Flows at the SQSO Gauge (Figure represents flows associated with the no-action alternative and the proposed action in years 21–30.)



Deschutes River from Bend to Culver

Like the DEBO gauge, the Culver gauge (CULO) shows the effects of higher winter minimum flows associated with the proposed action (Figure 45). Increasing minimum flows over the permit term, primarily influences winter flows. Irrigation period flows are similar under the proposed action in years 1 through 5 and years 21 through 30. Groundwater inputs to the Deschutes River in the Culver reach also contribute to streamflow, increasing the year-round magnitude of flows.

Figure 45. The Deschutes River Hydrograph for Years 1–5 (upper) and Years 21–30 (lower) of the No-Action Alternative and Proposed Action Based on Modeled Flows at the CULO Gauge at Culver (Figures show the median flow and 20 to 80% flow range for the alternatives.)



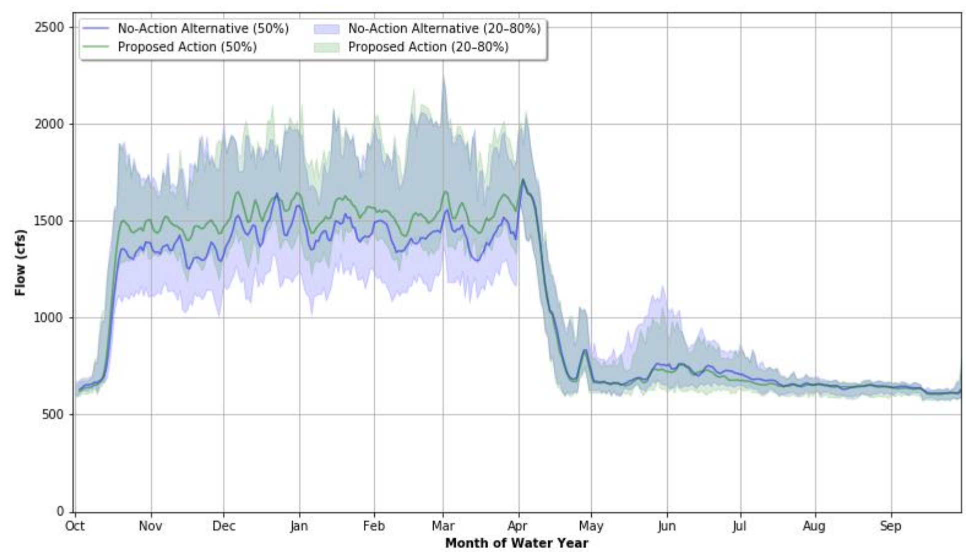


Table 22 includes a comparison of seasonal differences in minimum and maximum median flows based on CULO gauge data. Winter storage period flows increase with increasing minimum flows for the Upper Deschutes River. Irrigation period flows are similar over the permit term and are only marginally different from the no-action alternative. Conservation measures approved for Tumalo ID and Swalley ID will increase diversion network efficiency. However, instream flow benefits associated with these improvements were not included in the RiverWare model logic. Conservation measures are anticipated to result in additional instream flow of 19.95 cfs in years 1 through 5, and 35.03 cfs in years 6 through 10, and 46.11 cfs in years 11 through 30 during the irrigation season at the CULO gauge.

Table 22. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Deschutes River at the CULO Gauge by Season for the No-Action Alternative and Proposed Action over the Permit Term

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	Minimum (cfs)	Maximum (cfs)	Minimum (cfs)	Maximum (cfs)
No-Action	1,334.4	1,474.7	622.7	1,071.4
Proposed Action (Years 1–5)	1,322.5	1,465.6	620.8	1,077.5
Proposed Action (Years 6–10)	1,363.6	1,496.5	619.1	1,119.5
Proposed Action (Years 11–20)	1,414.1	1,543.0	618.8	1,177.8
Proposed Action (Years 21–30)	1,460.6	1,588.8	617.6	1,220.7

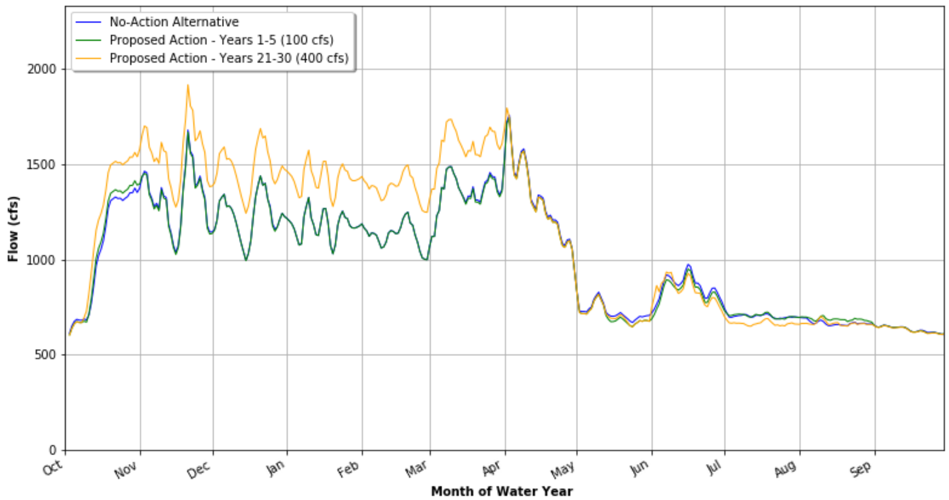
Total monthly streamflow volume (af) for representative wet, normal, and dry years was evaluated to assess changes in seasonal streamflow. Proposed action results were compared to the no-action alternative and proposed action results are reported as the percent difference from the no-action alternative (Table 23). Total streamflow volume decreases 1% in a wet year, but increases 8% and 11% in a normal and dry years, respectively as winter storage period flows increase up to 18% in a dry year. Irrigation period flows increase in normal and dry years by 1% and 2%, respectively. Monthly flow variability increases from wet to dry years, with the greatest variability associated with a dry year in years 21 through 30 of the permit term due to the influence of minimum winter flows on the Upper Deschutes River.

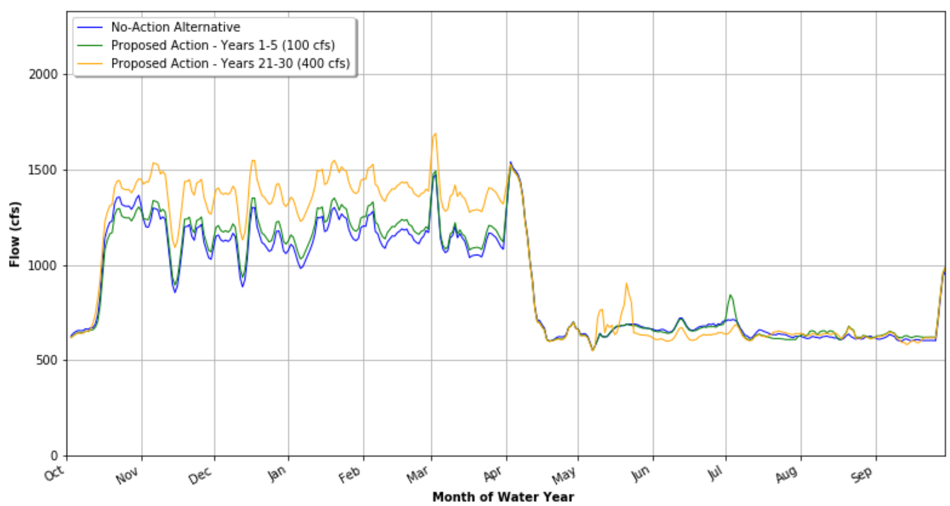
Table 23. Percent Differences in Streamflow Volume between the No-Action Alternative and Proposed Action for the Irrigation Period (April 1 to October 31), WINTER STORAGE PERIOD (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years for the CULO Gauge

		Proposed Action			
Water Year Type	Time Period	Years 1–5	Years 6–10	Years 11–20	Years 21–30
Wet	Irrigation Period	-4%	-1%	-1%	-1%
	Winter/Storage Period	1%	0%	0%	0%
	Annual	-1%	-1%	-1%	-1%
	1 SD	6%	-1%	-1%	-1%
Normal	Irrigation Period	-4%	0%	0%	1%
	Winter/Storage Period	-6%	4%	8%	15%
	Annual	-5%	2%	4%	8%
	1 SD	-3%	8%	15%	27%
Dry	Irrigation Period	-4%	1%	2%	2%
	Winter/Storage Period	-5%	6%	14%	18%
	Annual	-5%	4%	9%	11%
	1 SD	-5%	12%	30%	41%

Figure 46 includes the representative normal and dry year hydrographs for the CULO gauge under the proposed action in years 21 through 30 of the permit term. Streamflow patterns are similar to the DEBO gauge results with proposed action flows higher in the winter and lower or similar to the no-action alternative during the irrigation period.

Figure 46. The Deschutes River Hydrograph for the No-Action Alternative and Proposed Action in Years 1–5 and Years 21–30 in Representative Normal (upper) and Dry (lower) Years at the CULO Gauge





Deschutes River from Pelton Round Butte Dam to Madras

The Deschutes River at the Madras (MADO) gauge has similar median flows and flow variability for the no-action alternative and proposed action (Figure 47). Proposed action median winter flows slightly increase as minimum flows increase on the Upper Deschutes River over the permit term. Likewise, irrigation period median flows decrease with increasing minimum winter flows.

Figure 47. The Deschutes River Hydrograph for Years 1–5 (upper) and Years 21–30 (lower) of the No-Action Alternative and Proposed Action Based on Modeled Flows at the MADO Gauge Downstream from Lake Billy Chinook (Figures show the median flow and 20 to 80% flow range for the alternatives.)

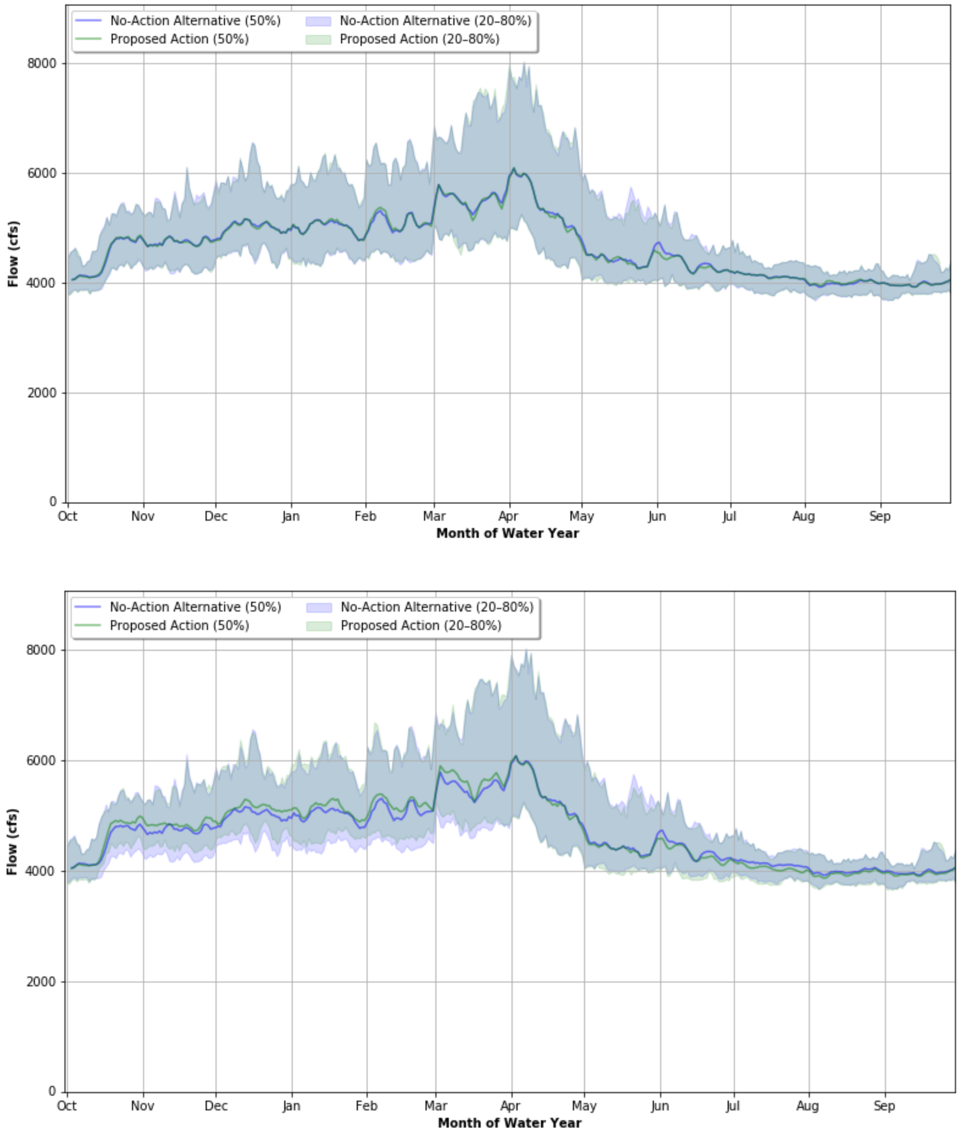


Table 24 includes a comparison of seasonal differences in minimum and maximum median flows based on MADO gauge data. The proposed action in years 21 through 30 has higher minimum and maximum median winter flows, suggesting the effects of the higher minimum winter flow prescription. Irrigation period flows are similar for the no-action alternative and proposed action.

Table 24. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Deschutes River at the MADO Gauge by Season for the No-Action Alternative and Proposed Action over the Permit Term

Alternative	Winter (Nov 1–Mar 31) Minimum (cfs)	Winter (Nov 1–Mar 31) Maximum (cfs)	Irrigation (Apr 1–Oct 31) Minimum (cfs)	Irrigation (Apr 1–Oct 31) Maximum (cfs)
No-Action	4,725.5	5,503.7	3,966.8	5,366.1
Proposed Action (Years 1–5)	4,720.5	5,530.4	3,962.5	5,346.9
Proposed Action (Years 6–10)	4,750.1	5,554.3	3,957.7	5,346.3
Proposed Action (Years 11–20)	4,785.8	5,598.0	3,952.1	5,343.8
Proposed Action (Years 21–30)	4,819.2	5,664.0	3,941.8	5,339.2

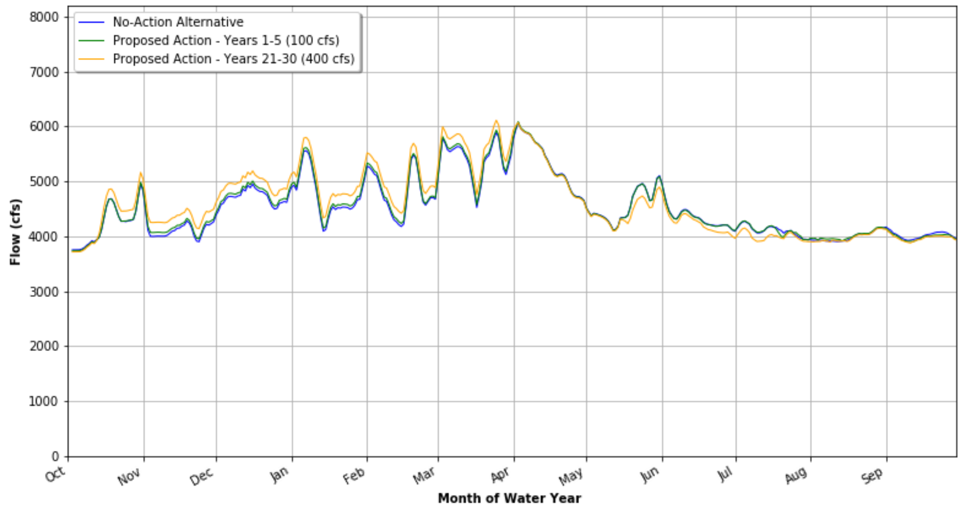
Total monthly streamflow volume (af) for representative wet, normal, and dry years was evaluated to assess changes in seasonal streamflow. Proposed action results were compared to the no-action alternative and proposed action results are reported as the percent difference from the no-action alternative (Table 25). Streamflow changes are minimal in wet and normal years over the permit term. Flows are more variable in dry years as minimum winter flows increase over the permit term.

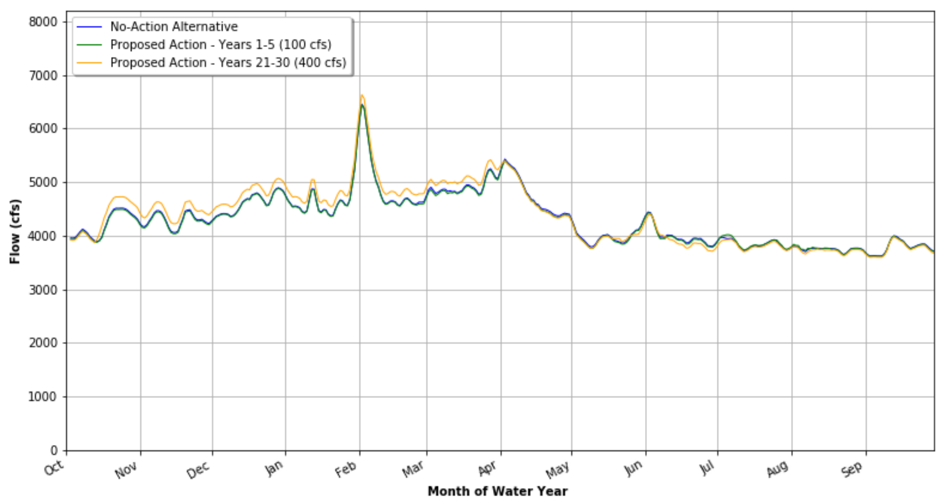
Table 25. Percent Differences in Streamflow Volume between the No-Action Alternative and Proposed Action for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years for the MADO Gauge

Water Year Type	Time Period	Proposed Action Years 1–5	Proposed Action Years 6–10	Proposed Action Years 11–20	Proposed Action Years 21–30
Wet	Irrigation Period	-1%	-1%	-1%	-1%
	Winter/Storage Period	1%	1%	1%	1%
	Annual	0%	0%	0%	0%
	1 SD	5%	1%	1%	1%
Normal	Irrigation Period	-2%	0%	0%	0%
	Winter/Storage Period	0%	1%	1%	2%
	Annual	-1%	0%	0%	1%
	1 SD	3%	1%	2%	3%
Dry	Irrigation Period	-1%	0%	0%	0%
	Winter/Storage Period	-1%	1%	3%	4%
	Annual	-1%	0%	1%	2%
	1 SD	-3%	4%	12%	18%

Figure 48 includes the representative normal and dry year hydrographs for the MADO gauge under the proposed action in years 1 through 5 and years 21 through 30 of the permit term. Streamflow patterns are similar to the CULO gauge results with proposed action flows higher in the winter and lower or similar to the no-action alternative during the irrigation period. Flows are generally lower during the representative dry year.

Figure 48. The Deschutes River Hydrograph for the No-Action Alternative and Proposed Action in Years 21 through 30 in Representative Normal (upper) and Dry (lower) Years at the MADO Gauge





Deschutes River Flood Flows

The Deschutes River flood flow analysis assessed effects of the proposed action on the magnitude of the regulatory base flood (1%, 100-year flood) and 500-year (0.2% flood) floods, and more frequent floods associated with shallow floodplain inundation.

The base flood and the 500-year flood were evaluated for the Benham Falls (BENO) gauge. The base flood associated with the proposed action would be essentially the same as the no-action alternative, the base flood and the 500-year event would have a small reduction in the predicted flow.

To assess the proposed action's influence on more frequent, low magnitude floods, recent flood reports for the Deschutes River between La Pine and Sunriver and near Tumalo were used to determine threshold flood flows for the WICO, BENO, DEBO, and TUMO gauges (Hendricks 2014; Kato 2017; Shumway 2017; Gorman pers. comm; and LaMarche pers. comm [c]). The sum of flows recorded at the DEBO and TUMO gauges was used to assess potential flooding near the town of Tumalo. Localized flooding may be influenced by Deschutes River flows, tributary contributions, aquatic vegetation growth in the Deschutes River channel, and diversion operation. Peak flows alone may not cause flooding, while lower flows on the Deschutes River combined with elevated tributary flows and dense aquatic vegetation in the river channel may cause flooding.

Table 26 includes the threshold flood flows and the average number of days per year the threshold flood flows were exceeded under the no-action alternative and proposed action based on mean daily flows over the permit term.

The number of days that flows exceed flood flow thresholds varies by gauge location and timing within the permit term. The number of days of flood flow exceedance remains the same or decreases over the permit term for each of the reviewed gauges, although the number of days of exceedance increases slightly for the DEBO+TUMO results when a flood flow threshold of 1,400 cfs is applied. Figure 48 includes the maximum daily flow hydrographs for WICO, BENO, and DEBO gauges. Based on the peak flow hydrographs, flooding in the La Pine to Sunriver reach typically occurs late in the irrigation season when irrigation flows are released from Wickiup Dam and aquatic vegetation densities in Deschutes River channel are at the their peak. Since irrigation period flows would decrease over the permit term, modeling results suggest there would be fewer days when the WICO gauge exceeds 1,600 cfs. Table 27 includes the percent change in flood flow exceedance for each gauge over the permit term.

Table 26. Flood Flow Thresholds and Days of Flow Exceedance for the No-Action Alternative and Proposed Action averaged over the Permit Term (Two flood flow thresholds are included for the DEBO+TUMO gauge data.)

Gauge	Flood Flow Threshold (cfs)	Average Number of Days of Flood Flow Threshold Exceedance per Year				
		No-Action	Proposed Action			
			Years 1–5	Years 6–10	Years 11–20	Years 21–30
WICO	1,600	2.3	2.5	2.1	1.6	1.3
BENO	2,000	27.4	25.4	22.7	20.5	19.0
DEBO+TUMO	1,400	26.8	30.0	29.6	29.1	29.7
DEBO+TUMO	2,000	1.9	1.7	1.5	1.3	1.3

Table 27. Percent Change in Days of Flow Exceedance for the No-Action Alternative and Proposed Action averaged over the Permit Term (Two flood flow thresholds are included for the DEBO+TUMO gauge data.)

Gauge	Flood Flow Threshold (cfs)	Days of Exceedance	Percent Change in the Average Number of Days of Flood Flow Threshold Exceedance per Year			
			Proposed Action			
		No-Action	Years 1–5	Years 6–10	Years 11–20	Years 21–30
WICO	1,600	2.3	9%	-7%	-31%	-42%
BENO	2,000	27.4	-8%	-17%	-25%	-31%
DEBO+TUMO	1,400	26.8	12%	10%	8%	11%
DEBO+TUMO	2,000	1.9	-11%	-20%	-28%	-30%

Crooked River Outflow from Bowman Dam

Conservation Measure CR-1 provides guidance for Crooked River flow downstream from Bowman Dam. Conservation Measure CR-1 is intended to maintain minimum winter flows of 50 cfs at the PRVO gauge. The no-action alternative and proposed action for years 1 through 5 of the permit term have similar influence on flow levels at the PRVO gauge downstream from Bowman Dam (Figure 49). Increasing minimum flows from 100 cfs (years 1–5 of the permit term) to 400 cfs (years 21–30 of the permit term) on the Upper Deschutes River results in water delivery shortage for North Unit ID, which in turn requires North Unit ID to rely more heavily on Crooked River water. To meet North Unit ID demand, additional water is released from Prineville Reservoir and higher Crooked River flows are marked by elevated median flows from mid-May through late August under the proposed action in years 21 through 30.

Figure 49. The Crooked River Hydrograph for Years 1–5 (upper) and Years 21–30 (lower) of the Proposed Action Based on Modeled Flows at the PRVO Gauge Downstream from Bowman Dam (Figures show the median flow and 20 to 80% flow range for the no-action alternative and proposed action.)

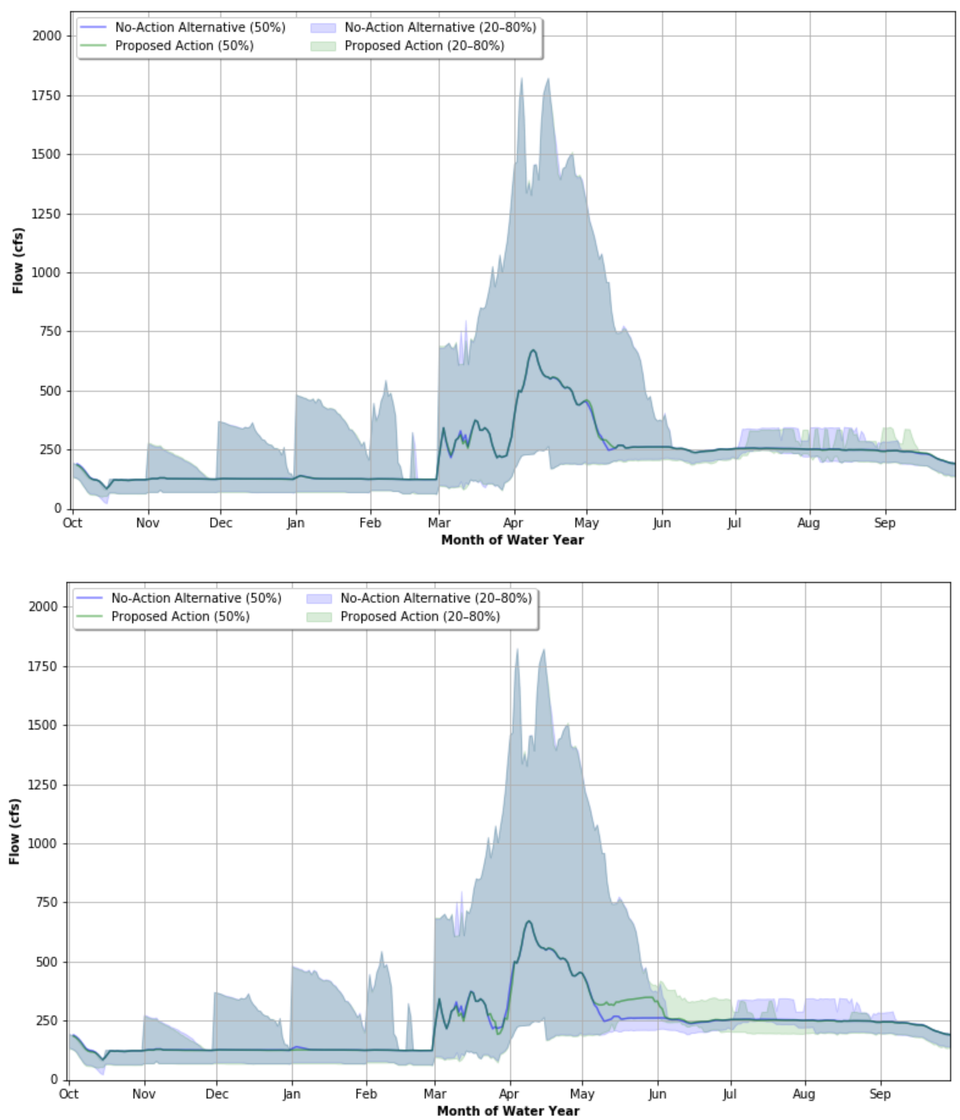


Table 28 includes a comparison of seasonal differences in minimum and maximum median flows based on PRVO gauge data. There are minor differences in the minimum and maximum flows during the winter storage and irrigation periods since the proposed action follows the model logic included in the no-action alternative.

Table 28. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Crooked River at the PRVO Gauge by Season for the No-Action Alternative and Proposed Action over the Permit Term

Alternative	Winter (Nov 1–Mar 31) Minimum (cfs)	Winter (Nov 1–Mar 31) Maximum (cfs)	Irrigation (Apr 1–Oct 31) Minimum (cfs)	Irrigation (Apr 1–Oct 31) Maximum (cfs)
No-Action	123.8	297.6	119.9	518.2
Proposed Action (Years 1–5)	123.7	294.3	119.0	518.7
Proposed Action (Years 6–10)	123.7	293.9	118.5	518.7
Proposed Action (Years 11–20)	123.7	290.3	118.4	518.7
Proposed Action (Years 21–30)	123.7	288.8	118.4	518.7

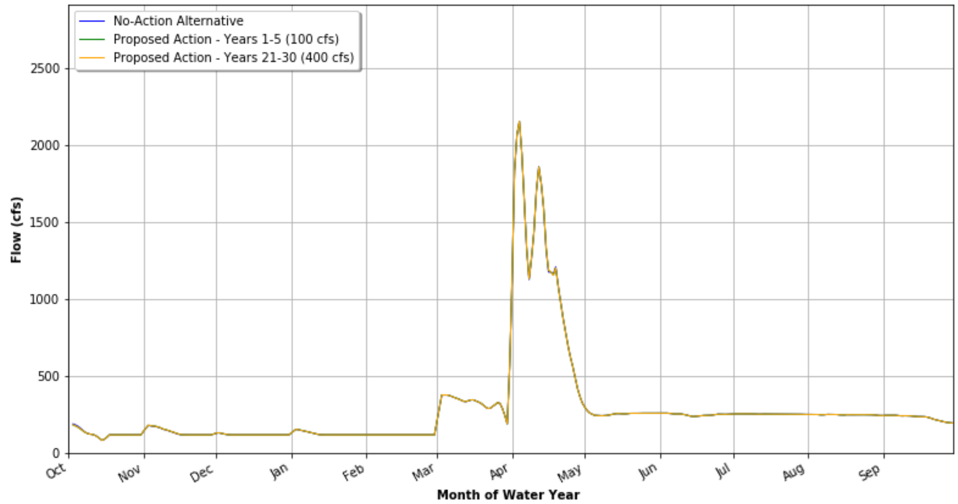
Total monthly streamflow volume (af) for representative wet, normal and dry years was evaluated to assess changes in seasonal streamflow. Proposed action results were compared to the no-action alternative and proposed action results are reported as the percent difference from the no-action alternative (Table 29). Streamflow would experience minimal changes except in a dry year when winter storage period flows increase 11% due to the minimum instream flows in winter.

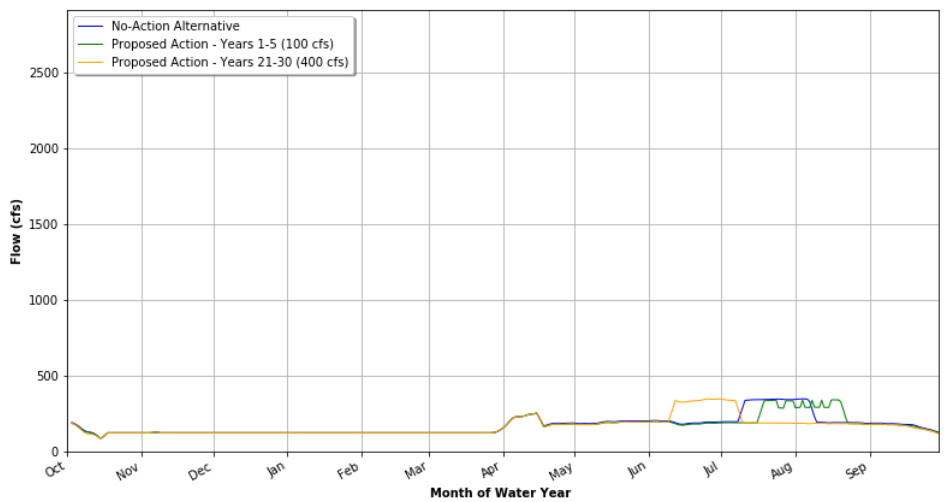
Table 29. Percent Differences in Streamflow Volume between the Proposed Action and the No-Action Alternative for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years for the PRVO Gauge

Water Year Type	Time Period	Proposed Action Years 1–5	Proposed Action Years 6–10	Proposed Action Years 11–20	Proposed Action Years 21–30
Wet	Irrigation Period	-3%	1%	1%	1%
	Winter/Storage Period	2%	-4%	-4%	-4%
	Annual	-2%	-1%	-1%	0%
	1 SD	-3%	-3%	-3%	-3%
Normal	Irrigation Period	0%	0%	0%	0%
	Winter/Storage Period	0%	0%	0%	0%
	Annual	0%	0%	0%	0%
	1 SD	0%	0%	0%	0%
Dry	Irrigation Period	-10%	-2%	-2%	-2%
	Winter/Storage Period	11%	11%	11%	11%
	Annual	-5%	1%	1%	1%
	1 SD	-32%	-11%	-13%	-13%

Figure 50 includes the representative normal and dry year hydrographs for the PRVO gauge under the proposed action in years 21 through 30. Normal year flows are substantially higher than dry year flows, although minimum winter flows are similar in both year types. In a dry year, stored water is released between mid-June and mid-July. Following the release, streamflow declines through September.

Figure 50. The Crooked River Hydrograph for the No-Action Alternative and Proposed Action in Years 21–30 in Representative Normal (upper) and Dry (lower) Years at the PRVO Gauge (Note flow scale differences.)

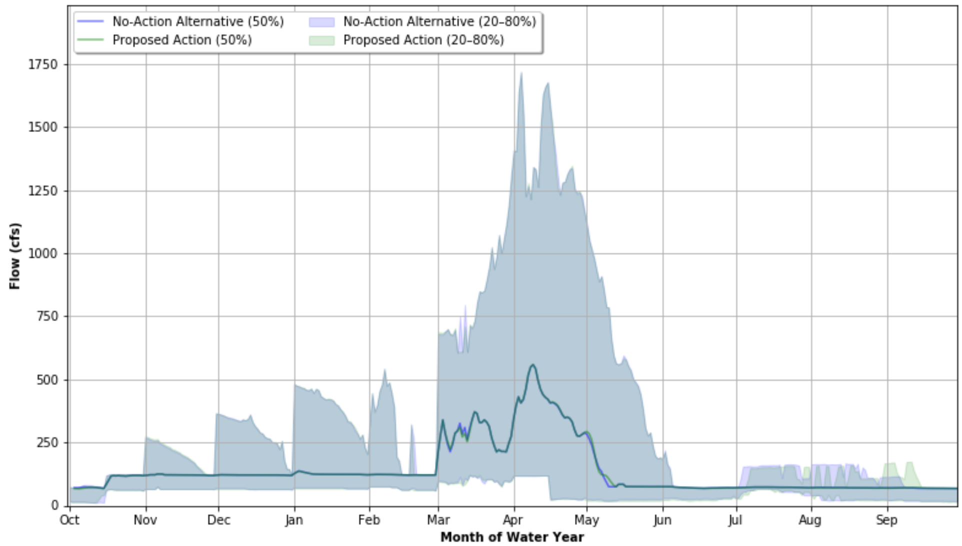




Crooked River from Bowman Dam to Highway 126 Crossing

Several diversions draw water from the Crooked River between Bowman Dam and the Highway 126 bridge (location of the CAPO gauge). Diversions including Rice Baldwin, Peoples, and the Crooked River Feed Canal are the primary diversions; smaller secondary diversions are also located in the reach. Comparative hydrographs for the no-action alternative and proposed action in years 1 through 5 and years 21 through 30 suggest similar flows at the CAPO gauge (Figure 51). In years 21 through 30, higher flows from May through August suggest flow releases to meet North Unit ID demands associated with the depletion of stored water in Wickiup Reservoir.

Figure 51. The Crooked River Hydrograph for Years 1–5 (upper) and Years 21–30 (lower) of the Proposed Action Based on Modeled Flows at the CAPO Gauge at the Highway 126 Bridge (Figures show the median flow and 20 to 80% flow range for the no-action alternative and proposed action.)



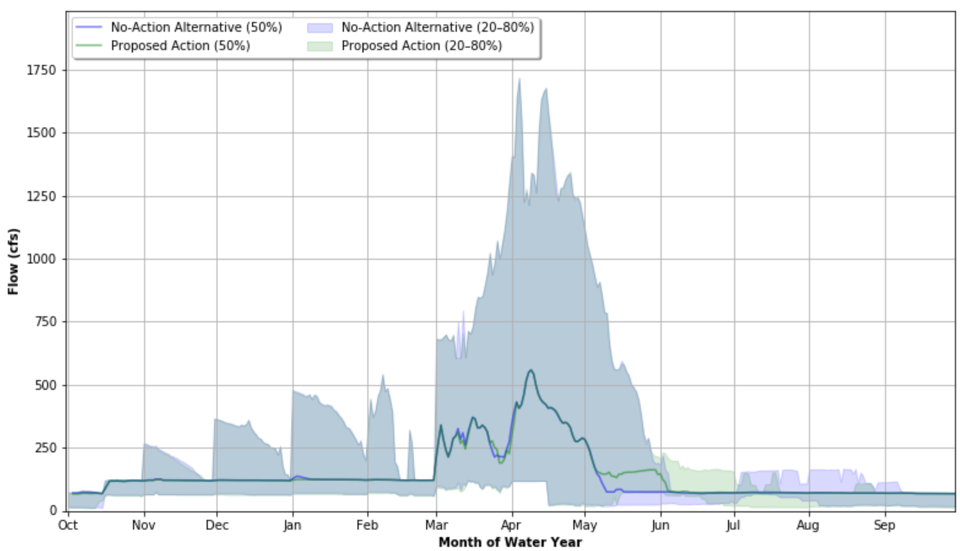


Table 30 includes a comparison of seasonal differences in minimum and maximum median flows based on CAPO gauge data. There are minimal differences in the minimum and maximum flow values for the winter and irrigation periods.

Table 30. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Crooked River at the CAPO Gauge by Season for the No-Action Alternative and Proposed Action over the Permit Term

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	**Minimum (cfs)**	**Maximum (cfs)**	**Minimum (cfs)**	**Maximum (cfs)**
No-Action	120.6	288.3	68.1	389.3
Proposed Action (Years 1–5)	120.5	281.7	68.7	389.6
Proposed Action (Years 6–10)	120.5	280.6	68.9	389.6
Proposed Action (Years 11–20)	120.5	280.4	68.7	391.4
Proposed Action (Years 21–30)	120.1	280.2	68.3	391.3

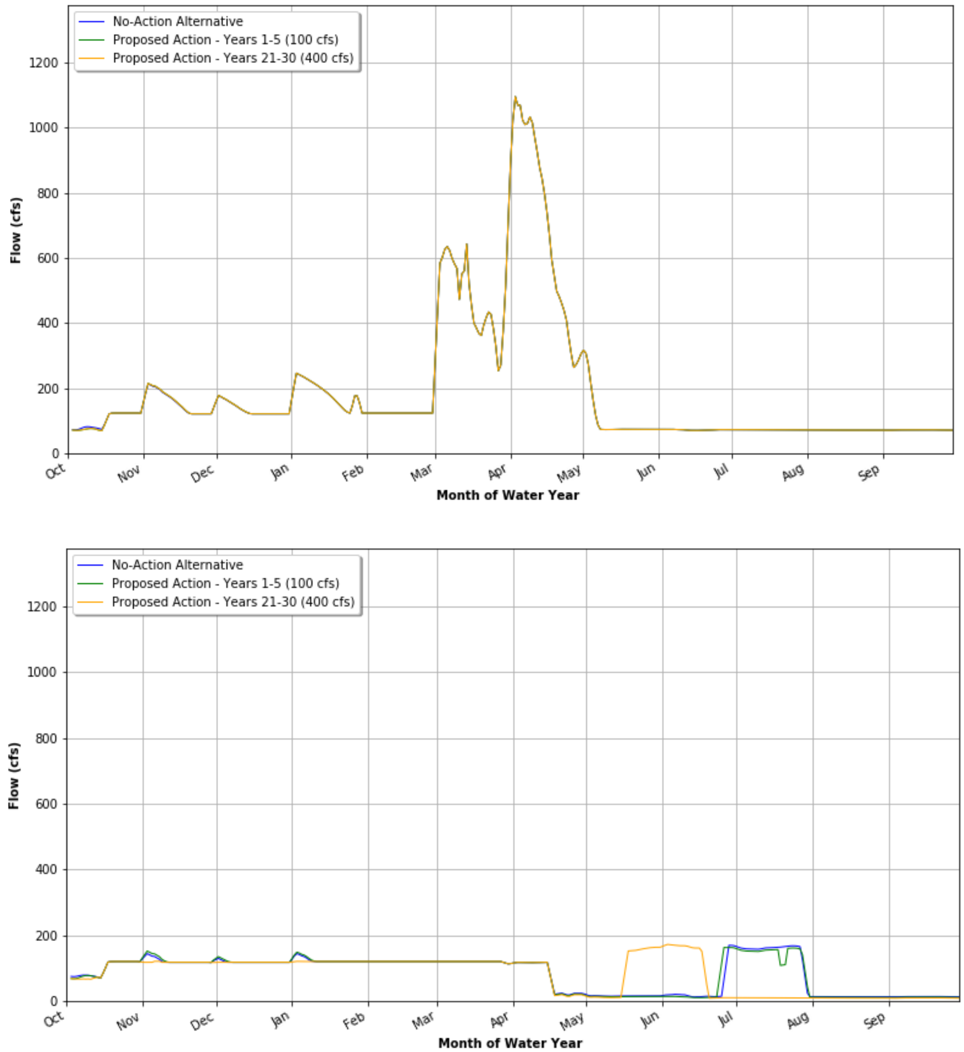
Total monthly streamflow volume (af) for representative wet, normal, and dry years was evaluated to assess changes in seasonal streamflow. Proposed action results were compared to the no-action alternative and proposed action results are reported as the percent difference from the no-action alternative (Table 31). Flow changes are greatest in a dry year and approximately the same as the no-action alternative in a normal year.

Table 31. Percent Differences in Streamflow Volume between the No-Action Alternative and Proposed Action for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years for the CAPO Gauge

		Proposed Action			
Water Year Type	**Time Period**	**Years 1–5**	**Years 6–10**	**Years 11–20**	**Years 21–30**
Wet	Irrigation Period	-4%	1%	1%	1%
	Winter/Storage Period	3%	-4%	-4%	-4%
	Annual	-2%	-1%	-1%	-1%
	1 SD	-3%	-4%	-4%	-4%
Normal	Irrigation Period	0%	0%	0%	0%
	Winter/Storage Period	0%	0%	0%	0%
	Annual	0%	0%	0%	0%
	1 SD	0%	0%	0%	0%
Dry	Irrigation Period	-1%	-5%	-5%	-5%
	Winter/Storage Period	8%	-1%	-1%	-1%
	Annual	4%	-3%	-2%	-3%
	1 SD	-9%	-11%	7%	-10%

Figure 52 includes the representative normal and dry year hydrographs for the CAPO gauge under the proposed action in years 1 through 5 and years 21 through 30. During a dry year, minimum flows are maintained during winter storage and a flow release to meet North Unit demand occurs from mid-May to mid-June, whereas in the no-action alternative, the flow release occurs between August and early September. Irrigation period flows are otherwise lower under the proposed action.

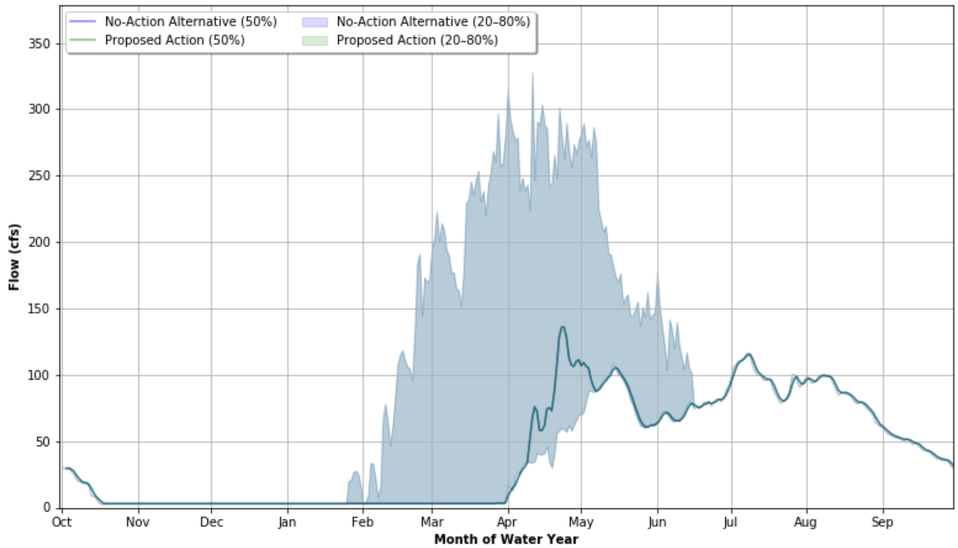
Figure 52. The Crooked River Hydrograph for the No-Action Alternative and Proposed Action in Years 1–5 and Years 21–30 in Representative Normal (upper) and Dry (lower) Years at the CAPO Gauge (Note flow scale differences.)

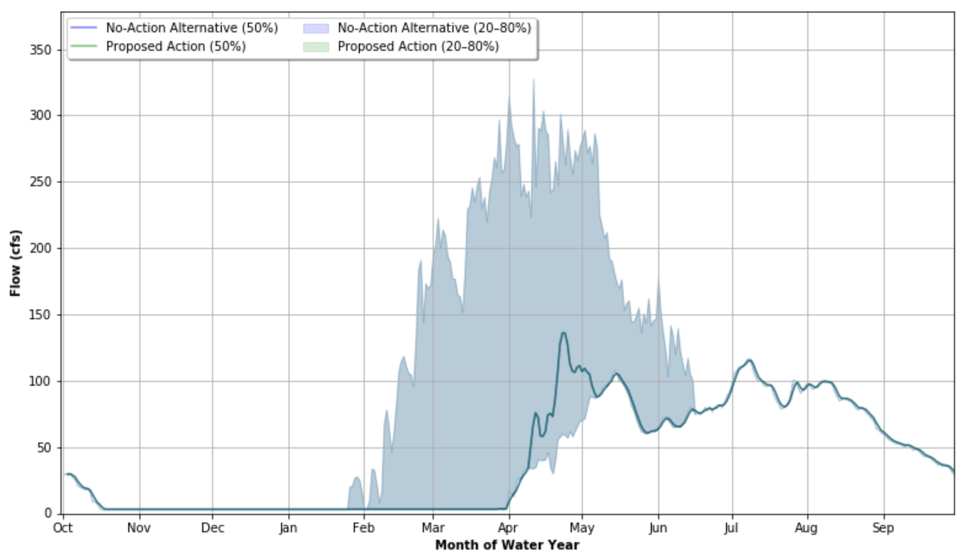


Ochoco Creek from Ochoco Dam to Crooked River

The no-action alternative and proposed action have similar flow results for Ochoco Creek based on the hydrographs developed for the OCHO gauge (Figure 53). Conservation Measure CR-2 will eliminate extreme low flows (historically as low as 0 cfs) by establishing minimum flows for the entire reach between Ochoco Dam and the mouth.

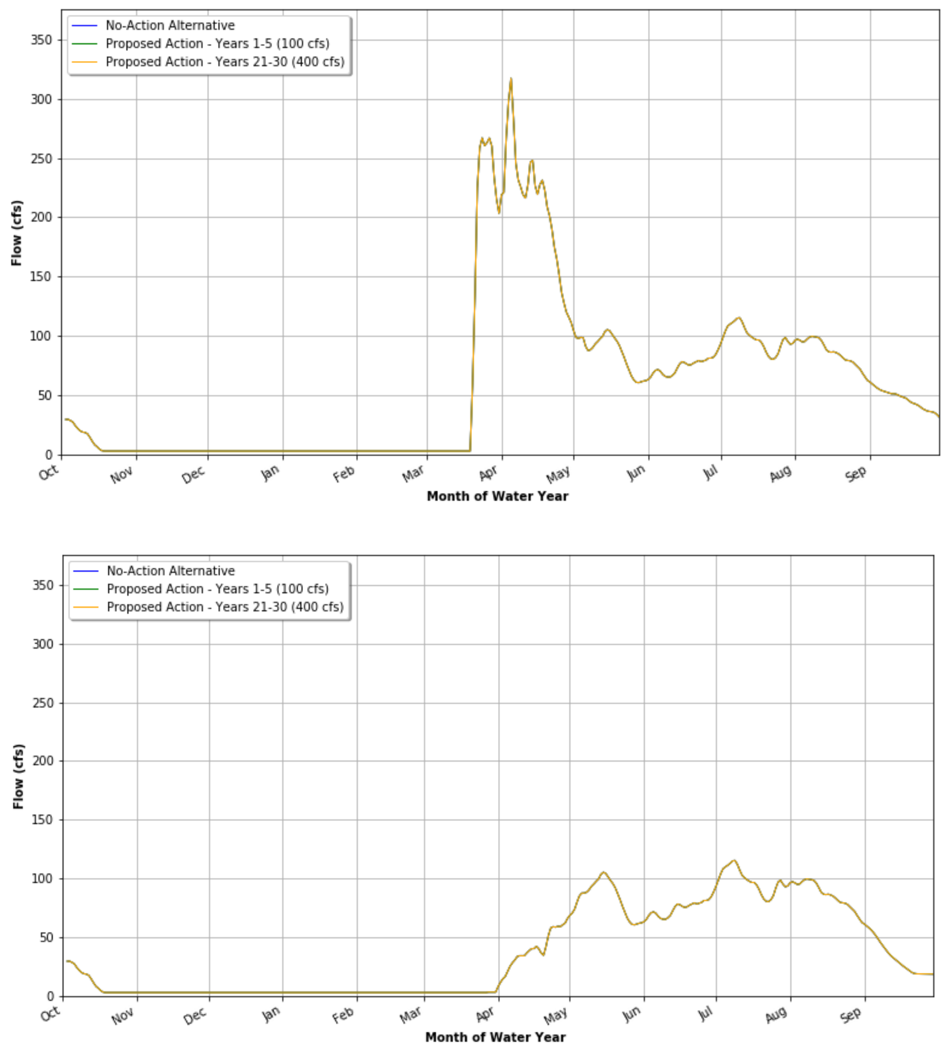
Figure 53. The Ochoco Creek Hydrograph for Years 1–5 (upper) and Years 21–30 (lower) of the Proposed Action based on Modeled Flows at the OCHO Gauge Downstream from Ochoco Reservoir (Figures show the median flow and 20 to 80% flow range for the no-action alternative and proposed action.)





There were no summary flow differences between the proposed action and no-action alternative for wet, normal, and dry years, although minimum flows will increase from approximately 0 cfs to 5 cfs during the irrigation season with implementation of Conservation Measure CR-2. Figure 54 includes normal year and dry year hydrographs for the OCHO gauge.

Figure 54. The Ochoco Creek Hydrograph for the No-Action Alternative and Proposed Action in Years 1–5 and 21–30 in Representative Normal (top) and Dry (bottom) Years at the OCHO Gauge



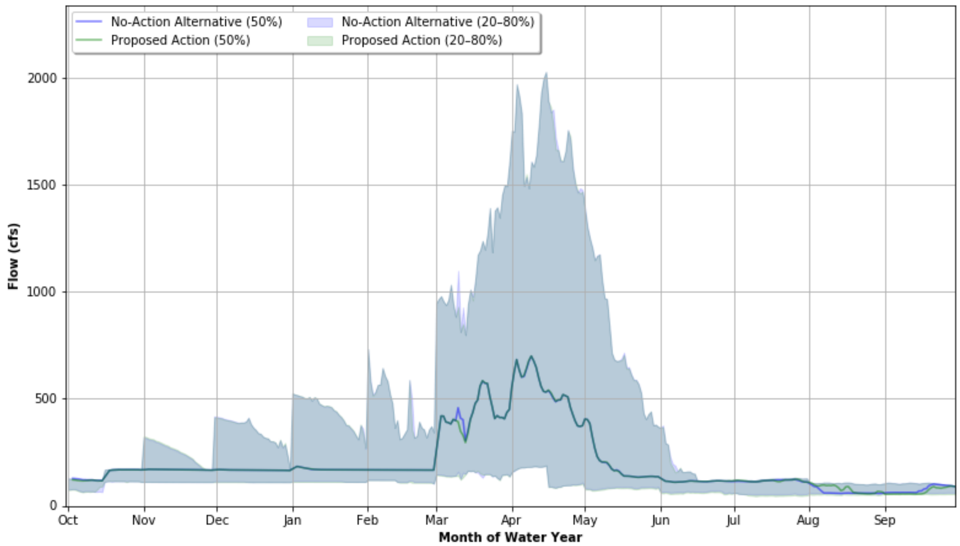
McKay Creek from Jones Dam to Crooked River

Conservation Measure CR-3 would result in increased minimum flows in McKay Creek during the irrigation season. Minimum flows would be between 2 and 5 cfs, depending on the reach, compared to as low as 1 cfs under the no-action alternative. Streamflow outside of the irrigation season would be unchanged.

Crooked River from North Unit Irrigation District Pump Station to Smith Rock State Park

Crooked River streamflow at the Smith Rock gauge (CRSO) located downstream from the North Unit ID pump station is shown in hydrographs for the proposed action in years 1 through 5 and years 21 through 30 of the permit term (Figure 55). The hydrographs are similar although median flows are lower from mid-June through early August as water is diverted by the North Unit ID pump station to meet water user demand.

Figure 55. The Crooked River Hydrograph for Years 1–5 (upper) and Years 21–30 (lower) of the No-Action Alternative and Proposed Action Based on Modeled Flows at the CRSO Gauge Downstream from the North Unit ID Pump Station (Figures show the median flow and 20 to 80% flow range for the no-action alternative and proposed action. Increased pumping at the North Unit ID pump station influences CRSO flows from June through August.)



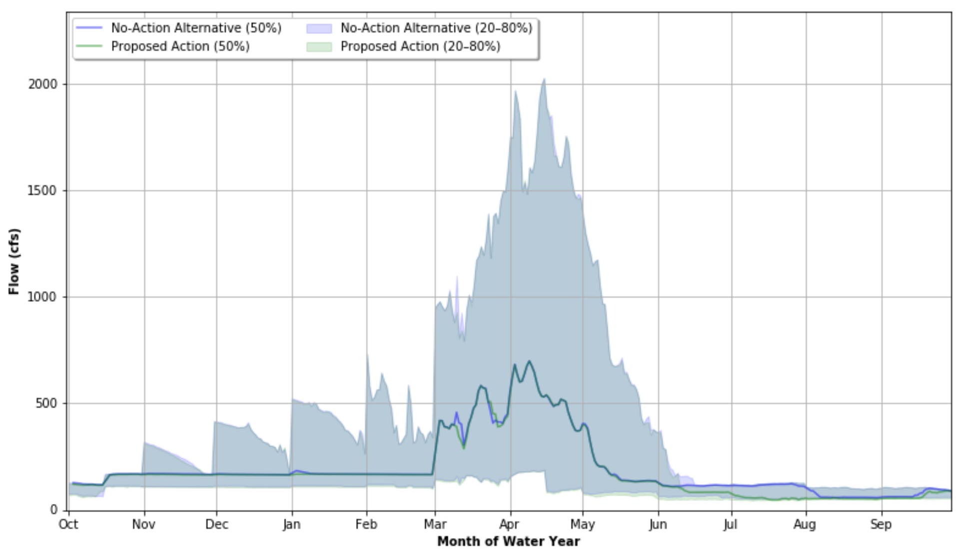


Table 32 includes a comparison of seasonal flow volume differences in minimum and maximum median flows based on CRSO gauge data. There are minimal flow differences over the permit term in both the winter storage and irrigation periods although minimum irrigation period flows decrease over time due to the additional pumping at the North Unit ID pump station.

Table 32. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Crooked River at the CRSO Gauge Downstream from the North Unit Irrigation District Pump Station by Season for the No-Action Alternative and Proposed Action

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	Minimum (cfs)	Maximum (cfs)	Minimum (cfs)	Maximum (cfs)
No-Action	166.1	413.9	59.2	511.7
Proposed Action (Years 1–5)	166.0	412.8	61.7	512.9
Proposed Action (Years 6–10)	165.5	410.3	53.5	512.6
Proposed Action (Years 11–20)	165.0	406.0	52.3	511.9
Proposed Action (Years 21–30)	164.5	405.6	52.2	511.7

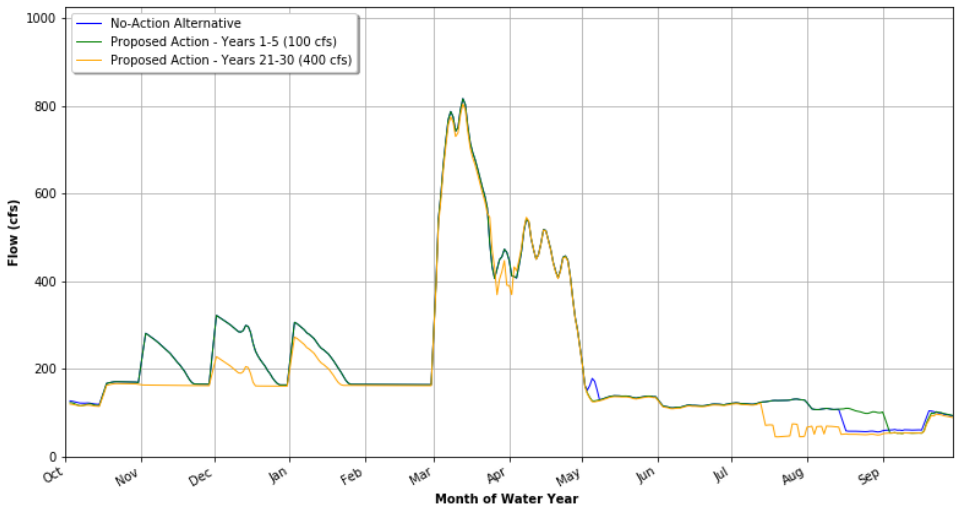
Total monthly streamflow volume (af) for representative wet, normal, and dry years were evaluated to assess changes in seasonal streamflow. Proposed action results were compared to the no-action alternative and proposed action results are reported as the percent difference from the no-action alternative (Table 33). Annual flows and irrigation period flows decrease between 4% and 8% in wet and normal years and increase 7% during a dry year winter storage period. Winter flows decrease in wet (4%) and normal (4%) years as reservoir releases are reduced in favor of storage, but increase 7% in dry years. Irrigation period flows decrease in all three water year types with the greatest reduction (8%) during normal years as the North Unit ID pumps divert more water to satisfy water user needs.

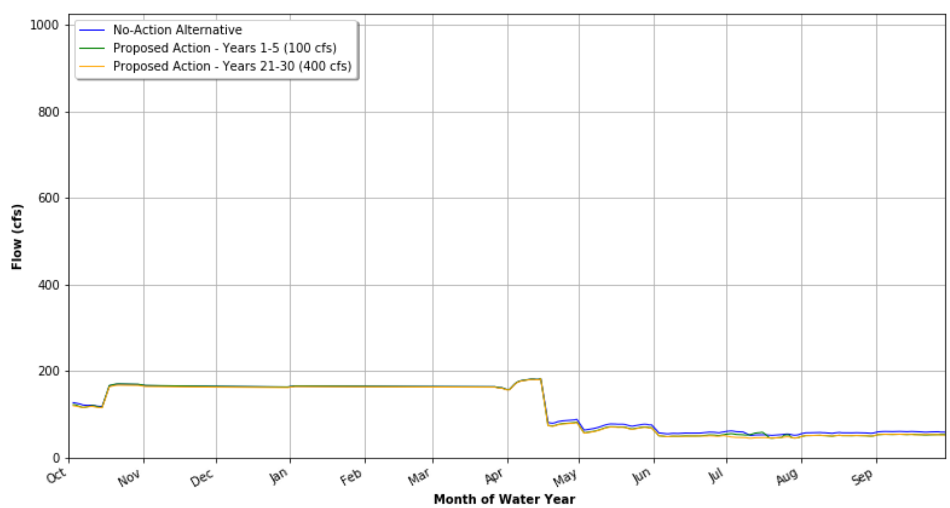
Table 33. Percent Differences between the Proposed Action and the No-Action Alternative for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years for the CRSO Gauge

Water Year Type	Time Period	Proposed Action			
		Years 1–5	Years 6–10	Years 11–20	Years 21–30
Wet	Irrigation Period	2%	-1%	-2%	-4%
	Winter/Storage Period	3%	-3%	-4%	-4%
	Annual	2%	-2%	-3%	-4%
	1 SD	-4%	-3%	-2%	-2%
Normal	Irrigation Period	5%	-1%	-3%	-8%
	Winter/Storage Period	2%	-1%	-2%	-4%
	Annual	3%	-1%	-3%	-5%
	1 SD	-2%	0%	0%	1%
Dry	Irrigation Period	-1%	-5%	-5%	-6%
	Winter/Storage Period	12%	7%	7%	7%
	Annual	6%	2%	1%	1%
	1 SD	0%	0%	0%	0%

Figure 56 presents the representative normal and dry year hydrographs for the CRSO gauge under the proposed action in years 1 through 5 and years 21 through 30. The hydrographs show the influence of the North Unit ID pump station flow diversion during the irrigation period in both normal and dry years. In a dry year, Crooked River flows are used to meet North Unit ID water needs as stored water in the Upper Deschutes River is depleted. Proposed action irrigation flows are lower than the no-action alternative from mid-April through the end of September.

Figure 56. The Crooked River Hydrograph for the No-Action Alternative and Proposed Action in Years 1–5 and 21–30 in Representative Normal (upper) and Dry (lower) Years at the CRSO Gauge (Note flow scale differences.)





Crooked River from Smith Rock State Park to Opal Springs Dam

Groundwater inputs between the Smith Rocks State Park gauge (CRSO) and the Crooked River below Opal Springs gauge (CROO), substantially increase Crooked River flows, especially in the winter when flows may increase tenfold between the CRSO and CROO gauges (Figure 57). Winter and irrigation period flows decrease relative to the no-action alternative beginning in year 6 of the permit term. With increasing minimum winter flows on the Upper Deschutes River, flow at the CROO gauge decreases slightly between mid-June and mid-September as flow is diverted at the North Unit ID pump station.

Figure 57. The Crooked River Hydrograph for Years 1–5 (upper) and Years 21–30 (lower) of the Proposed Action Based on Modeled Flows at the CROO Gauge Downstream from Opal Springs Dam (Figures show the median flow and 20 to 80% flow range for the no-action alternative and proposed action.)

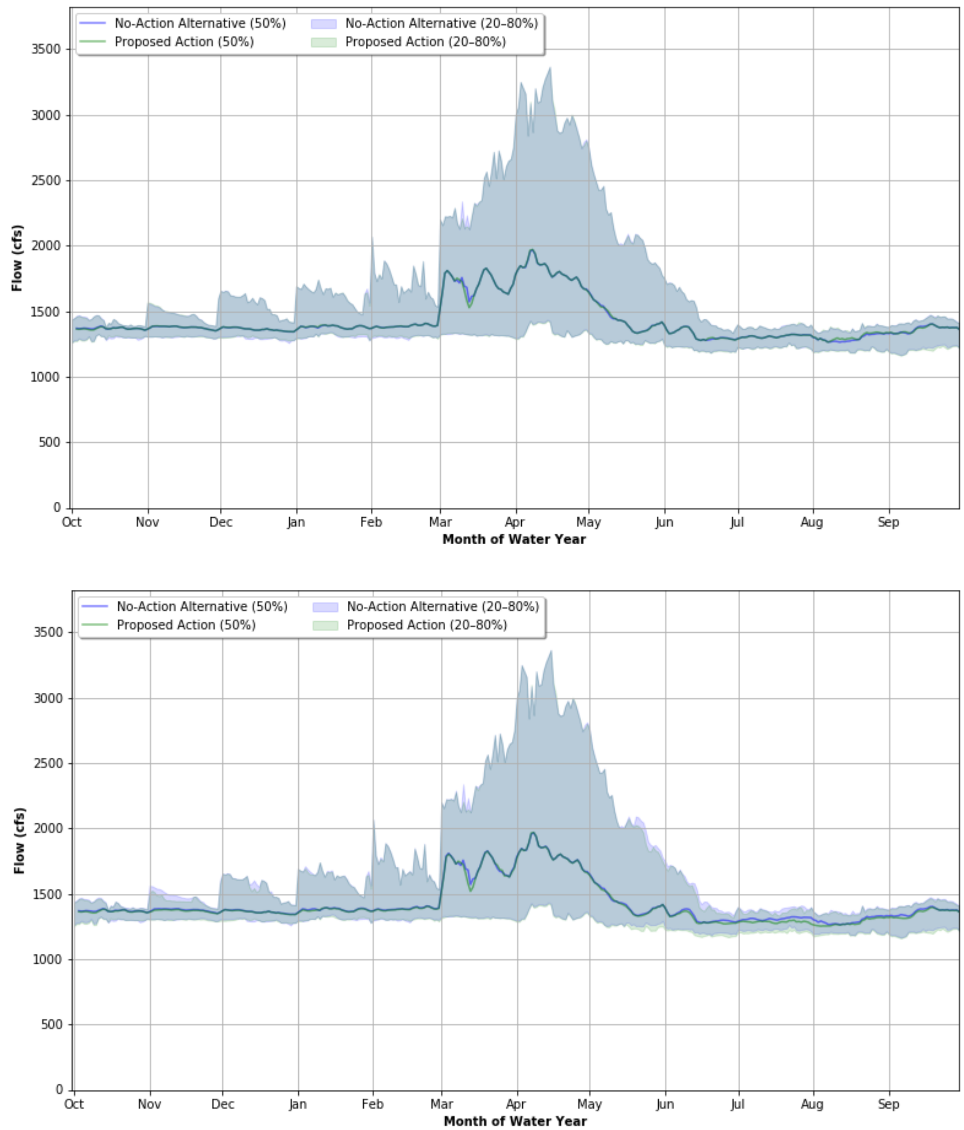


Table 34 includes a comparison of seasonal differences in minimum and maximum median flows based on CROO gauge data. The no-action alternative and proposed action have similar minimum and maximum median flows in the winter and summer suggesting the influence of groundwater inputs.

Table 34. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Crooked River at the CROO Gauge by Season for the No-Action Alternative and Proposed Action over the Permit Term

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	**Minimum (cfs)**	**Maximum (cfs)**	**Minimum (cfs)**	**Maximum (cfs)**
No-Action	1,361.2	1,698.6	1,291.0	1,777.3
Proposed Action (Years 1–5)	1,361.6	1,698.8	1,300.9	1,776.1
Proposed Action (Years 6–10)	1,361.0	1,698.0	1,295.9	1,775.0
Proposed Action (Years 11–20)	1,360.2	1,696.0	1,278.1	1,773.9
Proposed Action (Years 21–30)	1,358.9	1,692.0	1,273.8	1,772.7

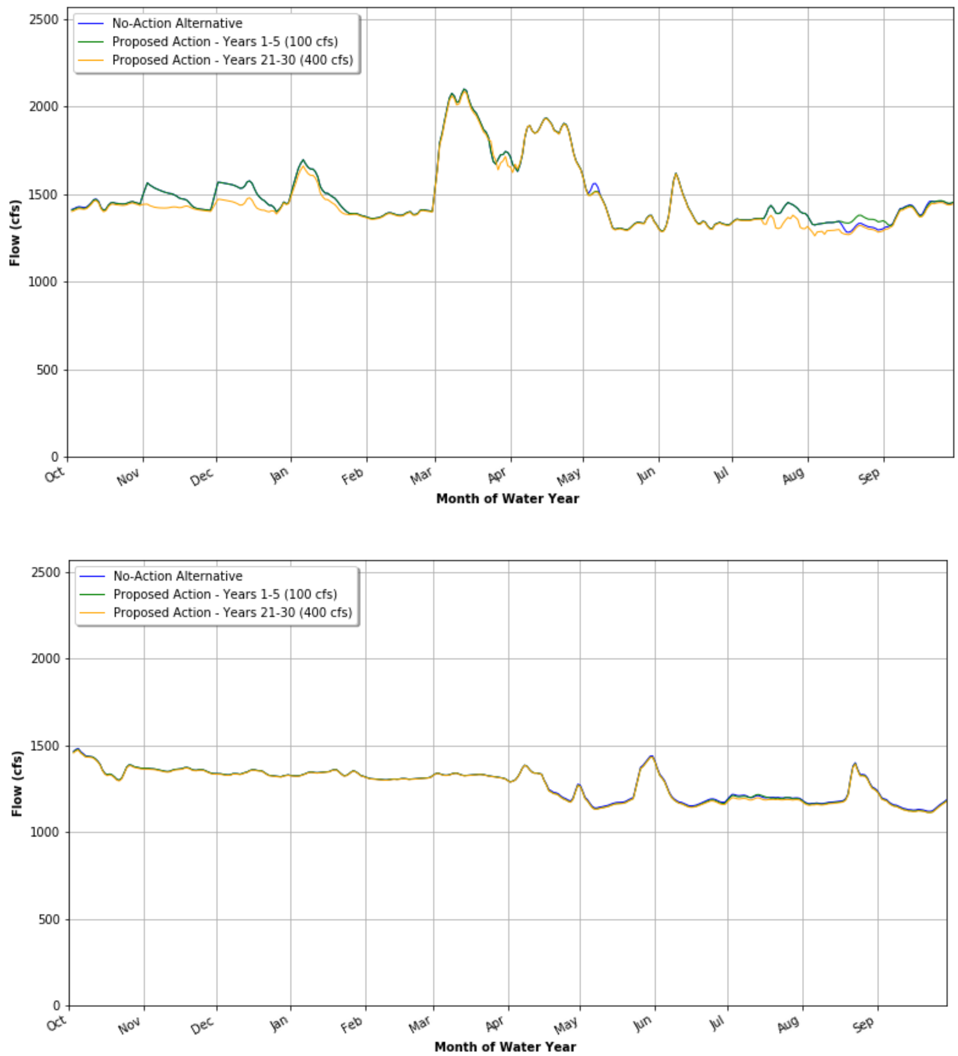
There are small differences in streamflow volumes in all water year types and over the permit term (Table 35). Differences relate to reduced winter storage flows as excess flow above minimum flow targets is stored in Prineville Reservoir, and the North Unit ID pump station diverts water to compensate for the effects of minimum flow targets on the Upper Deschutes River. The influence of the North Unit ID pump station diversion is less influential at the CROO gauge due to the large volume of groundwater inputs between the pump station and the CROO gauge.

Table 35. Percent Differences between the No-Action Alternative and Proposed Action for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years for the CROO Gauge

		Proposed Action			
Water Year Type	**Time Period**	**Years 1–5**	**Years 6–10**	**Years 11–20**	**Years 21–30**
Wet	Irrigation Period	1%	0%	-1%	-1%
	Winter/Storage Period	1%	-1%	-1%	-1%
	Annual	1%	-1%	-1%	-1%
	1 SD	-4%	-3%	-2%	-2%
Normal	Irrigation Period	1%	0%	0%	-1%
	Winter/Storage Period	0%	0%	-1%	-1%
	Annual	1%	0%	0%	-1%
	1 SD	-1%	0%	0%	0%
Dry	Irrigation Period	0%	18%	0%	-1%
	Winter/Storage Period	1%	17%	1%	1%
	Annual	1%	18%	0%	0%
	1 SD	6%	192%	6%	6%

Figure 58 includes the representative normal and dry year hydrographs for the CROO gauge under the proposed action in years 21 through 30. In a normal year, the proposed action has lower flows from November through mid-January and from late July through mid-September. In a dry year, proposed action flows are lower in July, but otherwise similar to the no-action alternative.

Figure 58. The Crooked River Hydrograph for the No-Action Alternative and Proposed Action in Years 21–30 in Representative Normal (top) and Dry (bottom) Years at the CROO Gauge



Crooked River Flood Flows

The Crooked River flood flow analysis assessed effects on the magnitude of the regulatory base flood (100-year) and 500-year floods, and more frequent floods associated with shallow floodplain inundation.

The base flood (1%, 100-year event) and the 500-year (0.2%) event were evaluated for the CAPO gauge (OR 126 crossing) to capture flood risk areas between the CAPO gauge and the City of Prineville. The base flood flow would increase by approximately 5% and the 500-year event would increase by approximately 8%. Because Ochoco Reservoir and Crooked River Reservoir are operated in tandem to reduce flood potential on the Crooked River, reservoir managers would continue to operate the reservoirs for flood control. Based on the proposed action's minimal influence on the base flood and 500-year flood, the proposed action is not expected to affect flood risk for properties in the Crooked River portion of the study area.

To assess the proposed action's influence on more frequent, low magnitude floods, recent flood reports from March 2017 (West 2017) for the Crooked River upstream from Prineville were used to determine a threshold flood flow of 2,500 cfs. The maximum flow for each day of the water year was calculated from the RiverWare model output. The no-action alternative and proposed action each resulted in 64 days that exceeded the 2,500 cfs flood threshold. The proposed action is therefore not anticipated to increase the frequency of shallow floodplain inundation relative to the no-action alternative.

WR-5: Affect Groundwater Recharge

Reservoirs and Deschutes River

Changes to the operation of Crane Prairie Reservoir could result in a change in seepage losses that vary with reservoir stage. Narrower limits on the range of surface elevations in Crane Prairie Reservoir under the proposed action would result in generally higher reservoir stages from approximately late September through early May and relatively lower reservoir stages from mid-May through mid-September. Seepage losses from this reservoir increase with higher reservoir stages. Although a large portion of this seepage loss from Crane Prairie Reservoir returns to the river system just downstream of the reservoir at the Sheep Springs complex, some small portion could be reaching the basin's groundwater system. The proposed action at the Crane Prairie Reservoir could have a small beneficial effect on the regional groundwater system water levels. However, the resulting small increase in groundwater recharge from the reservoir would likely be *de minimus* compared to the average annual groundwater recharge of 3,800 cfs (Gannett et al. 2001: 29).

Adjustments to the timing and flow in the Deschutes below Wickiup Dam would have no effect on the groundwater system with the exception of the river segment downstream of Sunriver. In this river segment, seepage from the river to the groundwater system is proportional to the flow rate. Increases in winter flows under the proposed action would result in an increase of recharge to the groundwater system after the first 5 years of implementing the proposed action, resulting in a small beneficial effect on the groundwater system. However, based on the relationship of seepage to flow described in the Affected Environment section, at the proposed action's peak winter discharge rate of 400 cfs, the resulting increase to groundwater recharge would be less than 0.3% of the average annual groundwater recharge of 3,800 cfs (Gannett et al. 2001: 29) and would likely be masked by the naturally occurring basin-scale groundwater level fluctuations associates with climatic cycles (Gannett and Lite:33).

Additional changes to the flows in the Middle Deschutes River during the winter period for livestock diversions are not expected to affect the groundwater system because the stream reaches downstream of Bend are either neutral or are gaining reaches. Impacts on the regional groundwater system from increases in streamflow within gaining reaches would only result in potential minor localized effects on groundwater levels that would be attenuated and absorbed by the regional groundwater system and, therefore, would not affect the overall system.

Crescent Creek and Little Deschutes River

Changes in the release, and rate of releases from Crescent Lake are not expected to affect the regional groundwater system. The water table elevation in this portion of the study area is near land surface and the stream gains and losses along most of reaches of Crescent Creek are small, indicating relatively little net exchange of water between the groundwater and river systems.

Whychus Creek

Whychus Creek is either a neutral or gaining stream (with a short losing reach just upstream of Sisters), therefore the minor localized effects on the groundwater system from additional flow provided to Whychus Creek and modifications to the Three Sisters ID diversion would be attenuated and absorbed by the regional groundwater system. There would be no change to the regional groundwater system from increased flows.

Crooked River

Changes in the scheduled release of water from Prineville Reservoir are not expected to affect the regional groundwater system because the Crooked River is either a neutral or gaining stream (LaMarche pers. comm. [a, b]). Potential minor localized impacts on the water levels from increases in streamflow will be attenuated and absorbed by the regional groundwater system.

Impact Summary

The proposed action could result in minor changes in groundwater recharge within the study area. However, these minor changes in groundwater recharge would likely be *de minimus* compared to the average annual groundwater recharge and likely masked by the naturally occurring basin-scale groundwater level fluctuations associates with climatic cycles. The potential for City of Prineville groundwater pumping to affect Crooked River streamflow would be mitigated by the current groundwater pumping mitigation program. Therefore, there would be no adverse effect on the groundwater recharge under the proposed action.

Alternative 3: Enhanced Variable Streamflows

Alternative 3 would increase fall and winter flows in the Deschutes River below Wickiup Dam sooner than under the proposed action, add a Deschutes River Conservation Fund, provide improved pumping flexibility at North Unit ID's Crooked River pumping station, and protect uncontracted storage releases on the Crooked River instream to Lake Billy Chinook. All other conservation measures and the adaptive management and monitoring program would be the same as under the proposed action.

Changes in streamflows and reservoir elevations and variability would be the same as described for the proposed action for all reaches except for the Crooked River and the Upper and Middle Deschutes River. In the Crooked River reaches changes would be of slightly greater magnitude compared to those described for the proposed action.

Under Alternative 3, as under the proposed action, summer flows would diminish and winter flows would increase compared to the no-action alternative. Alternative 3 would alter the timing of those changes, such that winter minimum flow targets would be achieved earlier in the permit term and would end at a higher level compared to the proposed action. Although Alternative 3 targets the higher minimum flow (500 cfs) in above-normal and wet years, the model used the same assumption for release of flows in excess of the minimum for the proposed action in above-normal and wet years. Therefore, modeled flow values presented for the proposed action and Alternative 3 at these flows (400 cfs and 400 to 500 cfs, respectively) are the same.

Alternative 3 minimum winter flow targets on the Upper Deschutes River would be implemented in three stages: 200 cfs in years 1 through 5, 300 cfs in years 6 through 10, and 400 to 500 cfs in years 11 through 30.

The values presented in the effects analysis are direct RiverWare model outputs (without rounding). They are not intended as exact predictions of future conditions, but and are used for purposes of comparing among alternatives.

WR-1: Change Reservoir Storage

Modeled changes in reservoir water supply storage under Alternative 3 would be the same as described for the proposed action except in Prineville Reservoir, described below. In addition, modeled changes in Wickiup and Crescent Lake Reservoir storage described for the proposed action would occur earlier in the permit term, as described below.

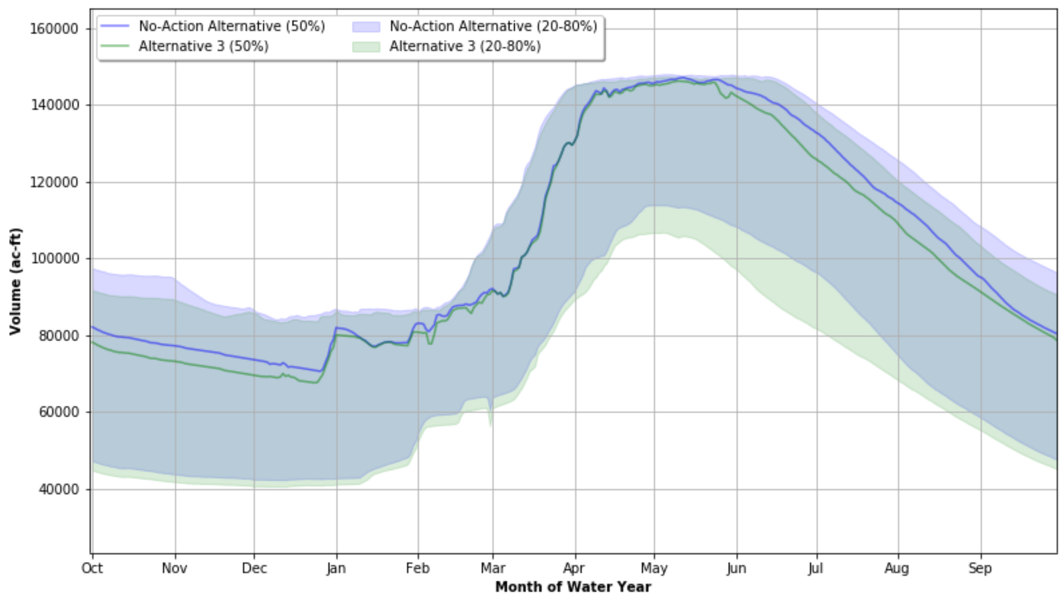
Modeled changes in Crane Prairie Reservoir and Ochoco Reservoir storage would be the same as described under the proposed action.

Modeled changes in Wickiup Reservoir and Crescent Lake Reservoir storage would be the same as described for the proposed action but would occur earlier in the permit term:

- Alternative 3 years 1 through 5 would be equivalent to proposed action years 6 through 10.
- Alternative 3 years 6 through 10 would be equivalent to proposed action years 11 through 20.
- Alternative 3 years 11 through 30 would be equivalent to proposed action years 21 through 30.

As winter flow releases out of Wickiup Reservoir increase starting in year 1 of the permit term, reducing North Unit ID's stored water supply in the Deschutes, North Unit ID's use of stored water from Prineville Reservoir would increase. This, combined with increased winter minimum flows in the Crooked River (Conservation Measure CR-1), would result in reduced Prineville Reservoir storage in most years. Changes in storage would range from a reduction of approximately 200 af during wet and very wet years to a reduction of 9,843 af during a very dry year. Although the reduction in Prineville Reservoir storage is high during very dry years, the average reduction in storage would be 2,180 af, equivalent to less than 2% of total storage. Figure 59 compares Prineville Reservoir storage under the no-action alternative to years 11 through 30 of the permit term under Alternative 3. Additionally, increasing bypass flows in McKay Creek and Ochoco Creek and protecting stored water under temporary instream leases for Ochoco ID patrons (Conservation Measures CR-2, CR-3, and CR-4) may contribute to a decline in Prineville Reservoir storage by increasing Ochoco ID stored water releases in years that Prineville Reservoir does not fill.

Figure 59. Modeling Results comparing Prineville Reservoir Storage under the No-Action Alternative and Alternative 3 during Years 11–30 of the Permit Term



WR-2: Change Water Supply for Irrigation Districts and Other Surface Water Users

Modeled changes water supply under Alternative 3 would be the same as described for the proposed action except for North Unit ID, described below. In addition, modeled changes for all water users described for the proposed action would occur earlier in the permit term, as described below.

Modeled changes in water supply would be the same as described for the proposed action but would occur earlier in the permit term:

- Alternative 3 years 1 through 5 would be equivalent to proposed action years 6 through 10.
- Alternative 3 years 6 through 10 would be equivalent to proposed action years 11 through 20.
- Alternative 3 years 11 through 30 would be equivalent to proposed action years 21 through 30.

However, compared to the proposed action, there is only a small reduction in water supply for North Unit ID under Alternative 3 caused by changes in management of Prineville Reservoir releases from the uncontracted storage account. Table 47 compares diversions under the no-action alternative, proposed action, Alternative 3, and Alternative 4. Table 47 shows the difference between North Unit ID diversions under the proposed action and Alternative 3 only exceeds 1% of diversions under the no-action alternative in normal years when Wickiup outflows are at their highest. Under those conditions, the reduction in diversions is equal to 1.6%.

WR-3: Changes in Reservoir Water Surface Elevations and Flood Storage Capacity

Modeled changes in reservoir water surface elevation and related flood storage capacity would be the same as described for the proposed action except in Prineville Reservoir, described below. In addition, modeled changes in Wickiup Reservoir and Crescent Lake Reservoir for the proposed action would occur earlier in the permit term, as described below.

Modeled changes in Crane Prairie Reservoir and Ochoco Reservoir storage would be the same as described under the proposed action.

Modeled changes in Wickiup Reservoir and Crescent Lake Reservoir storage would be the same as described for the proposed action but would occur earlier in the permit term:

- Alternative 3 years 1 through 5 would be equivalent to proposed action years 6 through 10.
- Alternative 3 years 6 through 10 would be equivalent to proposed action years 11 through 20.
- Alternative 3 years 11 through 30 would be equivalent to proposed action years 21 through 30.

Instream protection of released uncontracted storage water from Bowman Dam to Lake Billy Chinook, as part of Conservation Measure CR-1 under Alternative 3, would result in slightly lower median and maximum Prineville Reservoir elevations under Alternative 3 compared to both the no-action alternative and proposed action. Differences in reservoir elevation between Alternative 3 and the no-action alternative are greatest early in the winter storage period (October through December). Under Alternative 3, median (Figure 60) and maximum (Figure 61) monthly water surface elevations are less than the 90% flood storage capacity.

Figure 60. Comparison of Monthly Median Water Surface Elevations for Prineville Reservoir (The reference elevation associated with the outlet works is 3,234.80 ft [red line]. The 90% flood storage capacity is based on a total reservoir capacity of 148,633 af.)

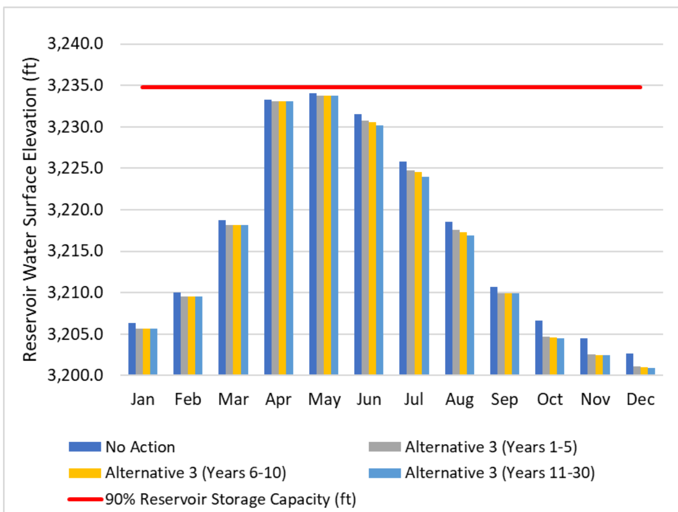
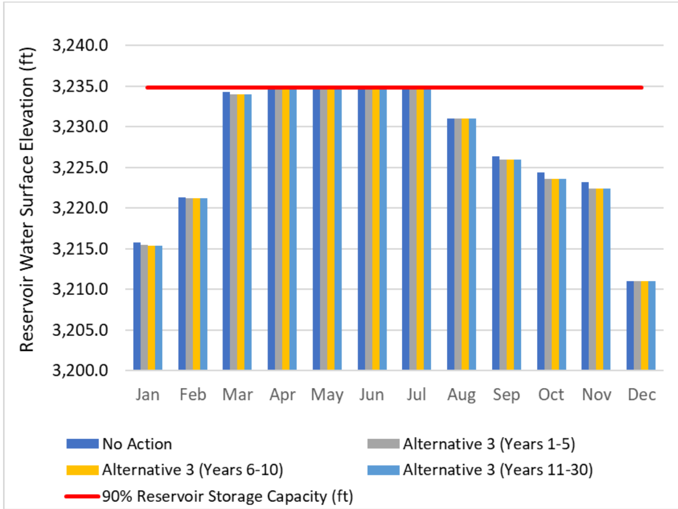


Figure 61. Comparison of Monthly Maximum Water Surface Elevations for Prineville Reservoir (The reference elevation associated with the outlet works is 3,234.80 ft [red line]. The 90% flood storage capacity is based on a total reservoir capacity of 148,633 af.)



WR-4: Change Seasonal River and Creek Flow and Flood Flows

Modeled changes in streamflows are the same as described for the proposed action for all reaches except for the Crooked River, described below. In addition, modeled changes for the Deschutes River downstream of Wickiup Reservoir and for Crescent Creek would occur earlier in the permit term:

- Alternative 3 years 1 through 5 would be equivalent to proposed action years 6 through 10.
- Alternative 3 years 6 through 10 would be equivalent to proposed action years 11 through 20.

Alternative 3 years 11 through 30 would be equivalent to proposed action years 21 through 30. Flood flow magnitude and number of days exceeding the flood flow threshold would be the same as described for the proposed action for both the Deschutes and Crooked River.

Crooked River Outflow from Bowman Dam

As under the proposed action, if uncontracted storage water is insufficient to meet the 50 cfs storage season minimum flow, Ochoco ID would release contracted water or bypass live flow to meet the minimum flow. Increasing minimum flows from 200 cfs (years 1–5 of the permit term) to 400 cfs (years 11–30 of the permit term) on the Upper Deschutes River results in water delivery shortage for North Unit ID, which in turn requires North Unit ID to rely more heavily on Crooked River water. To meet North Unit ID demand, additional water is released from Prineville Reservoir and higher Crooked River flows are marked by elevated median flows from early-May through late June under Alternative 3 (Figure 62). Higher flows are released in years 11 through 30 to meet the higher demand associated with the 400 cfs minimum winter flows on the Upper Deschutes River.

Figure 62. The Crooked River Hydrograph for Years 1–5 (upper) and Years 11–30 (lower) for the No-Action Alternative and Alternative 3 Based on Modeled Flows at the PRVO Gauge (Figures show the median flow and 20 to 80% flow range for the two alternatives.)

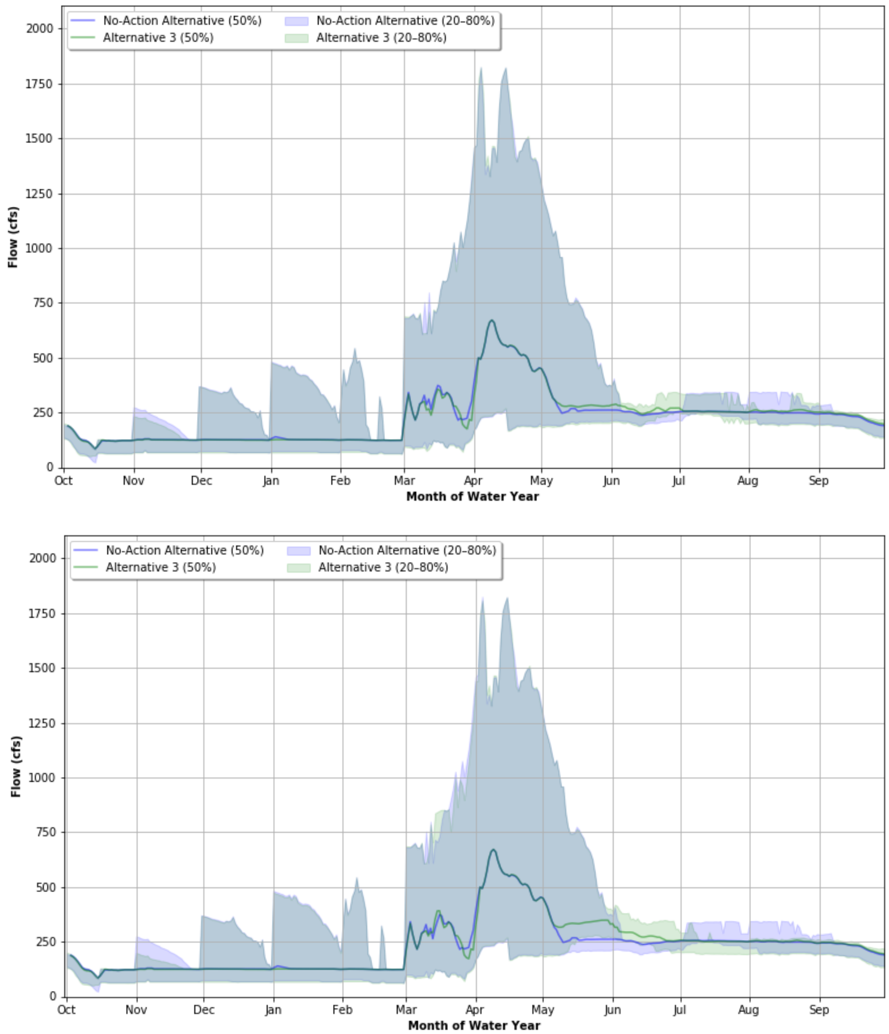


Table 36 includes a comparison of seasonal differences in minimum and maximum median flows based on PRVO gauge data. There are minor differences in the winter storage flows over the permit term and differences in the maximum median flows relative to the no-action alternative is due to a reduction in Alternative 3 flows in late March. The Alternative 3 winter period maximum flows are also about 10% less than the proposed action flows. Irrigation period flows are similar to the no-action alternative and proposed action flows.

Table 36. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Crooked River at the PRVO Gauge by Season for the No-Action Alternative and Alternative 3 over the Permit Term

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	Minimum (cfs)	Maximum (cfs)	Minimum (cfs)	Maximum (cfs)
No-Action	123.8	297.6	119.9	518.2
Alternative 3 (Years 1–5)	123.7	262.5	118.6	518.4
Alternative 3 (Years 6–10)	123.7	272.1	118.4	518.4
Alternative 3 (Years 11–30)	123.7	271.0	118.4	518.4

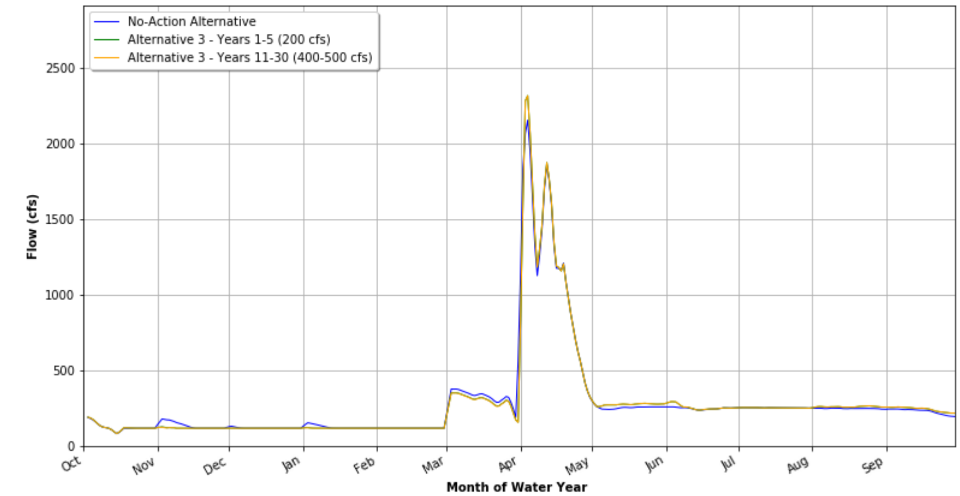
Total monthly streamflow volume (af) for representative wet, normal and dry years was evaluated to assess changes in seasonal streamflow (Table 37). Under Alternative 3, flows within a water year type remain the same relative to the no-action alternative over each of the three time periods. Alternative 3 flows under representative wet and dry years have the same results as the proposed action when compared to the no-action alternative. However, in a normal year, Alternative 3 flows differ from the no-action alternative with higher irrigation period flows, lower winter storage period flows, and slightly greater annual flows.

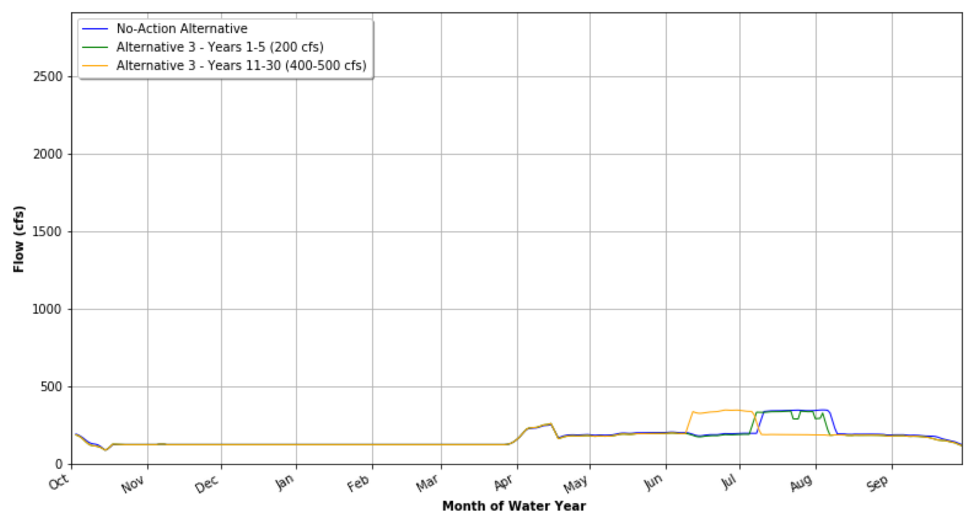
Table 37. Percent Differences in Streamflow Volume between the No-Action Alternative and Alternative 3 for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years at the PRVO Gauge

		Alternative 3		
Water Year Type	Time Period	Years 1–5	Years 6–10	Years 11–30
Wet	Irrigation Period	1%	1%	1%
	Winter/Storage Period	-4%	-4%	-4%
	Annual	-1%	-1%	0%
	1 SD	-3%	-3%	-3%
Normal	Irrigation Period	4%	4%	4%
	Winter/Storage Period	-8%	-8%	-8%
	Annual	1%	1%	1%
	1 SD	3%	3%	3%
Dry	Irrigation Period	-2%	-2%	-2%
	Winter/Storage Period	11%	11%	11%
	Annual	1%	1%	1%
	1 SD	-11%	-13%	-13%

Figure 63 includes the representative normal and dry year hydrographs for the PRVO gauge under Alternative 3 in years 1 through 5 and years 11 through 30. In a representative normal year, flows associated with Alternative 3 and the no-action alternative are very similar. In a representative dry year, month-long elevated flows occur from early August to early September under the no-action alternative and years 1 through 5 of Alternative 3. The elevated flow period occurs from early June to early July in year 11 through 30 of Alternative 3 as stored water is released from Prineville Reservoir for North Unit ID.

Figure 63. The Crooked River Hydrograph for the No-Action Alternative and Alternative 3 in Years 1–5 and Years 11–30 in Representative Normal (upper) and Dry (lower) Years at the PRVO Gauge

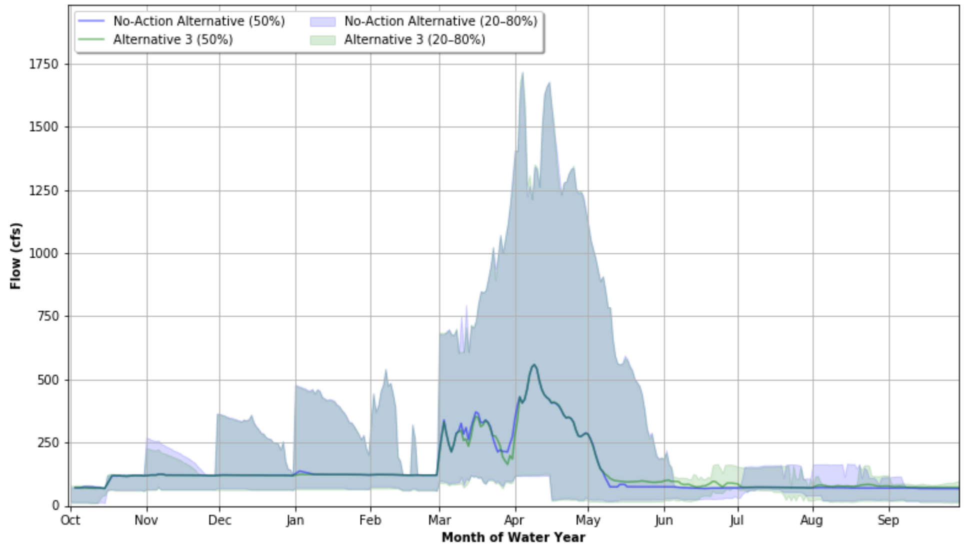




Crooked River from Bowman Dam to Highway 126 Crossing

A similar pattern of lower maximum median winter storage period flows, and similar irrigation period flows occur at the CAPO gauge under Alternative 3. Like the results for the PRVO gauge, Alternative 3 flows increase in years 1 through 5 from early May through the end of June to meet North Unit ID water demand (Figure 64). Flows during this time period increase in years 11 through 30 when more of North Unit ID's demand is met by Crooked River flows due to depleted stored water Wickiup Reservoir on the Upper Deschutes River.

Figure 64. The Crooked River Hydrograph for Years 1–5 (upper) and Years 11–30 (lower) for the No-Action Alternative and Alternative 3 Based on Modeled Flows at the CAPO Gauge (Figures show the median flow and 20 to 80% flow range for the two alternatives.)



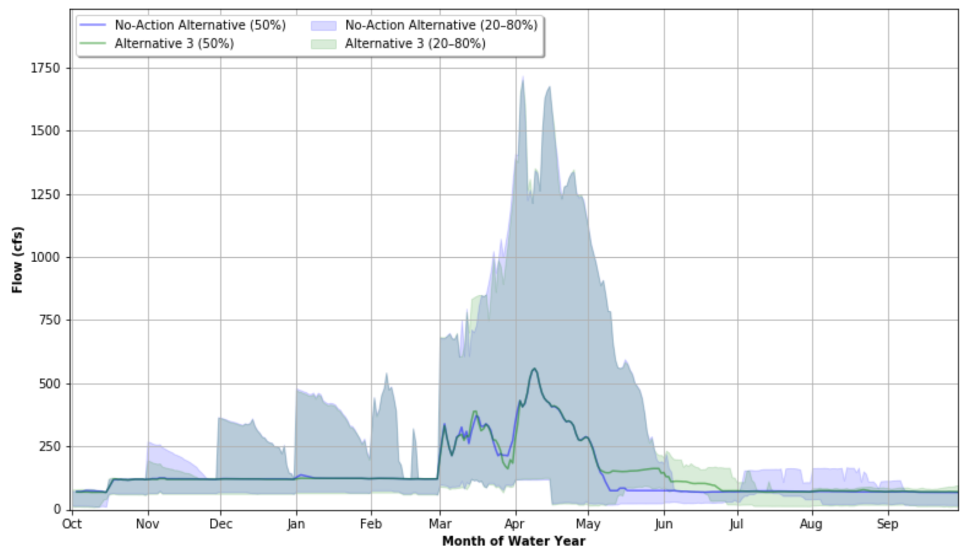


Table 38 includes a comparison of seasonal differences in minimum and maximum median flows based on CAPO gauge data. There are minimal differences in the minimum and maximum flow values for the winter and irrigation periods.

Table 38. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Crooked River at the CAPO by Season for the No-Action Alternative and Alternative 3 over the Permit Term

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	**Minimum (cfs)**	**Maximum (cfs)**	**Minimum (cfs)**	**Maximum (cfs)**
No-Action	120.6	288.3	68.1	389.3
Alternative 3 (Years 1–5)	120.5	260.1	72.1	391.5
Alternative 3 (Years 6–10)	120.5	263.1	70.5	391.3
Alternative 3 (Years 11–30)	119.1	262.9	70.3	391.3

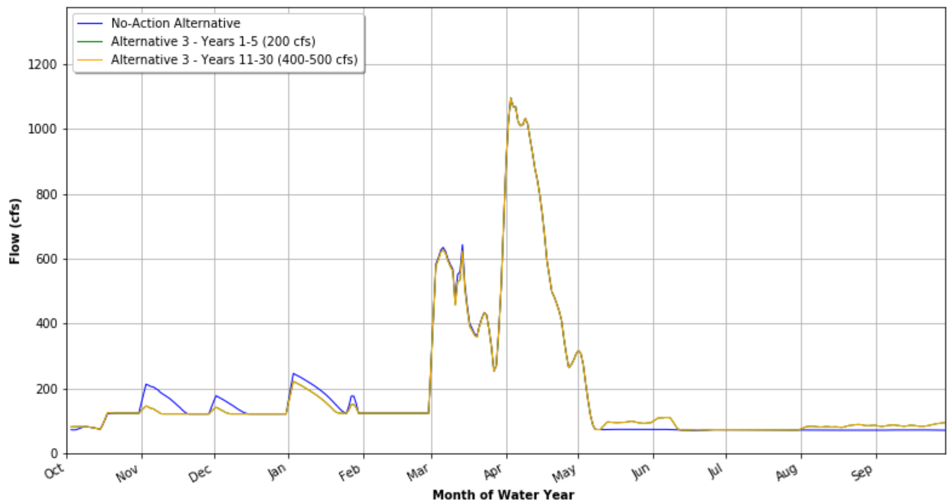
Total monthly streamflow volume (af) for representative wet, normal and dry years was evaluated to assess changes in seasonal streamflow (Table 39). Under Alternative 3, flows within a water year type remain the same relative to the no-action alternative over each of the three time periods. Alternative 3 flows under representative wet and dry years have the same results as the proposed action when compared to the no-action alternative. However, in a normal year, Alternative 3 flows differ from the no-action alternative with higher irrigation period flows, lower winter storage period flows, and slightly greater annual flows.

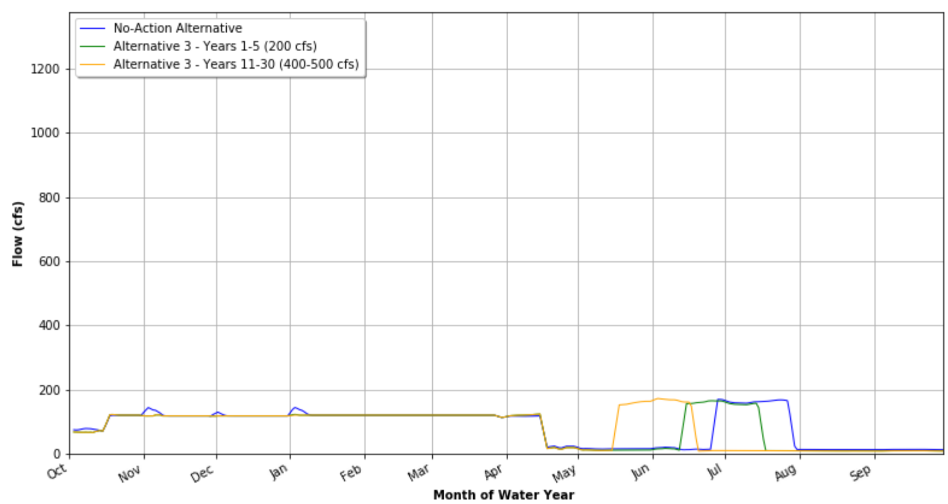
Table 39. Percent Differences in Streamflow Volume between the No-Action Alternative and Alternative 3 for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years at the CAPO Gauge

		Alternative 3		
Water Year Type	**Time Period**	**Years 1–5**	**Years 6–10**	**Years 11–30**
Wet	Irrigation Period	1%	1%	1%
	Winter/Storage Period	-4%	-4%	-4%
	Annual	-1%	-1%	-1%
	1 SD	-4%	-4%	-4%
Normal	Irrigation Period	5%	5%	5%
	Winter/Storage Period	-2%	-2%	-2%
	Annual	1%	1%	1%
	1 SD	-2%	-2%	-2%
Dry	Irrigation Period	-5%	-5%	-5%
	Winter/Storage Period	-1%	-1%	-1%
	Annual	-3%	-2%	-3%
	1 SD	-10%	7%	-10%

Figure 65 includes the representative normal and dry year hydrographs for the CAPO gauge under Alternative 3 in years 1 through 5 and years 11 through 30. In a representative normal year, flows associated with Alternative 3 and the no-action alternative are very similar. In a representative dry year, month-long elevated flows occur from late June to late July under the no-action alternative and from mid-June to mid-July in years 1through 5 of Alternative 3. The elevated flow period occurs from mid-May to mid-May in year 11 through 30 of Alternative 3 as stored water is released from Prineville Reservoir for North Unit ID.

Figure 65. The Crooked River Hydrograph for the No-Action Alternative and Proposed Action in Years 21–30 in Representative Normal (upper) and Dry (lower) Years at the CAPO Gauge (Note flow scale differences.)





Ochoco Creek from Ochoco Dam to Crooked River

No additional conservation measures are associated with Ochoco Creek under Alternative 3. Ochoco ID would be required to release or bypass flow from Ochoco Reservoir to meet minimum flows in Ochoco Creek. Based on the RiverWare modeling results, Alternative 3 flows are the same as the no-action alternative and proposed action.

Crooked River from North Unit Irrigation District Pump Station to Smith Rock State Park

Crooked River streamflow at the Smith Rock gauge (CRSO) located downstream from the North Unit ID pump station is shown in hydrographs for the no-action alternative and Alternative 3 in years 1 through 5 and years 11 through 30 (Figure 66). The hydrographs are similar although median flows are lower from mid-June through early August as water is diverted by the North Unit ID pump station to meet water user demand. The difference between Alternative 3 and no-action alternative irrigation period flows increases in years 11 through 30 as more water is pumped at the North Unit

ID pump station to meet water demand not met by the Upper Deschutes River. Under Alternative 3, releases of uncontracted storage from Prineville Reservoir would be protected instream year-round from Bowman Dam to Lake Billy Chinook.

Figure 66. The Crooked River Hydrograph for Years 1–5 (upper) and Years 11–30 (lower) for the No-Action Alternative and Alternative 3 Based on Modeled Flows at the CRSO Gauge (Figures show the median flow and 20 to 80% flow range for the two alternatives. Increased pumping at the North Unit ID pump station influences CRSO flows from June through August.)

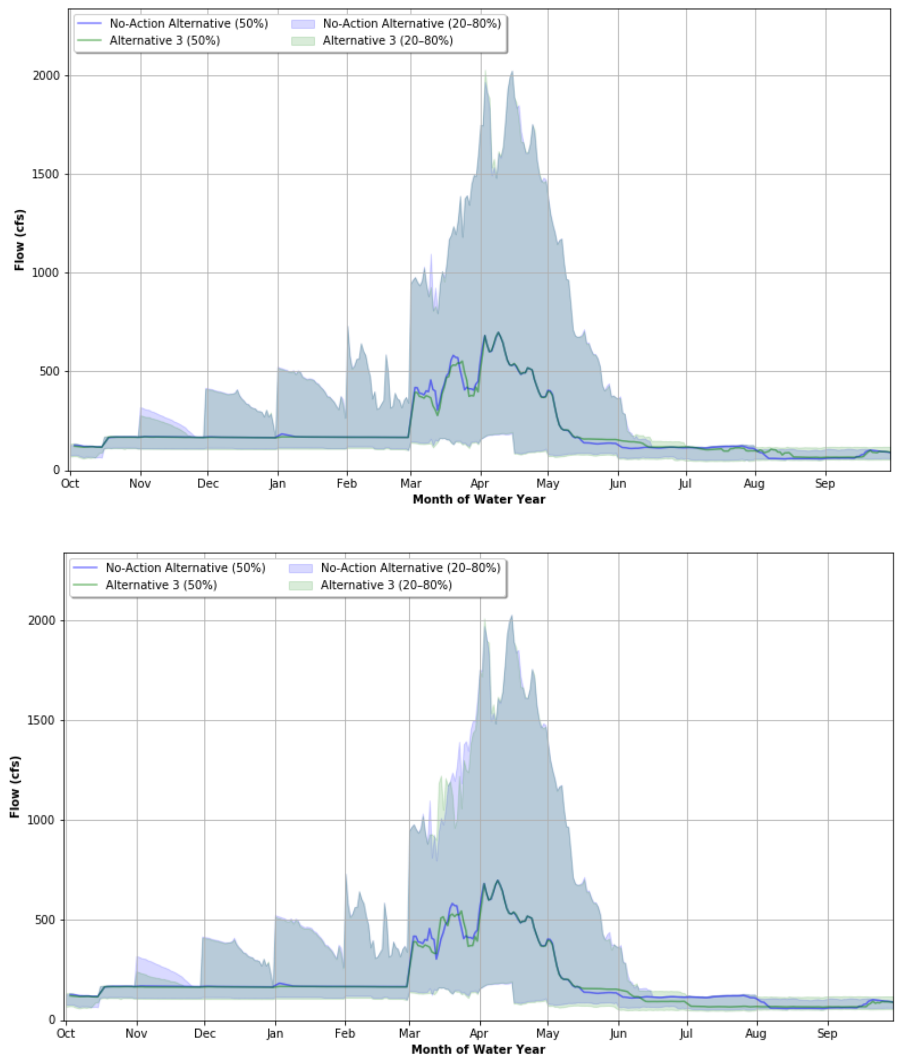


Table 40 includes a comparison of seasonal flow volume differences in minimum and maximum median flows based on CRSO gauge data. There are minimal flow differences over the permit term in both the winter storage and irrigation periods although maximum median winter storage flows decrease slightly for Alternative 3 relative to the no-action alternative. Minimum median irrigation period flows are lower than the winter storage flows, reflecting upstream irrigation withdrawals.

Table 40. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Crooked River at the CRSO Gauge Downstream from the North Unit Irrigation District Pump Station by Season for the No-Action Alternative and Alternative 3 over the Permit Term

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	**Minimum (cfs)**	**Maximum (cfs)**	**Minimum (cfs)**	**Maximum (cfs)**
No-Action	166.1	413.9	59.2	511.7
Alternative 3 (Years 1–5)	165.4	389.2	66.4	512.2
Alternative 3 (Years 6–10)	164.9	393.6	65.7	511.9
Alternative 3 (Years 11–30)	164.4	392.2	65.5	511.7

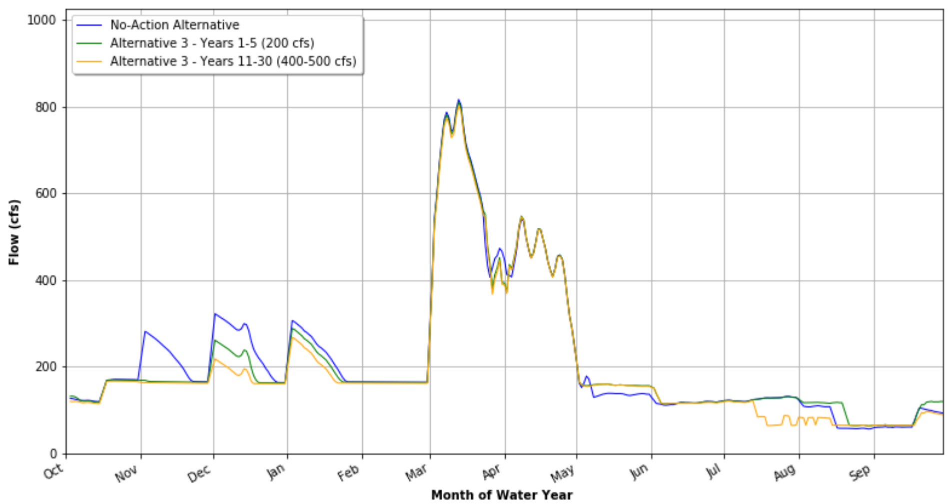
Total monthly streamflow volume (af) for representative wet, normal, and dry years were evaluated to assess changes in seasonal streamflow (Table 41). Compared to the no-action alternative, Alternative 3 flows experience minor flow decreases over time in each of the representative water year types. The Alternative 3 and proposed action results are also similar.

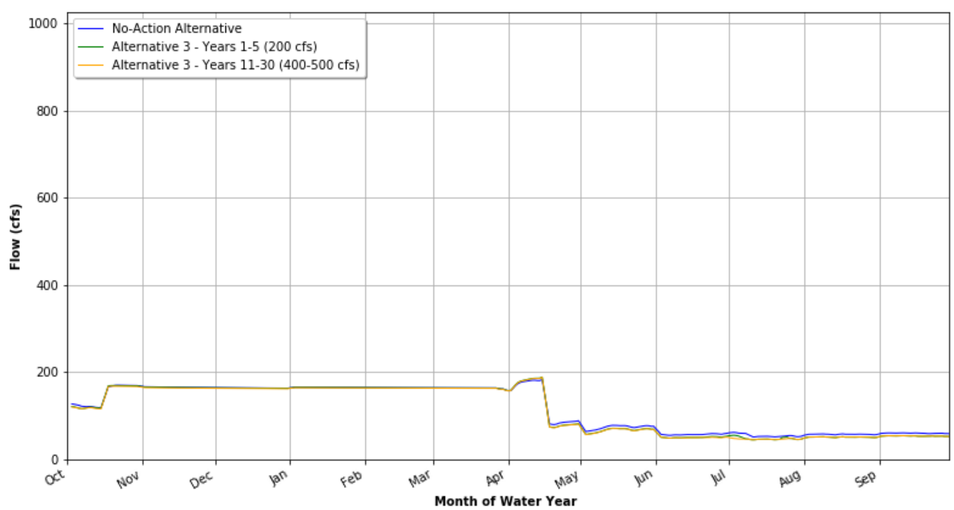
Table 41. Percent Differences in Streamflow Volume between the No-Action Alternative and Alternative 3 for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years at the CRSO Gauge

		Alternative 3		
Water Year Type	**Time Period**	**Years 1–5**	**Years 6–10**	**Years 11–30**
Wet	Irrigation Period	2%	-1%	-3%
	Winter/Storage Period	3%	-4%	-4%
	Annual	2%	-2%	-3%
	1 SD	-4%	-3%	-2%
Normal	Irrigation Period	5%	1%	-3%
	Winter/Storage Period	2%	-4%	-4%
	Annual	3%	-2%	-3%
	1 SD	-2%	-2%	-1%
Dry	Irrigation Period	-1%	-5%	-5%
	Winter/Storage Period	12%	7%	7%
	Annual	6%	2%	1%
	1 SD	0%	1%	1%

Figure 67 presents the representative normal and dry year hydrographs for the CRSO gauge under Alternative 3. The hydrographs show the influence of the North Unit ID pump station flow diversion during the irrigation period in both normal and dry years, although the effect is more persistent lasting from April through September in a dry year.

Figure 67. The Crooked River Hydrograph for the No-Action Alternative and Proposed Action in Years 21–30 in Representative Normal (upper) and Dry (lower) Years at the CRSO Gauge (Note flow scale differences.)

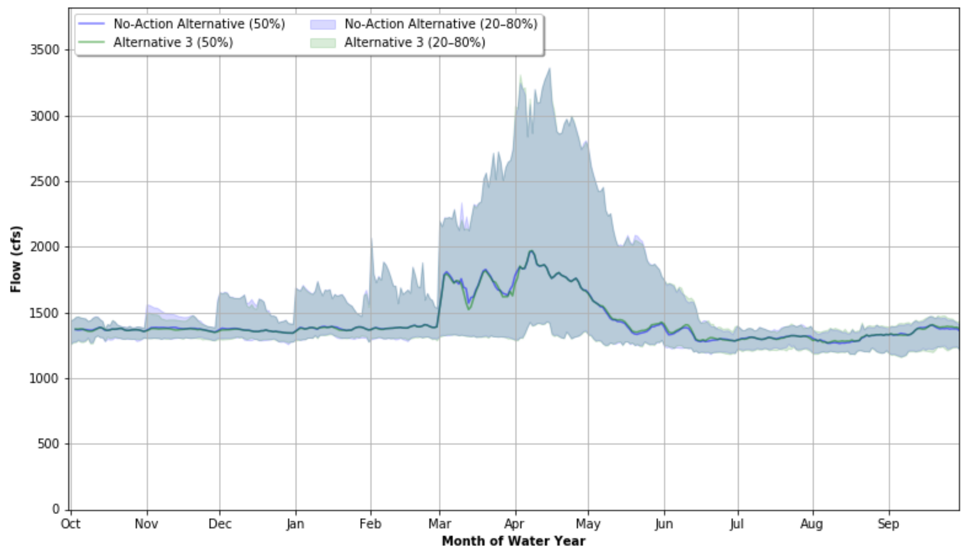




Crooked River from Smith Rock State Park to Opal Springs Dam

There are minor differences between no-action alternative and Alternative 3 flows at the CROO gauge downstream from Opal Springs Dam. Substantial groundwater inputs in this reach mask water management-related changes to Crooked River flows. Compared to the no-action alternative, there is a slight decrease in streamflow from late July through early August in years 11 through 30 of Alternative 3 (Figure 68). Otherwise, there are minor differences in the median flow values.

Figure 68. The Crooked River Hydrograph for Years 1–5 (upper) and Years 11–30 (lower) for the No-Action Alternative and Alternative 3 Based on Modeled Flows at the CROO Gauge Downstream from Opal Springs Dam (Figures show the median flow and 20 to 80% flow range for the two alternatives.)



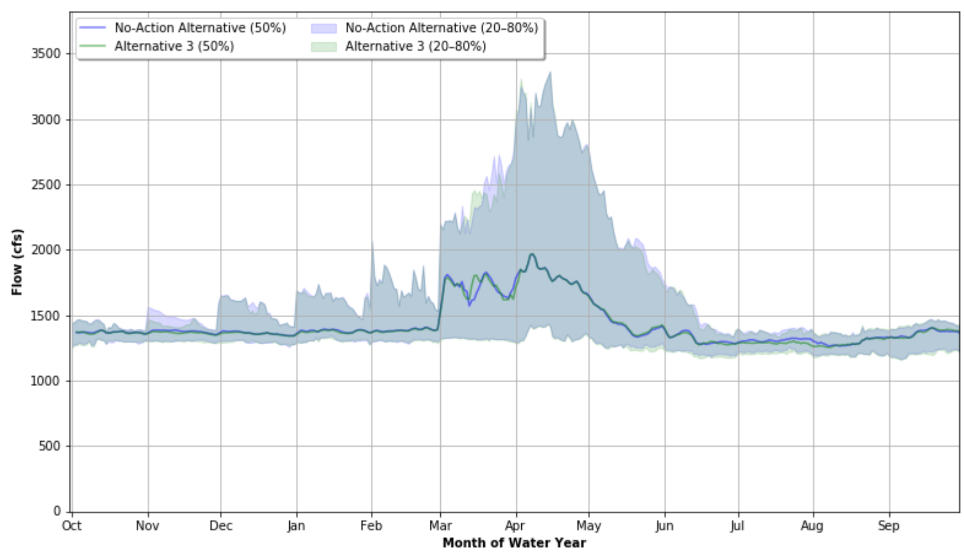


Table 42 includes a comparison of seasonal differences in minimum and maximum median flows based on CROO gauge data. The no-action alternative and Alternative 3 have similar minimum and maximum median flows in the winter and summer suggesting the influence of groundwater inputs.

Table 42. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Crooked River at the CROO Gauge for the No-Action Alternative and Alternative 3 over the Permit Term

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	Minimum (cfs)	Maximum (cfs)	Minimum (cfs)	Maximum (cfs)
No-Action	1,361.2	1,698.6	1,291.0	1,777.3
Alternative 3 (Years 1–5)	1,359.4	1,683.9	1,301.6	1,775.0
Alternative 3 (Years 6–10)	1,358.5	1,692.0	1,288.7	1,773.9
Alternative 3 (Years 11–30)	1,357.5	1,690.1	1,282.8	1,772.7

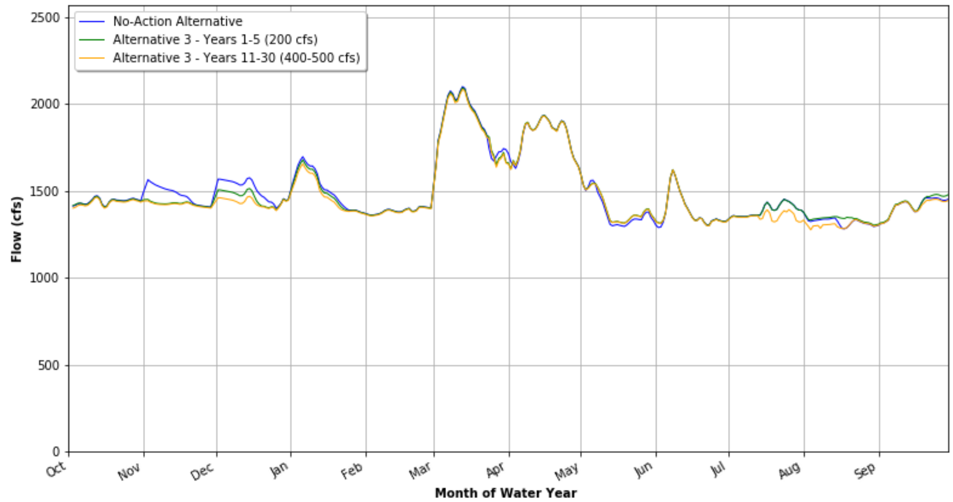
There are small differences in streamflow volumes in all water year types and over the permit term (Table 43). Differences relate to reduced winter storage flows as excess flow above minimum flow targets is stored in Prineville Reservoir, and the North Unit ID pump station diverts water to compensate for the effects of minimum flow targets on the Upper Deschutes River. The influence of the North Unit ID pump station diversion is less influential at the CROO gauge due to the large volume of groundwater inputs between the pump station and the CROO gauge. In short, flow differences related to Alternative 3 conservation measures have little influence on flows at the CROO gauge.

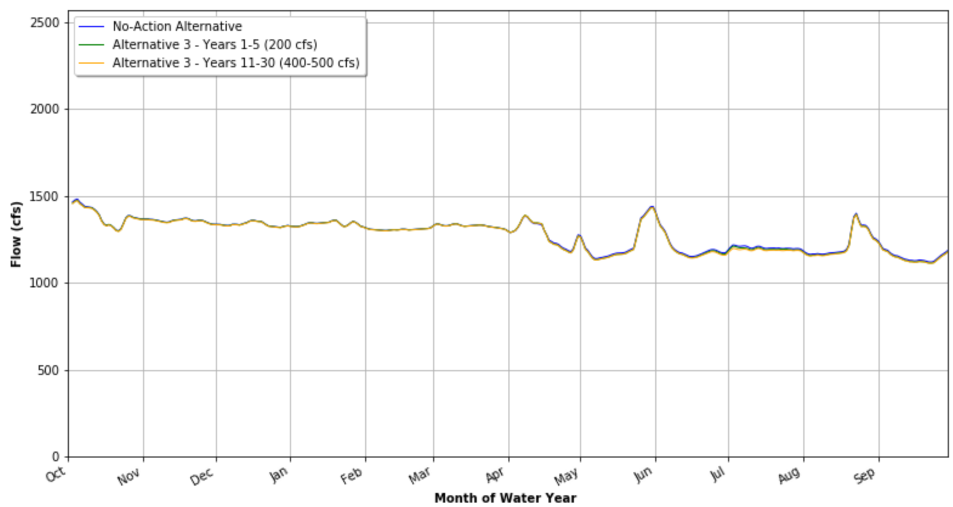
Table 43. Percent Differences in Streamflow Volume between the No-Action Alternative and Alternative 3 for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years at the CROO Gauge

		Alternative 3		
Water Year Type	Time Period	Years 1–5	Years 6–10	Years 11–30
Wet	Irrigation Period	0%	0%	-1%
	Winter/Storage Period	-1%	-1%	-1%
	Annual	0%	-1%	-1%
	1 SD	-3%	-3%	-2%
Normal	Irrigation Period	0%	0%	0%
	Winter/Storage Period	0%	-1%	-1%
	Annual	0%	0%	-1%
	1 SD	-2%	-2%	-1%
Dry	Irrigation Period	0%	0%	0%
	Winter/Storage Period	1%	1%	1%
	Annual	0%	0%	0%
	1 SD	5%	6%	6%

Figure 69 includes the representative normal and dry year hydrographs for the CROO gauge under Alternative 3 in normal and dry years. Similar to the preceding analyses, there are minimal flow differences between the no-action alternative and Alternative 3.

Figure 69. The Crooked River Hydrograph for the No-Action Alternative and Proposed Action in Years 21–30 in Representative Normal (top) and Dry (bottom) Years at the CROO Gauge





WR-5: Affect Groundwater Recharge

Effects under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action except that changes in the increase in seepage associate with the Deschutes river segment downstream of Sunriver would occur earlier in the permit term. There would be no meaningful adverse effect on the regional groundwater system.

Alternative 4: Enhanced and Accelerated Variable Streamflows

Alternative 4 is similar to Alternative 3, with the following exceptions: the permit term is 20 years rather than 30 years, fall and winter Deschutes River flows increase at a faster rate with a higher minimum flow range of 400 to 600 cfs, and storage season minimum flows on the Crooked River increase to 80 cfs from 50 cfs. All other conservation measures and the adaptive management and monitoring program are the same in Alternative 4 as under the proposed action.

The values presented in the effects analysis are direct RiverWare model outputs (without rounding). They are not intended as exact predictions of future conditions, but and are used for purposes of comparing among alternatives.

WR-1: Change Reservoir Storage

Modeled changes in Crane Prairie and Ochoco Reservoir storage are the same as described for the proposed action. Changes in Wickiup, Crescent Lake, and Prineville Reservoir storage are described below.

See Table 9 for modeled reservoir storage volumes and associated water surface elevations associated with the 90% total storage capacity of each reservoir during the October through June period. Exceedance of 90% of reservoir storage capacity was set as the threshold for changes to flood storage capacity.

Wickiup Reservoir

Under Alternative 4, as under the proposed action and Alternative 3, increased fall/winter releases from Wickiup Reservoir would result in decreased water supply storage in Wickiup Reservoir. Alternative 4 would accelerate the implementation of those changes and reach at a higher fall/winter minimum compared to the proposed action and Alternative 3. In years 1 to 5, Wickiup releases and associated storage would be the same as years 11 through 20 of the proposed action. In years 6 through 20,[16] the higher minimum fall/winter flow target would further decrease storage compared to the proposed action years 21 through 30.

As winter flow releases from Wickiup Reservoir increase above no-action levels beginning in year 1 (Conservation Measure WR-1), Wickiup Reservoir storage would decline, with the greatest declines observed in years 6 through 20 of the permit term (Table 44, Table 45, and Figure 70). In a normal water year during years 6 through 20, water supply storage would be reduced by 73,278 af.

Table 44. Wickiup Reservoir Storage under the No-Action Alternative and Alternative 4

Water Year Conditions	No-Action Alternative (af)	Alternative 4 (af)	
		Years 1–5	Years 6–20
Very Dry	97,654	54,676	29,550
Dry	109,445	59,818	38,773
Normal	126,096	81,228	52,818
Wet	191,249	170,843	162,151
Very Wet	200,976	200,071	197,340

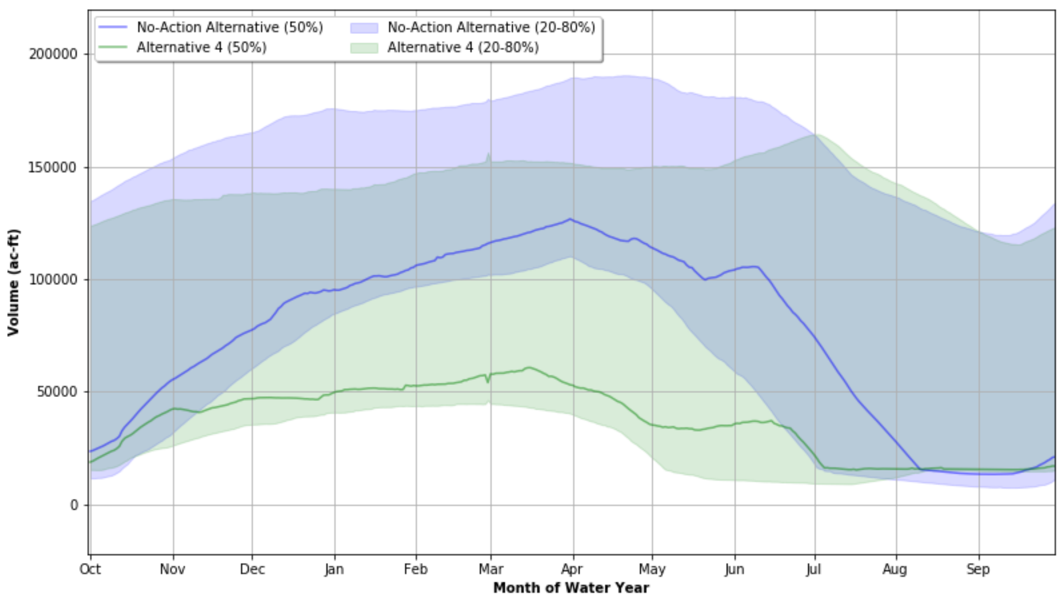
af = acre-feet; cfs = cubic feet per second

[16] Alternative 4 considers a shorter permit term than the proposed action and Alternative 3.

Table 45. Frequency of Wickiup Reservoir Fill under the No-Action Alternative and Alternative 4

Maximum Fill Volume April–August (af)	No-Action Alternative	Alternative 4	
		Years 1–5	Years 6–20
25,000	100%	100%	100%
50,000	100%	100%	52%
75,000	100%	52%	41%
100,000	97%	38%	38%
125,000	55%	34%	34%
150,000	38%	31%	28%
175,000	31%	21%	17%

Figure 70. Modeling Results Comparing Wickiup Reservoir Storage under the No-Action Alternative in Years 21–30 of the Permit Term to Alternative 4 in Years 6–20 of the Permit Term



Crescent Lake Reservoir

Reduced minimum flows below the Crescent Lake Dam from March 15 through November 30 (Conservation Measure CC-1) would generally result in an increase in Crescent Lake Reservoir storage (Figure 71) In years 1 through 5 of the permit term, the maximum storage volume attained would increase by an approximately 21% in a dry year, although there would be a minimal increase in a normal year (Table 46). Changes in all water year types would be similar to the proposed action and Alternative 3, with the exception of wet years, in which maximum storage volume attained would decrease by approximately 4,000 af. This change is a modeling artifact and does not represent expected changes in wet year conditions. Over two or more water years, there is no change in Crescent Lake storage volume compared to the proposed action.

Figure 71. Modeling Results Comparing Crescent Lake Reservoir Storage under the No-Action Alternative in Year 21–30 of the Permit Term to Alternative 4 in Years 6–20 of the Permit Term

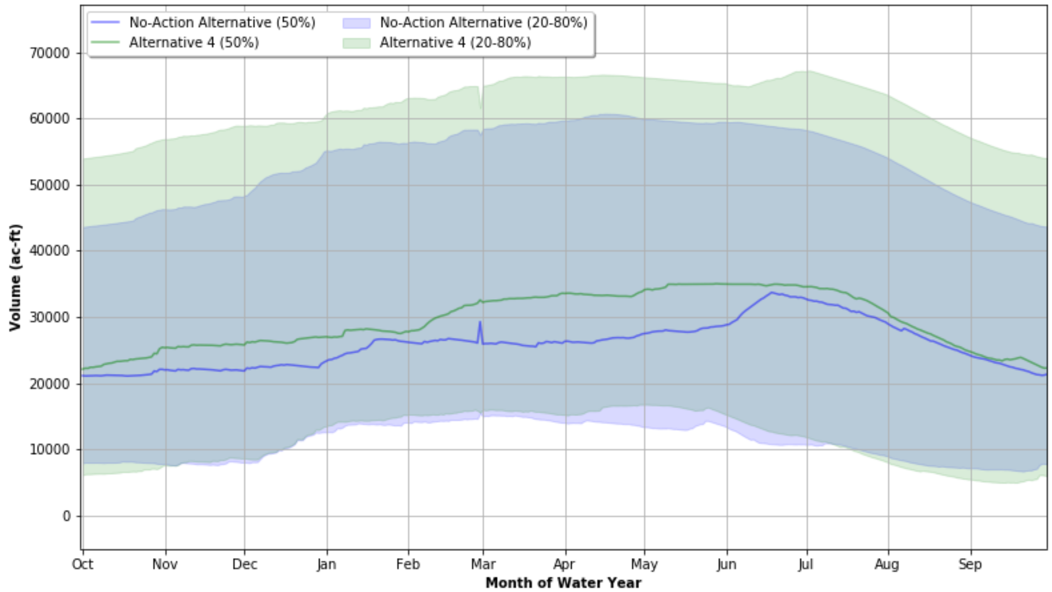


Table 46. Change in Crescent Lake Storage under the No-Action Alternative and Alternative 4

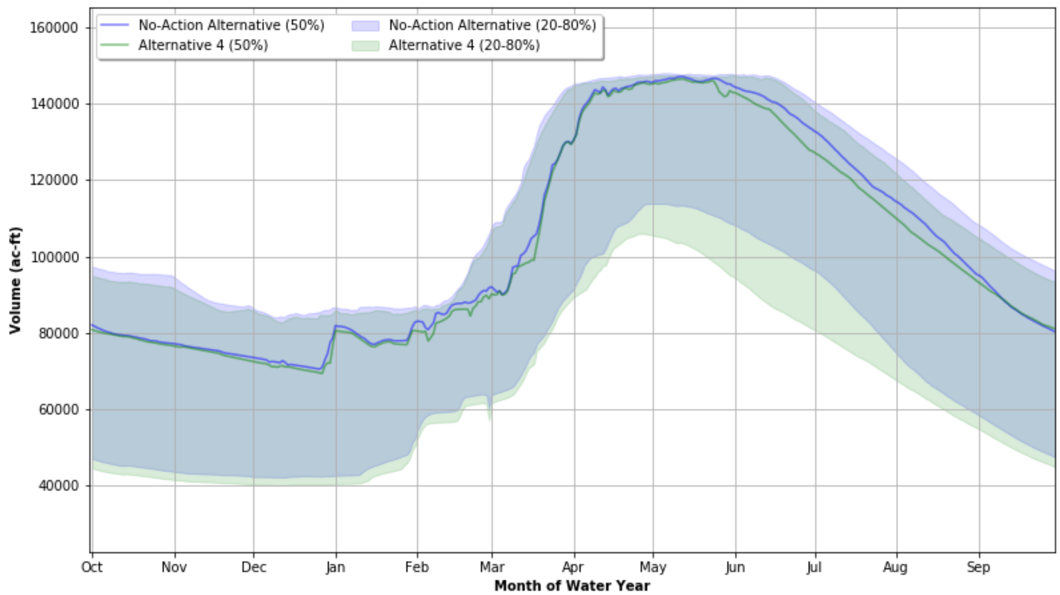
Water Year Conditions	No-Action Alternative	Alternative 4	
		Years 1–5	Years 6–20
Very Dry	7,020	7,281	7,223
Dry	14,681	17,764	17,779
Normal	34,956	35,020	34,993
Wet	58,872	64,526	60,716
Very Wet	76,631	77,135	77,843

af = acre-feet; cfs = cubic feet per second

Prineville Reservoir

As winter flow releases out of Wickiup Reservoir increase starting in year 1 of the permit term, reducing North Unit ID's stored water supply in the Deschutes, North Unit ID's use of stored water from Prineville Reservoir would increase. This, combined with increased releases of uncontracted storage during the storage season in the Crooked River (Conservation Measure CR-1), would result in reduced Prineville Reservoir storage in most years. Changes in storage would range from a reduction of approximately 200 af during wet and very wet years to a reduction of 9,843 af during a very dry year. Although the reduction in Prineville Reservoir storage is high during very dry years, the average reduction in storage compared to the no action would be 2,723 af, equivalent to less than 2% of total storage. The average reduction under the proposed action would be 1,796 af, a difference of 927 af. In very dry and dry years Figure 72 compares Prineville Reservoir storage under the no-action alternative to years 6 through 20 of the permit term under Alternative 4. Additionally, increasing bypass flows in McKay Creek and Ochoco Creek and protecting stored water under temporary instream leases for Ochoco ID patrons (Conservation Measures CR-2, CR-3, and CR-4) may contribute to a decline in Prineville Reservoir storage by increasing Ochoco ID stored water releases in years that Prineville Reservoir does not fill.

Figure 72. Modeling Results Comparing Prineville Reservoir Storage under the No-Action Alternative in Years 21–30 of the Permit Term to Alternative 4 in Years 6–20 of the Permit Term



WR-2: Change Water Supply for Irrigation Districts and Other Surface Water Users

As for WR-1, above, the most significant difference between Alternative 3 and the proposed action would be an accelerated schedule for increasing releases from Wickiup Reservoir. For Central Oregon, Ochoco, Tumalo, Swalley, and Three Sisters IDs, and other Deschutes and Crooked River water users, the change in water supply under Alternative 4 would be the same or nearly the same as the change in water supply under the proposed action at equivalent storage season Wickiup outflows (e.g., years 1 through 5 under Alternative 4 and years 11 through 20 of the proposed action).

For North Unit, Arnold, and Lone Pine IDs, change in water supply under Alternative 4 would be greater than under the proposed action and Alternative 3 as a result of increased fall/winter releases from Wickiup Reservoir. The change in water supply for these districts is discussed in greater detail below. Table 47, below, compares the no-action alternative, proposed action, Alternative 3, and Alternative 4 to show the impact of accelerating the timetable for storage season Wickiup outflows and highlights the water users and scenarios in which water supply is different under Alternative 4 than under the proposed action.

Table 47. Comparison of Irrigation Diversion (thousands of acre-feet) under the No-Action Alternative, Proposed Action, Alternative 3, and Alternative 4 at Varying Storage Season Wickiup Outflows (Regardless of the timetable for increasing outflows, water supply is the same under equivalent water conditions and at equivalent Wickiup outflow levels. The impact of higher variable outflows on North Unit, Arnold and Central Oregon IDs compared to the Proposed Action and Alternative 3 are highlighted in the table below if the impact exceeds 1 percent of water supply under the No-Action Alternative.)

Water Year Type	Scenario	Wickiup Outflows (cfs)	North Unit	Central Oregon	Arnold	Lone Pine	Ochoco	Tumalo	Swalley	Three Sisters	Walker Basin	Other Crooked
Normal	No Action	100	187.4	287.6	31.1	11.9	77.7	49.8	24.6	29.0	5.2	22.8
	PA (Years 1–5)	100	192.8	287.0	30.9	11.9	77.7	49.8	24.6	29.0	5.2	22.8
	PA (Years 6–10)	200	181.5	286.5	30.9	11.9	77.7	49.8	24.6	29.0	5.2	22.8
	Alt 3 (Years 1–5)	200	181.5	286.5	30.9	11.9	77.7	49.8	24.6	29.0	5.2	22.8
	PA (Years 11–20)	300	175.9	286.4	30.6	11.8	77.7	49.8	24.6	29.0	5.2	22.8
	Alt 3 (Years 6–10)	300	175.8	286.4	30.6	11.8	77.7	49.8	24.6	29.0	5.2	22.8
	Alt 4 (Years 1–5)	300	***158.6***	286.1	***29.7***	***11.5***	77.7	49.8	24.6	29.0	5.2	22.8
	PA (Years 21–30)	400–500	158.9	285.8	29.4	11.5	77.7	49.8	24.6	29.0	5.2	22.8
	Alt 3 (Years 11–30)	400–500	***155.9***	285.8	29.4	11.5	77.7	49.8	24.6	29.0	5.2	22.8
	Alt 4 (Years 6–20)	400–600	***149.4***	285.8	29.4	11.5	77.7	49.8	24.6	29.0	5.2	22.8
Dry	No Action	100	131.5	282.1	25.3	10.8	77.3	33.8	24.6	25.8	5.1	22.6
	PA (Years 1–5)	100	137.6	280.4	21.3	10.0	77.3	35.0	24.6	25.8	4.9	22.7
	PA (Years 6–10)	200	120.6	280.0	20.4	9.2	77.3	34.5	24.6	25.8	4.8	22.6
	Alt 3 (Years 1–5)	200	120.3	280.0	20.4	9.2	77.3	34.5	24.6	25.8	4.8	22.5
	PA (Years 11–20)	300	104.7	278.9	19.5	8.8	77.3	34.2	24.6	25.8	4.8	22.5
	Alt 3 (Years 6–10)	300	103.8	278.9	19.5	8.8	77.3	34.2	24.6	25.8	4.8	22.5
	Alt 4 (Years 1–5)	300	***96.4***	278.9	***19.1***	8.8	77.3	34.1	24.6	25.8	4.8	22.5
	PA (Years 21–30)	400–500	77.4	278.2	17.7	8.5	77.3	33.3	24.6	25.8	4.8	22.5
	Alt 3 (Years 11–30)	400–500	76.4	278.2	17.7	8.5	77.3	33.3	24.6	25.8	4.8	22.5
	Alt 4 (Years 6–20)	400–600	***67.4***	278.1	17.6	8.5	77.3	33.2	24.6	25.8	4.8	22.5

Water Year Type	Scenario	Wickiup Outflows (cfs)	North Unit	Central Oregon	Arnold	Lone Pine	Ochoco	Tumalo	Swalley	Three Sisters	Walker Basin	Other Crooked
Very Dry	No Action	100	108.1	266.8	14.8	7.3	54.2	16.7	24.6	23.5	4.3	20.4
	PA (Years 1–5)	100	112.4	260.9	12.5	6.2	45.3	16.0	24.6	23.5	4.1	19.4
	PA (Years 6–10)	200	98.2	258.6	12.1	5.3	45.0	16.0	24.6	23.5	4.1	19.3
	Alt 3 (Years 1–5)	200	98.2	258.6	12.1	5.3	45.0	16.0	24.6	23.5	4.1	19.3
	PA (Years 11–20)	300	71.1	257.3	11.9	4.7	44.9	15.8	24.6	23.5	4.1	19.3
	Alt 3 (Years 6–10)	300	71.1	257.3	11.9	4.7	44.9	15.8	24.6	23.5	4.1	19.3
	Alt 4 (Years 1–5)	300	70.5	256.0	***10.3***	***4.1***	44.8	15.8	24.6	23.5	4.1	19.3
	PA (Years 21–30)	400–500	58.6	256.5	10.1	4.1	44.9	15.8	24.5	23.5	4.1	19.3
	Alt 3 (Years 11–30)	400–500	58.6	256.5	10.1	4.1	44.9	15.8	24.5	23.5	4.1	19.3
	Alt 4 (Years 6–20)	400–600	***46.6***	255.2	***8.9***	***3.8***	44.8	15.8	24.6	23.5	4.1	19.3

North Unit Irrigation District. Reduced storage in Wickiup Reservoir, described in Impact WR-1, would reduce stored water supply available to North Unit ID starting in year 1 of the permit term in normal, dry, and very dry years. During wet and very wet years, there would be no reduction in water supply. In year 1, North Unit ID's diversions would decline by 35,055 af in a dry year. Beginning in year 6, North Unit ID's diversions would decline by 64,050 af in a dry year. It is expected that North Unit ID would make more frequent regulatory calls for Deschutes River live flow because of reduced Wickiup Reservoir storage over the permit term (Giffin pers. comm. [a, b]). Effects of the increase in these regulatory calls on water supply for other Deschutes River water users with junior water rights are described further for each irrigation district. It is also expected that North Unit ID would increase use of its Crooked River pumping plant to offset reduced water supply from Wickiup Reservoir storage beginning in year 1.[17] During years 6 through 20, when Crooked River water use would be highest, North Unit ID would increase use of the Crooked River pumping plant by 5,303 af in a normal year. However, in a very dry year, decreased Prineville Reservoir storage due to measure CR-1 would reduce North Unit ID's Crooked River water supply by approximately 2,000 af and would reduce its ability to offset reduced stored water supply from the Deschutes River.

Arnold Irrigation District. Reduced water supply storage in Crane Prairie Reservoir and increased Wickiup Reservoir outflows, would also reduce water supply available to Arnold ID. Effects on Arnold ID would be greater because of its more junior live flow Deschutes River water rights. In a dry year, Arnold ID's diversions would decline by 6,225 af starting in year 1 of the permit term and by 7,747 af starting in year 6. This represents approximately 25 and 31% of diversions under the no-action alternative, respectively.

Lone Pine Irrigation District. As described for Central Oregon ID, reduced water supply storage in Crane Prairie Reservoir would reduce water supply available to Lone Pine ID. It should be noted that Lone Pine ID is served through Central Oregon ID's distribution system, and RiverWare-modeled shortages may not accurately reflect how Lone Pine ID would be affected by regulation of its live-flow water rights. In a dry year, Lone Pine ID's diversions would decline by 2,035 af starting in year 1 and by 2,306 af starting in year 6. This represents approximately 19 and 21% percent of diversions, respectively.

WR-3: Changes in Reservoir Water Surface Elevations and Flood Storage Capacity

Modeled changes in Crane Prairie and Ochoco Reservoir water surface elevation and related flood storage capacity are the same as described for the proposed action. Changes in Wickiup, Crescent Lake, and Prineville Reservoir are described below.

See Table 9 for modeled reservoir storage volumes and associated water surface elevations associated with the 90% total storage capacity of each reservoir during the October through June period. Exceedance of 90% of reservoir storage capacity was set as the threshold for proposed action changes to flood storage capacity.

Wickiup Reservoir

Wickiup Reservoir water management under Alternative 4 results in lower median and similar maximum reservoir levels compared to the no-action alternative and proposed action (Figure 73). Lower median water surface elevations are due to the accelerated minimum winter flows on the Upper Deschutes River and how the minimum flows affect reservoir storage. Median water surface

[17] Depending on timing and need, this could be live flow or stored water from Prineville Reservoir. Because of how Prineville Reservoir is operated, water stored in the reservoir can be diverted as either stored water or live flow.

elevations differences are greatest from April to June (7 to 8 feet lower) in years 6 through 20 for Alternative 4 relative to the proposed action in years 21 through 30.

Figure 73. Comparison of Alternative 4 Monthly Median Water Surface Elevations for Wickiup Reservoir (The reference elevation associated with 90% flood storage capacity is 4,335.79 ft [red line]. The 90% flood storage capacity is based on a total reservoir capacity of 200,000 af.)

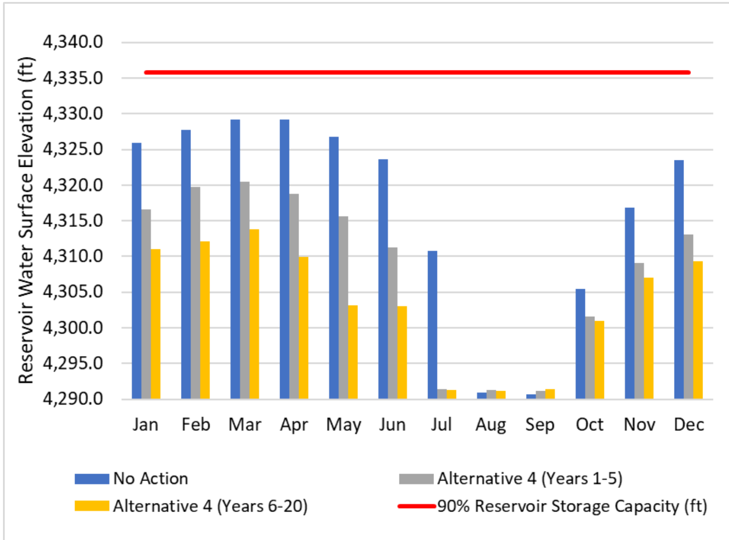
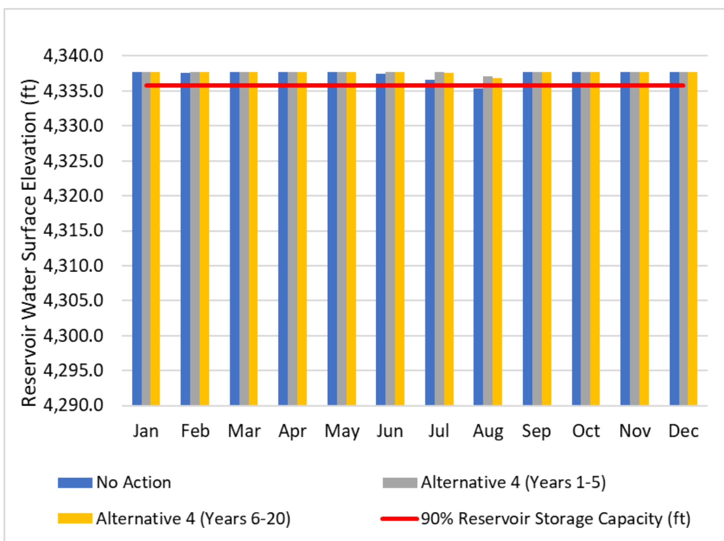


Figure 74. Comparison of Alternative 4 Monthly Maximum Water Surface Elevations for Wickiup Reservoir (The reference elevation associated with 90% flood storage capacity is 4,335.79 ft [red line]. The 90% flood storage capacity is based on a total reservoir capacity of 200,000 af.)



Crescent Lake Reservoir

Crescent Lake Reservoir water management under Alternative 4 results in higher median water surface elevations relative to the no-action alternative (Figure 75), and fractionally different median water surface elevations relative to the proposed action. Maximum water surface elevations are similar for Alternative 4 with water surface elevations meeting or slightly exceeding the 90% storage elevation from December through July (Figure 76).

Figure 75. Comparison of Alternative 4 Monthly Median Water Surface Elevations for Crescent Lake Reservoir (The reference elevation associated with 90% flood storage capacity is 4,843.21 ft [red line]. The 90% flood storage capacity is based on a total reservoir capacity of 86,500 af.)

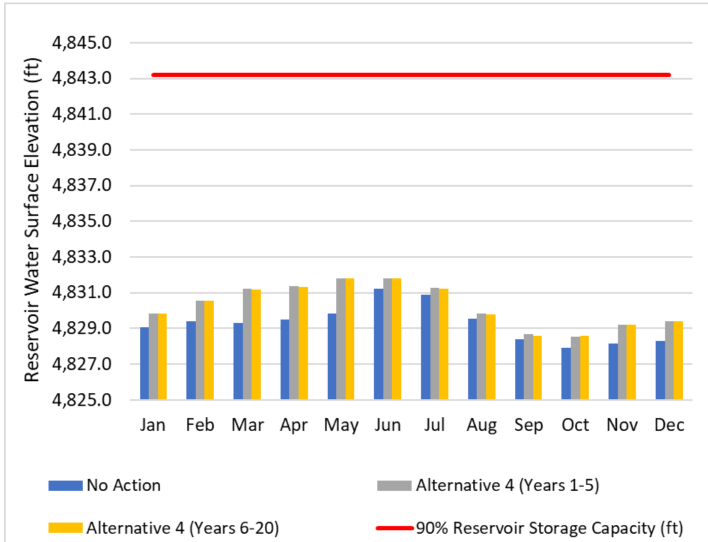
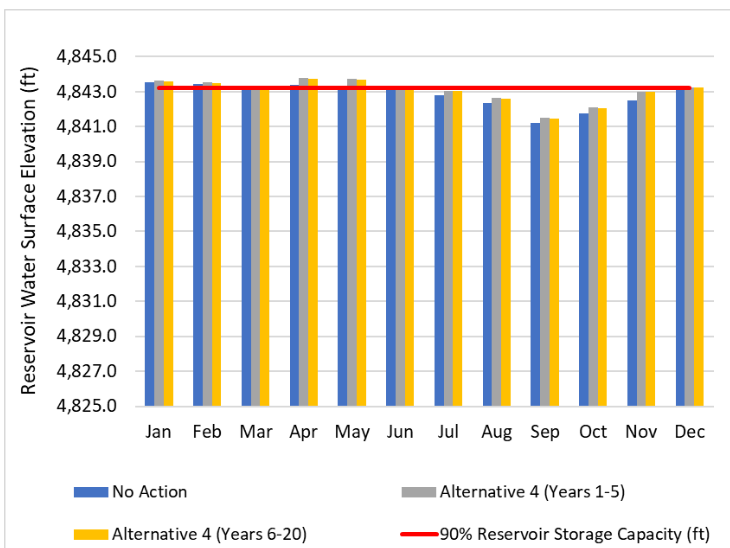


Figure 76. Comparison of Alternative 4 Monthly Maximum Water Surface Elevations for Crescent Lake Reservoir (The reference elevation associated with 90% flood storage capacity is 4,843.21 ft [red line]. The 90% flood storage capacity is based on a total reservoir capacity of 86,500 af.)



Prineville Reservoir

Prineville Reservoir would experience slightly lower median (Figure 77) and maximum (Figure 78) reservoir elevations under Alternative 4 compared to both the no-action alternative and proposed action. Water surface elevation differences are due to decreased Prineville Reservoir storage caused by increased storage season flow releases (80 cfs) to the Crooked River. Accelerated winter releases on the Deschutes River also diminishes Wickiup Reservoir storage volume causing North Unit ID to augment irrigation flows with Crooked River water. The combination of reduced storage in Prineville and Wickiup reservoirs affects Prineville Reservoir water surface elevations in both storage and irrigation seasons.

Figure 77. Comparison of Alternative 4 Monthly Median Water Surface Elevations for Prineville Reservoir (The reference elevation associated with the outlet works is 3,234.80 ft [red line]. The 90% flood storage capacity is based on a total reservoir capacity of 148,633 af.)

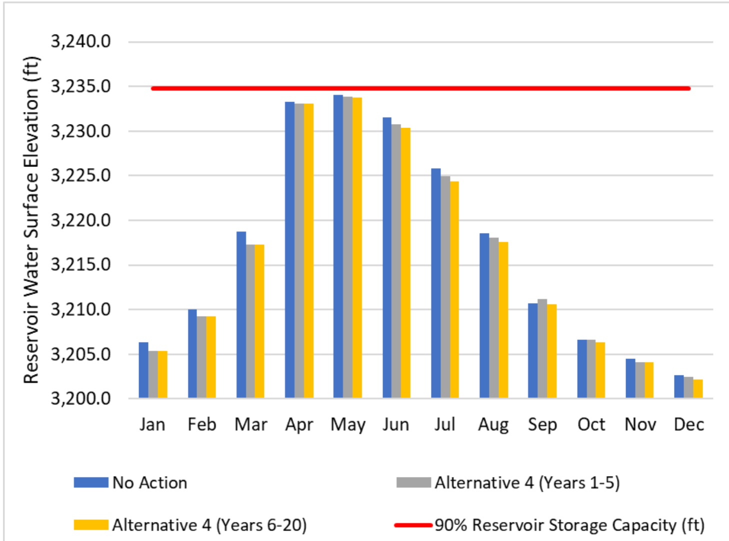
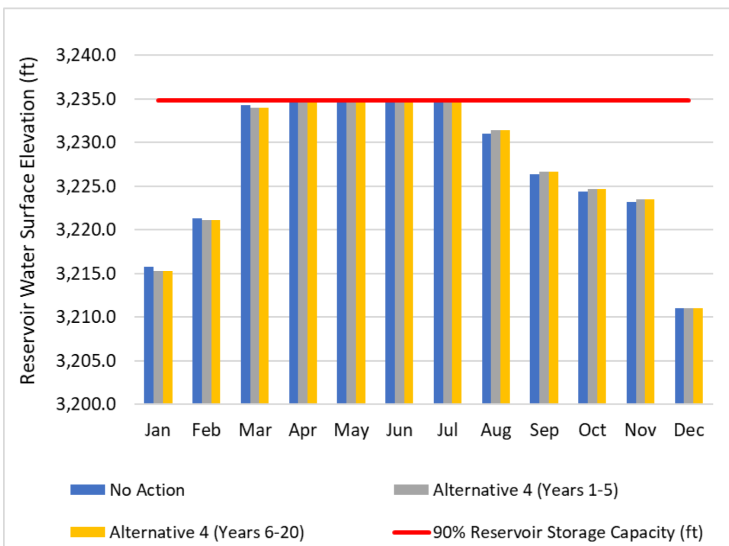


Figure 78. Comparison of Alternative 4 Monthly Maximum Water Surface Elevations for Prineville Reservoir (The reference elevation associated with the outlet works is 3,234.80 ft [red line]. The 90% flood storage capacity is based on a total reservoir capacity of 148,633 af.)



WR-4: Changes in Seasonal River and Creek Flow

Modeled changes in streamflows are the same as described for the proposed action for the Upper Deschutes River between Crane Prairie and Wickiup Reservoirs and in Ochoco, Whychus and Tumalo Creeks.

Modeled changes for the Deschutes River downstream of Wickiup Reservoir and for Crescent Creek in years 1 through 5 would be the same as under the proposed action in years 11 through 20, described below. Modeled changes in years 6 through 20 would be similar to those under the proposed action years 21 through 30 but would be of greater magnitude, as described below.

Under Alternative 4, Upper Deschutes River summer flows would decrease and winter flows would increase compared to the no-action alternative. The hydrologic changes would be implemented in two stages, the first in years 1 to 5 (300 cfs) and the second in years 6 to 20 (400 to 600 cfs) of the permit term. Higher minimum fall/winter flows would also correspond with lower irrigation period flows due to the reduction in reservoir storage.

Deschutes River from Wickiup Dam to the Little Deschutes River

In years 1 through 5, minimum winter flows downstream of Wickiup Dam would be 300 cfs, the same as under the proposed action in years 11 through 20 and Alternative 3 in years 6 through 10. This represents higher storage period flows and lower irrigation period flows compared to the proposed action and no-action alternative (Figure 79). In years 6 through 20, minimum winter flows would increase to a variable 400 to 600 cfs, which results in higher winter flows and lower irrigation season flows compared to both the proposed action and Alternative 3. As minimum winter flows increase, Wickiup Reservoir storage volumes decrease and there is less stored water available to meet irrigation season demand.

Figure 79. The Deschutes River Hydrograph for Years 1–5 (upper) and Years 6–20 (lower) for the No-Action Alternative and Alternative 4 Based on Modeled Flows at the WICO Gauge (Figures show the median flow and 20 to 80% flow range for the two alternatives.)

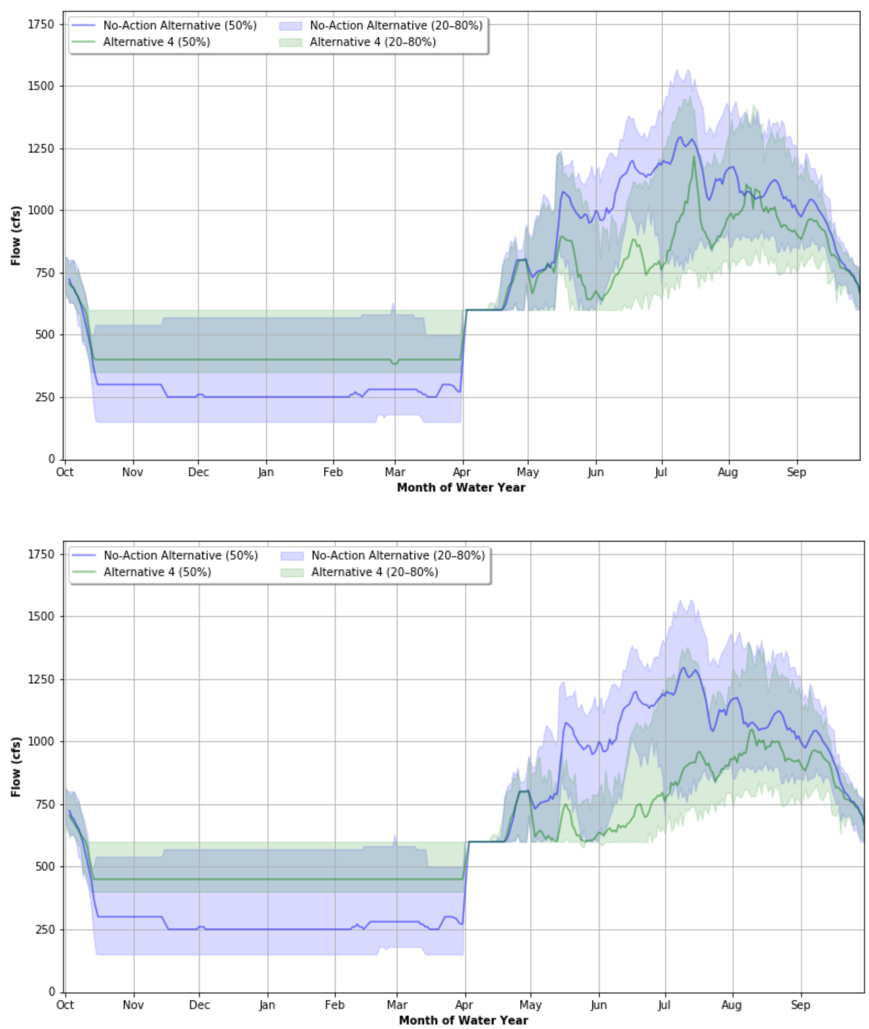


Table 48 includes a comparison of seasonal differences in minimum and maximum median flows based on WICO gauge data. Alternative 4 would have higher minimum and maximum median winter flows and higher minimum median irrigation period flows relative to the no-action alternative. Maximum median irrigation period flows would be lower for Alternative 4 due to the higher winter flow releases. Alternative 4 would also have higher minimum and maximum winter flows and higher minimum but lower maximum irrigation period flows relative to the proposed action.

Table 48. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Deschutes River Downstream from Wickiup Reservoir by Season for the No-Action Alternative and Alternative 4 over the Permit Term

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	Minimum (cfs)	Maximum (cfs)	Minimum (cfs)	Maximum (cfs)
No-Action	250.0	280.0	500.0	1,181.4
Alternative 4 (Years 1–5)	400.0	400.0	600.0	987.0
Alternative 4 (Years 6–20)	450.0	450.0	600.0	962.6

Total monthly streamflow volume (af) for representative wet, normal, and dry years was evaluated to assess changes in seasonal streamflow. Alternative 4 results are presented as the percent difference from the no-action alternative (Table 49). Irrigation period flows decreased in wet and dry years under both flow periods, but remained 2% less than the no-action alternative during a normal year. Winter storage period flows increased each of the three water year types with the greatest increase in years 6 through 20 in a dry year. Flows were also the least variable in years 6 through 20 of a dry year due to the higher winter storage flows and lower irrigation period flows which are more similar than under other water year types.

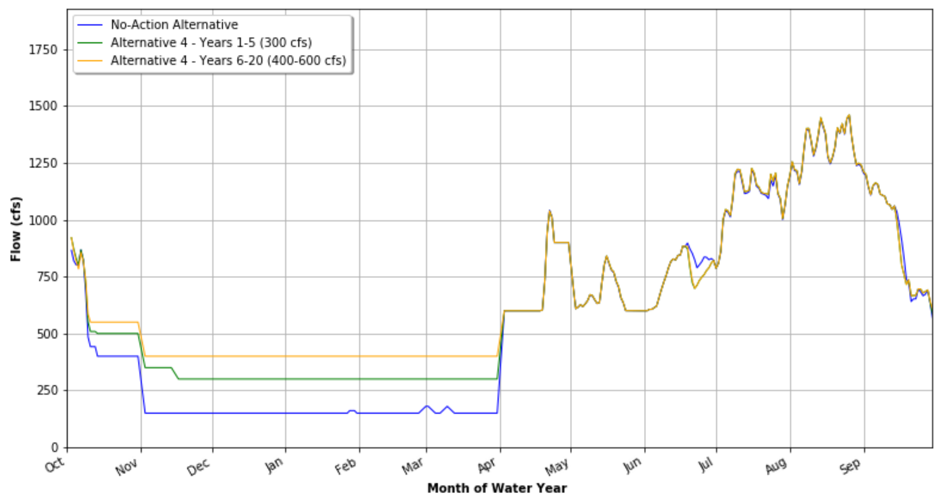
Compared to the proposed action, Alternative 4 in years 21 through 30 experience greater reductions in irrigation period flows during wet and dry years, and greater increases in winter period flows. Flow variability is most pronounced in dry years.

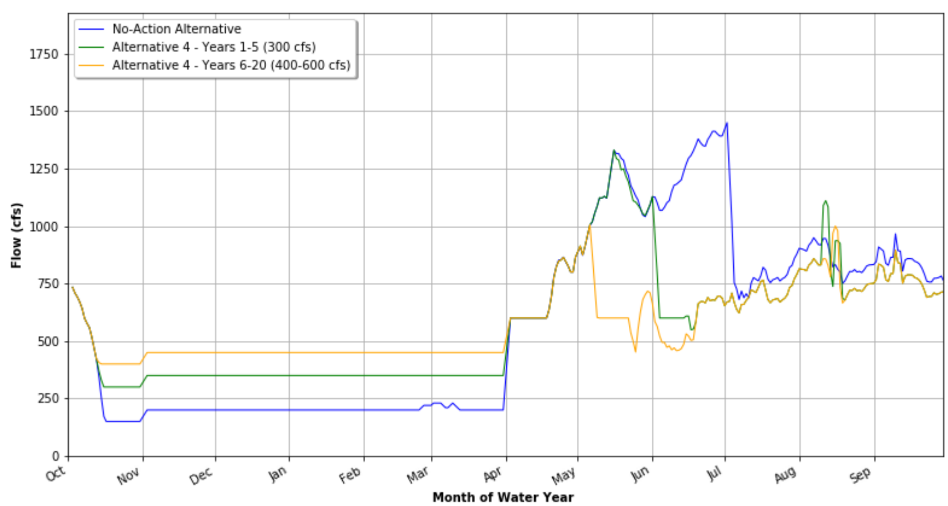
Table 49. Percent Differences in Streamflow Volume between the No-Action Alternative and Alternative 4 for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years at the WICO Gauge

		Alternative 4	
Water Year Type	Time Period	Years 1–5	Years 6–20
Wet	Irrigation Period	-1%	-8%
	Winter/Storage Period	10%	30%
	Annual	2%	0%
	1 SD	-6%	-26%
Normal	Irrigation Period	-2%	-2%
	Winter/Storage Period	26%	38%
	Annual	4%	7%
	1 SD	-12%	-18%
Dry	Irrigation Period	-13%	-21%
	Winter/Storage Period	92%	136%
	Annual	1%	0%
	1 SD	-37%	-63%

Figure 80 includes the representative normal and dry year hydrographs for the WICO gauge under Alternative 4. In both normal and dry years, median flows are higher during the winter storage period and generally lower during the irrigation period for the Alternative 4 flow scenarios relative to the no-action alternative. Irrigation period flow decrease faster during a dry year compared to a normal year.

Figure 80. The Deschutes River Hydrograph for the No-Action Alternative and Alternative 4 in Years 1–5 and Years 6–20 in Representative Normal (upper) and Dry (lower) Years at the WICO Gauge





Deschutes River from the Little Deschutes River to Benham Falls

Implementation of Conservation Measures WR-1 influences flows in the Deschutes River from the Little Deschutes River confluence downstream to Benham Falls. Similar to the WICO gauge results, Alternative 4 flows are higher relative to the proposed action and no-action alternative during the winter storage period and lower during the irrigation period (Figure 81). Lower irrigation period flows are due to the higher winter storage period minimum flows. Irrigation period flows also decline faster during years 6 through 20, marked by declining flows in early July.

Figure 81. The Deschutes River Hydrograph for Years 1–5 (upper) and Years 6–20 (lower) for the No-Action Alternative and Alternative 4 Based on Modeled Flows at the BENO Gauge (Figures show the median flow and 20 to 80% flow range for the two alternatives.)

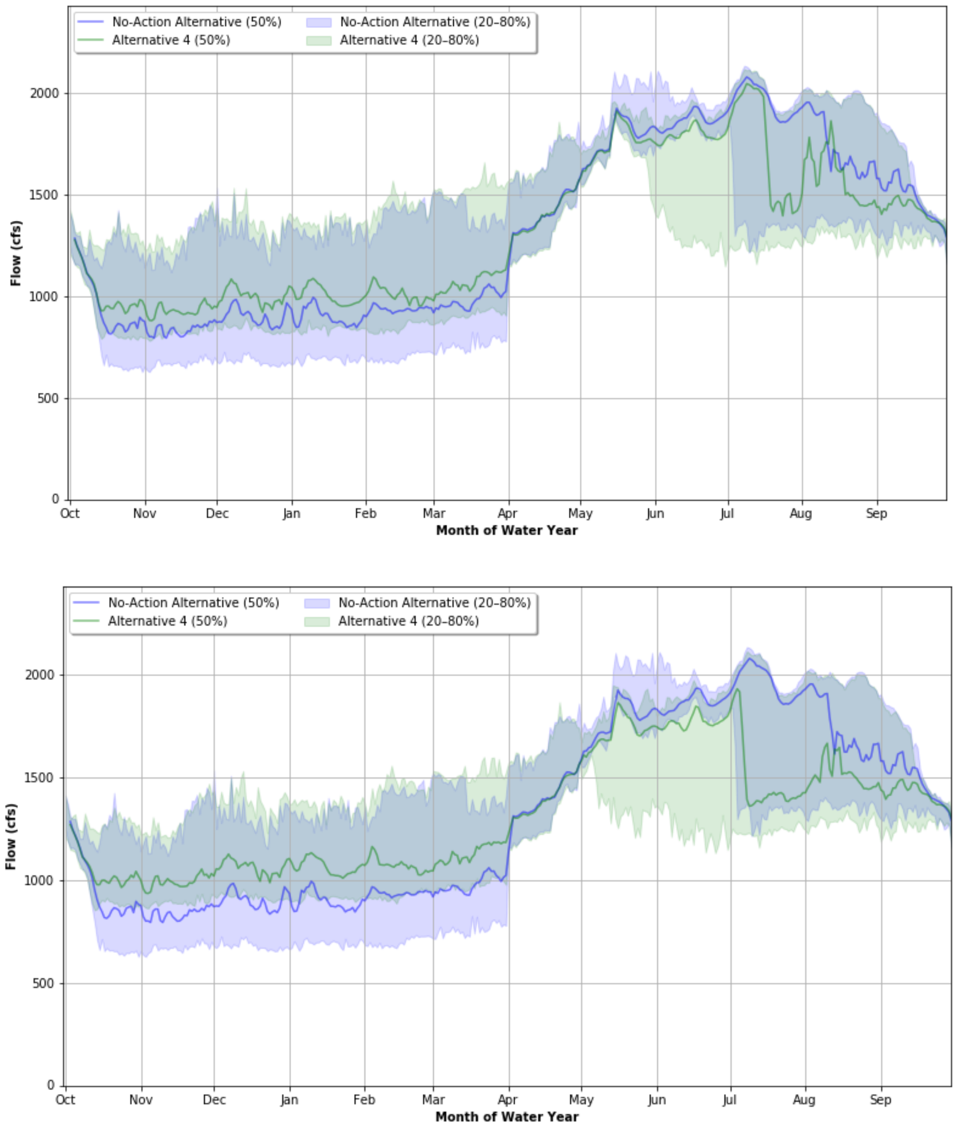


Table 50 includes a comparison of seasonal differences in minimum and maximum median flows based on BENO gauge data. Alternative 4 would have higher minimum and maximum median winter flows and higher minimum median irrigation period flows relative to the no-action alternative. Maximum median irrigation period flows would be lower for Alternative 4 due to the higher winter flow releases. Winter flows are higher in years 1 through 5 for Alternative 4 compared to proposed action in years 11 through 20 when the minimum flows are the same (300 cfs). During the irrigation season, Alternative 4 in years 1 through 5 has higher minimum flows (30 cfs higher) but lower maximum flows (90 cfs lower) relative to the proposed action in years 11 through 20 when minimum winter flows are the same. There is a similar result when Alternative 4 in years 6 through 20 is compared to the proposed action in years 21 through 30.

Table 50. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Deschutes River at the BENO Gauge by Season for the No-Action Alternative and Alternative 4 over the Permit Term

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	Minimum (cfs)	Maximum (cfs)	Minimum (cfs)	Maximum (cfs)
No-Action	824.2	976.0	1,078.0	1,922.2
Alternative 4 (Years 1–5)	921.6	1,079.9	1,098.2	1,781.7
Alternative 4 (Years 6–20)	982.0	1,143.8	1,099.2	1,756.7

Total monthly streamflow volume (af) for representative wet, normal, and dry years was evaluated to assess changes in seasonal streamflow. Alternative 4 results are presented as the percent difference from the no-action alternative (Table 51). Irrigation period flows decreased the most in years 6 through 20 of a dry year. Winter storage period flows increased in normal and dry years and are progressively greater in years 6 through 20. Annual flows are also less variable in a dry year as winter storage and irrigation period flows narrow in magnitude. Compared to the proposed action in years 21 through 30, Alternative 4 in years 6 through 20 has lower irrigation period flows and higher storage period flows.

Table 51. Percent Differences in Streamflow Volume between the No-Action Alternative and Alternative 4 for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years at the BENO Gauge

		Alternative 4	
Water Year Type	Time Period	Years 1–5	Years 6–20
Wet	Irrigation Period	1%	-1%
	Winter/Storage Period	-3%	-1%
	Annual	0%	-1%
	1 SD	-1%	-7%
Normal	Irrigation Period	-6%	-8%
	Winter/Storage Period	17%	23%
	Annual	0%	0%
	1 SD	-31%	-40%
Dry	Irrigation Period	-8%	-13%
	Winter/Storage Period	22%	33%
	Annual	1%	0%
	1 SD	-35%	-63%

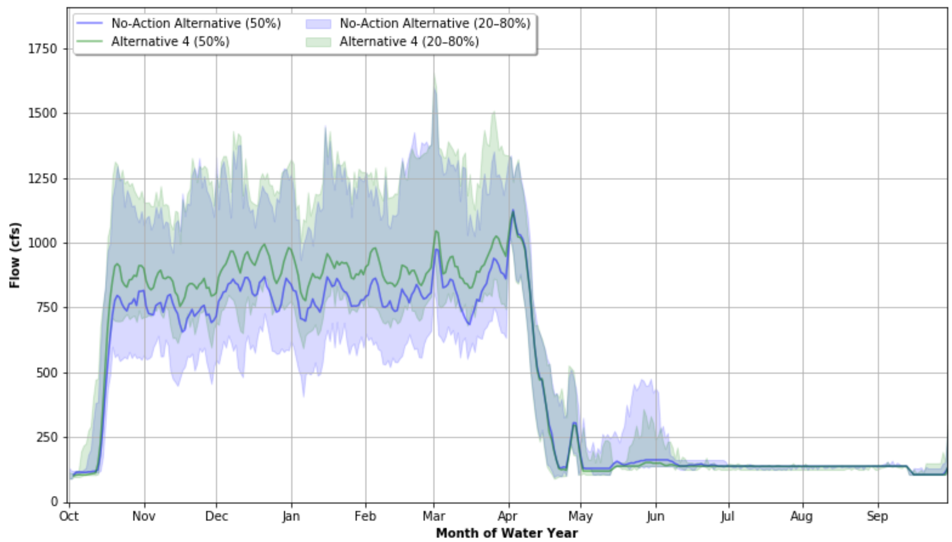
Figure 82 includes the representative normal and dry year hydrographs for the BENO gauge under Alternative 4. In both normal and dry years, Alternative 4 median flows are higher during the winter storage period and generally lower during the irrigation period relative to the no-action alternative. Irrigation period flow decrease more rapidly during a dry year compared to a normal year, and decline faster in years 6 through 20 compared to years 1 through 5.

Figure 82. The Deschutes River Hydrograph for the No-Action Alternative and Alternative 4 in Years 1–5 and Years 6–20 in Representative Normal (upper) and Dry (lower) Years at the BENO Gauge

Deschutes River from Benham Falls to Bend

Surface water diversions located between Lava Island and the DEBO gauge, and streamflow losses to groundwater, influence the amount of water remaining in the Deschutes River at the DEBO gauge (#14070500). Like the WICO and BENO gauges, winter storage period flows are higher under Alternative 4 compared to the no-action alternative (Figure 83). Winter flows are also greater for Alternative 4 in years 6 through 20 compared to years 1 through 5. Irrigation period flows between the no-action alternative and Alternative 4 are very similar except for lower Alternative 4 flows from early May to mid-June in years 1 through 5 and from mid-May to mid-June in years 6 through 20. Compared to the proposed action, Alternative 4 flows are higher in both years 1 through 5 and years 6 through 20 in the winter due to the higher minimum flows. Irrigation period flows are similar between the two alternatives.

Figure 83. The Deschutes River Hydrograph for Years 1–5 (upper) and Years 6–20 (lower) for the No-Action Alternative and Alternative 4 Based on Modeled Flows at the DEBO Gauge (Figures show the median flow and 20 to 80% flow range for the two alternatives.)



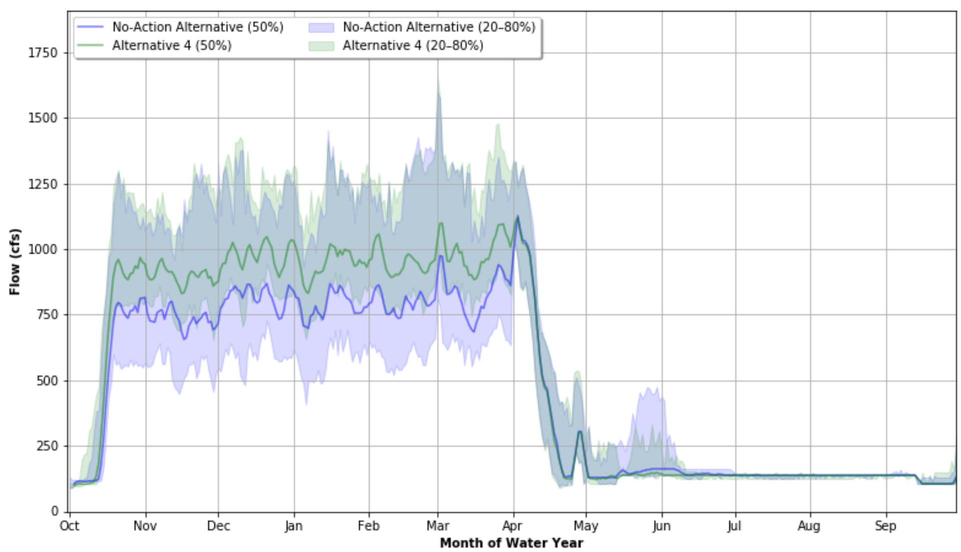


Table 52 includes a comparison of seasonal differences in minimum and maximum median flows based on DEBO gauge data. Alternative 4 would have higher minimum and maximum median winter flows and higher maximum median irrigation period flows relative to the no-action alternative. Minimum median irrigation period flows are similar to the no-action alternative. The irrigation period maximum flows included in Table 52 include the month of October when surface water diversions begin to shut down for the winter. If October is excluded from the calculations, the maximum median daily flows for the irrigation period flows would be very similar to the minimum median daily flows.

Table 52. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Deschutes River at the DEBO Gauge by Season for the No-Action Alternative and Alternative 4 over the Permit Term

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	**Minimum (cfs)**	**Maximum (cfs)**	**Minimum (cfs)**	**Maximum (cfs)**
No-Action	726.0	834.9	130.3	508.2
Alternative 4 (Years 1–5)	832.8	939.6	134.6	618.1
Alternative 4 (Years 6–20)	895.6	997.0	130.7	670.2

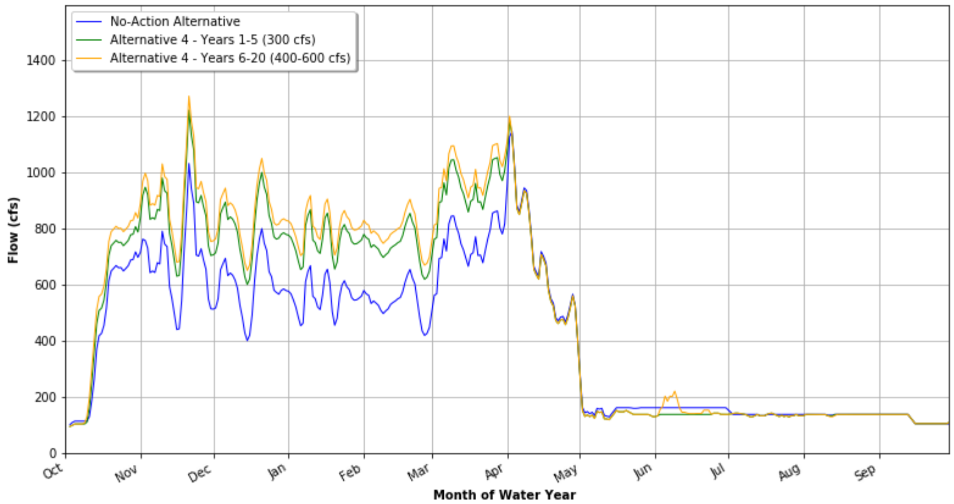
Total monthly streamflow volume (af) for representative wet, normal, and dry years was evaluated to assess changes in seasonal streamflow. Alternative 4 results are presented as the percent difference from the no-action alternative (Table 53). Winter storage and irrigation period flows increase relative to the no-action alternative in normal and dry years and from years 1 through 5 to year 6 through 20 of the flow scenarios. Annual flow variation also increases as winter storage period flows increase relative to the irrigation period flows. Alternative 4 has more variable flows, higher winter flows, and similar irrigation period flows compared to the proposed action.

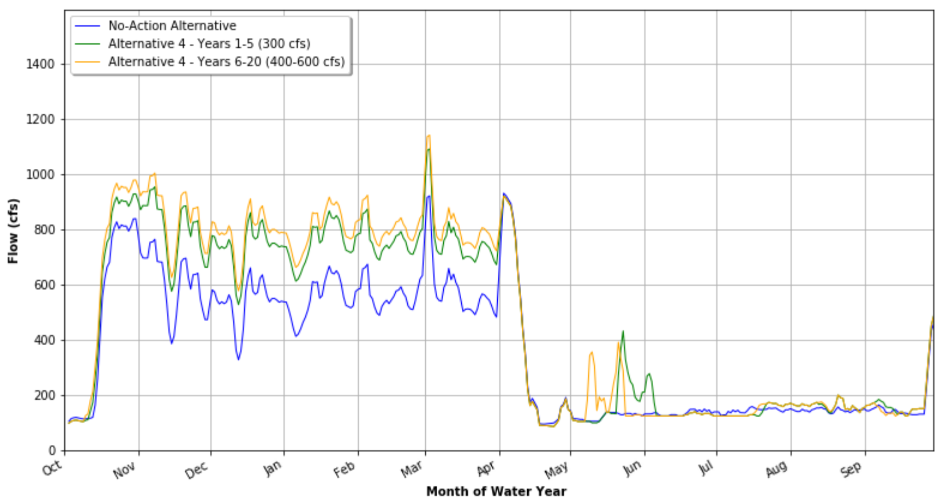
Table 53. Percent Differences in Streamflow Volume between the No-Action Alternative and Alternative 4 for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years at the DEBO Gauge

		Alternative 4	
Water Year Type	**Time Period**	**Years 1–5**	**Years 6–20**
Wet	Irrigation Period	0%	0%
	Winter/Storage Period	6%	6%
	Annual	4%	4%
	1 SD	6%	6%
Normal	Irrigation Period	3%	6%
	Winter/Storage Period	24%	32%
	Annual	17%	23%
	1 SD	25%	33%
Dry	Irrigation Period	13%	15%
	Winter/Storage Period	29%	41%
	Annual	24%	33%
	1 SD	35%	52%

Figure 84 includes the representative normal and dry year hydrographs for the DEBO gauge under the no-action alternative and Alternative 4. Hydrographs for representative normal and dry years have similar patterns with the Alternative 4 scenarios having higher median flows during the winter storage season and similar flows to the no-action alternative during the irrigation period. There is a spike in streamflow that occurs from mid-May to early June in years 1 through 5, and in early to mid-May in years 6 through 20. The earlier flow increase in years 6 through 20 suggests the need to release more stored water to mitigate for lower streamflow earlier in the irrigation period under dry year conditions.

Figure 84. The Deschutes River Hydrograph for the No-Action Alternative and Alternative 4 in Years 1–5 and Years 6–20 in Representative Normal (upper) and Dry (lower) Years at the DEBO Gauge

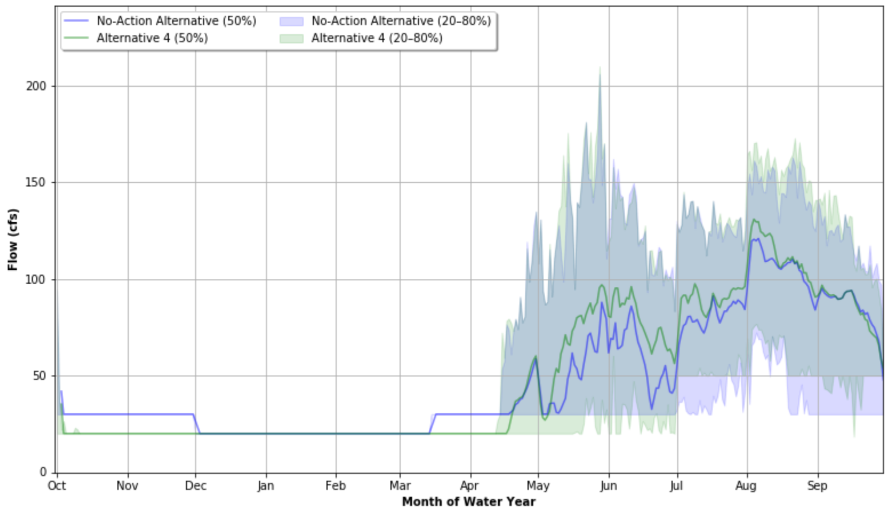




Crescent Creek from Crescent Lake to the Little Deschutes River

There are no additional conservation measures for Crescent Creek under Alternative 4. The accelerated minimum winter flows for the Deschutes River downstream from Wickiup Dam influences Crescent Creek flows by accelerating flow changes in Crescent Creek. For example, the seasonal flow changes that occur in years 11 through 20 under the proposed action, occur in years 1 through 5 of Alternative 3. Otherwise, there are no seasonal flow differences between Alternative 4 and the proposed action. Winter storage period flows have a lower minimum flow under Alternative 4 compared to the no-action alternative (Figure 85). Irrigation period flows are generally higher from early May to early August and similar from early August through the end of September. Flows are similar between Alternative 4 and the proposed action.

Figure 85. The Crescent Creek Hydrograph for Years 1–5 (upper) and Years 6–20 (lower) for the No-Action Alternative and Alternative 4 Based on Modeled Flows at the CREO Gauge (Figures show the median flow and 20 to 80% flow range for the two alternatives.)



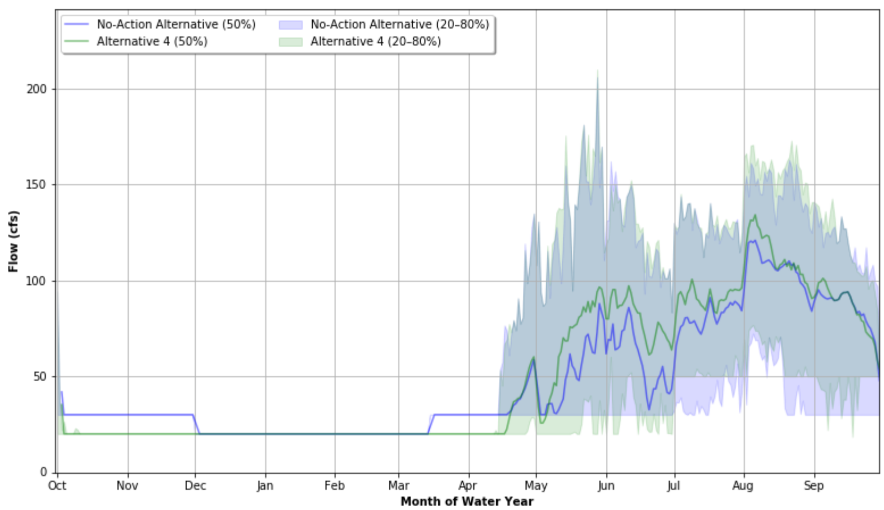


Table 54 includes a comparison of winter storage and irrigation period flows for the no-action alternative and Alternative 4. Minimum median flows are the same in the winter storage period and maximum median flows are slightly less reflecting the lower minimum flows at the CREO gauge. Minimum median irrigation period flows are lower and the maximum median flows are approximately the same for Alternative 4 relative to the no-action flows. Winter and irrigation period flows are similar between Alternative 4 and the proposed action.

Table 54. Comparison of Minimum and Maximum Median (50%) Daily Flows on Crescent Creek at the CREO Gauge by Season for the No-Action Alternative and Alternative 4 over the Permit Term

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	**Minimum (cfs)**	**Maximum (cfs)**	**Minimum (cfs)**	**Maximum (cfs)**
No-Action	20.0	30.0	30.0	107.9
Alternative 4 (Years 1–5)	20.0	20.0	20.0	110.5
Alternative 4 (Years 6–20)	20.0	20.0	20.0	110.0

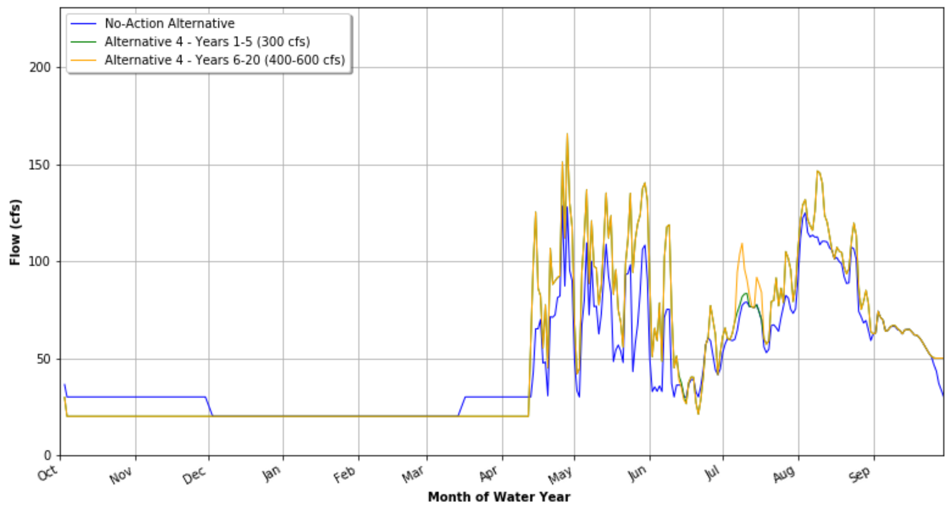
Total monthly streamflow volume (af) for representative wet, normal, and dry years was evaluated to assess changes in seasonal streamflow. Alternative 4 results were compared to the no-action alternative and Alternative 4 results are reported as the percent difference from the no-action alternative (Table 55). Winter storage period flows decrease due to the lower minimum flow requirement under Alternative 4. Irrigation period flows increase for all three year types, but most substantially in a normal year. Annual streamflow also increases the most in a normal year. Annual flows are more variable under each water year type, especially in a normal year as storage period flows decline and irrigation period flows increase. Water year type and time period flows are similar between Alternative 4 and the proposed action.

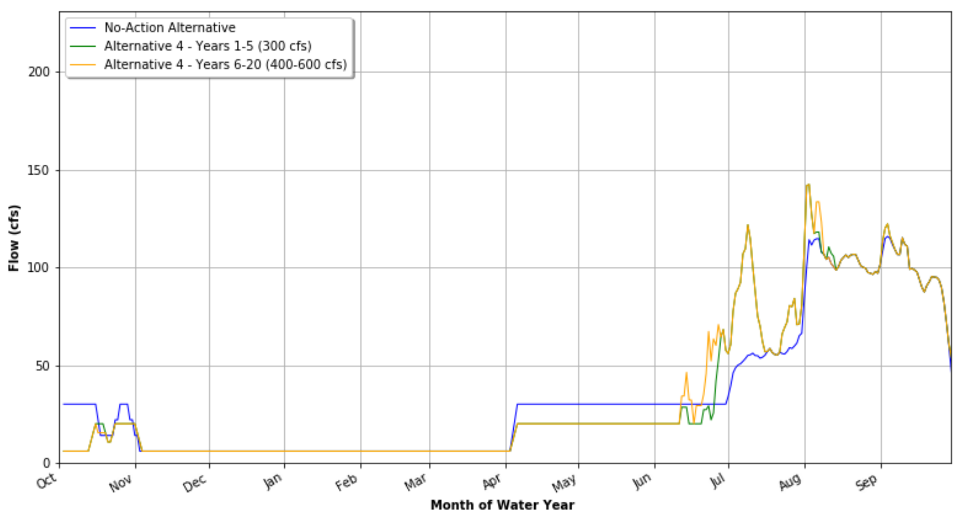
Table 55. Percent Differences in Streamflow Volume between the No-Action Alternative and Alternative 4 for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years at the CREO Gauge

		Alternative 4	
Water Year Type	**Time Period**	**Years 1–5**	**Years 6–20**
Wet	Irrigation Period	5%	3%
	Winter/Storage Period	-13%	-13%
	Annual	3%	1%
	1 SD	17%	14%
Normal	Irrigation Period	15%	16%
	Winter/Storage Period	-13%	-13%
	Annual	9%	9%
	1 SD	31%	33%
Dry	Irrigation Period	-1%	2%
	Winter/Storage Period	-15%	-15%
	Annual	-3%	-1%
	1 SD	12%	12%

Figure 86 includes the representative normal and dry year hydrographs for the no-action alternative and Alternative 4 at the CREO gauge. There are similar minimum winter flows reflecting minimal inputs into and release from Crescent Lake Reservoir. In a normal year, flows increase for the no-action alternative and Alternative 4 scenarios in mid-April as TID water needs increase. Compared to the no-action alternative, flows associated with Alternative 4 in years 6 through 20 are generally highest through the irrigation season but otherwise follow the no-action alternative hydrograph. In a dry year, flow is released from mid-June to mid-July to meet demand. Alternative 4 flows then generally follow the no-action alternative flows for the remainder of the year.

Figure 86. The Crescent Creek Hydrograph for the No-Action Alternative and Alternative 4 in Years 1–5 and Years 6–20 in Representative Normal (upper) and Dry (lower) Years at the CREO Gauge





Little Deschutes River from Crescent Creek Confluence to the Deschutes River

There are no additional conservation measures for the Little Deschutes River under Alternative 4, however, flow changes on Crescent Creek influence flows on the Little Deschutes River at the LAPO gauge. Early storage period flows are lower for Alternative 4 reflecting the lower minimum flows downstream from Crescent Lake Reservoir. Flows from December through mid-May are similar for Alternative 4, and Alternative 4 flows are greater from mid-May through mid-June as flow is released from Crescent Lake Reservoir to meet downstream water demand (Figure 87). From mid-June through September, median flows are similar but slightly greater for Alternative 4 in years 1 through 5 and years 6 through 20 compared to the no-action alternative.

Figure 87. The Little Deschutes River Hydrograph for Years 1–5 (upper) and Years 6–20 (lower) for the No-Action Alternative and Alternative 4 Based on Modeled Flows at the LAPO Gauge (Figures show the median flow and 20 to 80% flow range for the two alternatives.)

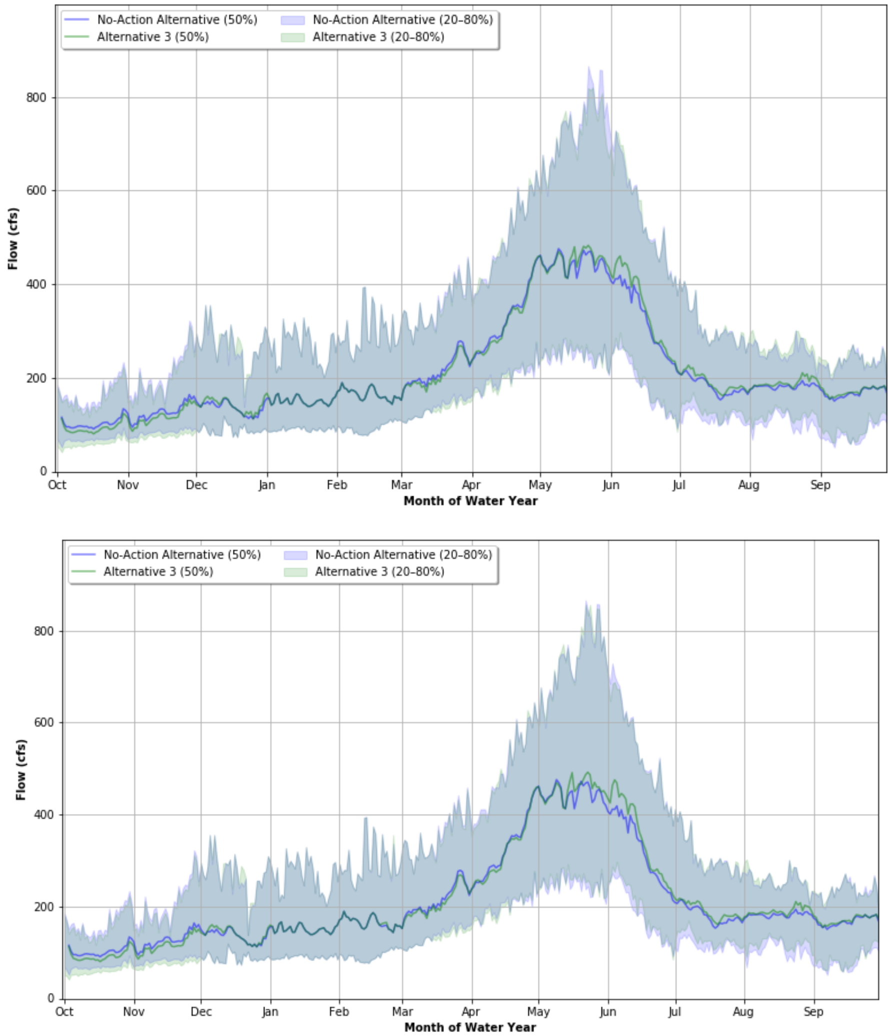


Table 56 includes a comparison of winter storage and irrigation period flows for the no-action alternative and Alternative 4 at the LAPO gauge. Alternative 4 minimum and maximum median flows are lower during the winter storage period reflecting the influence of lower Crescent Creek minimum flows. Irrigation period minimum median flows tend to be about 10% less for Alternative 4 and maximum median flows are similar to the no-action alternative. Winter and irrigation period flows are similar between Alternative 4 and the proposed action.

Table 56. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Little Deschutes River at the LAPO Gauge by Season for the No-Action Alternative and Alternative 4 over the Permit Term

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	**Minimum (cfs)**	**Maximum (cfs)**	**Minimum (cfs)**	**Maximum (cfs)**
No-Action	126.2	213.2	103.1	445.4
Alternative 4 (Years 1–5)	116.6	204.9	93.1	450.1
Alternative 4 (Years 6–20)	116.6	205.8	93.1	447.3

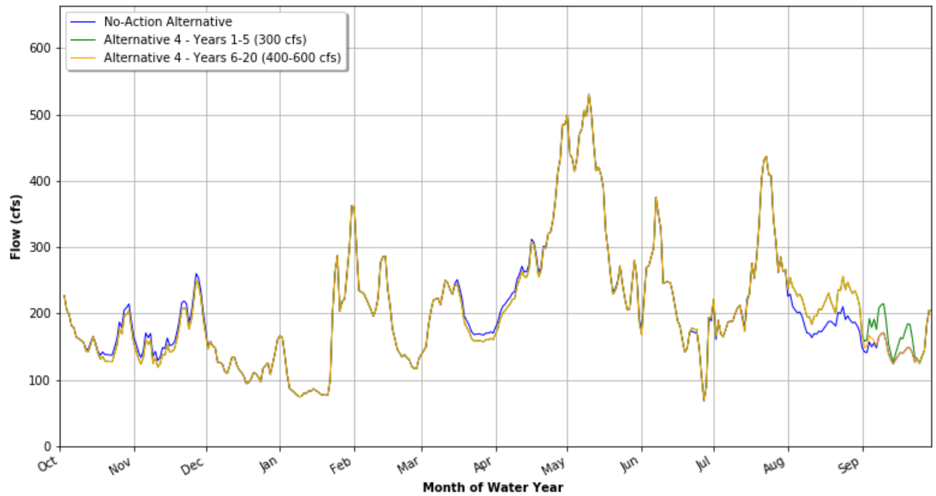
Total monthly streamflow volume (af) for representative wet, normal, and dry years was evaluated to assess changes in seasonal streamflow. Alternative 4 results were compared to the no-action alternative and Alternative 4 results are reported as the percent difference from the no-action alternative (Table 57). There are very minor differences between the no-action alternative and Alternative flows with flow differences related to management effects on Crescent Creek. Water year type and time period flows are similar between Alternative 4 and the proposed action.

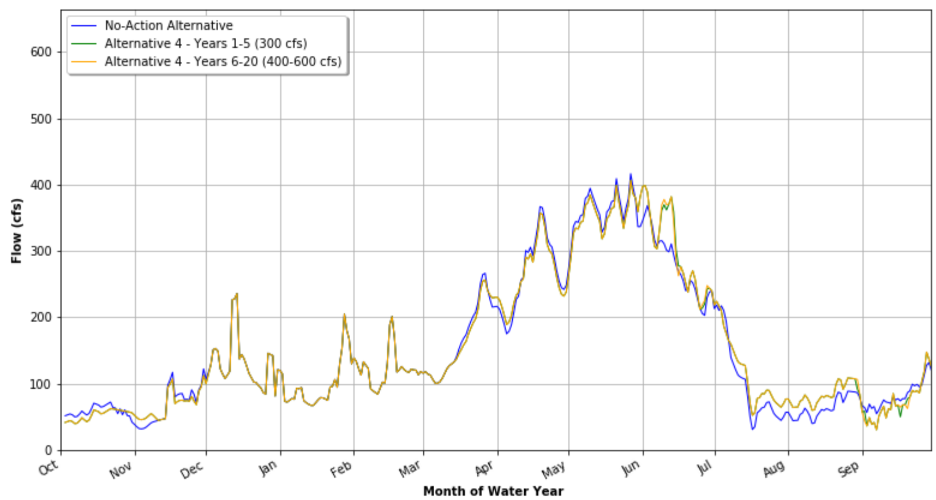
Table 57. Percent Differences in Streamflow Volume between the No-Action Alternative and Alternative 4 for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years at the LAPO Gauge

		Alternative 4	
Water Year Type	**Time Period**	**Years 1–5**	**Years 6–20**
Wet	Irrigation Period	0%	0%
	Winter/Storage Period	-1%	-1%
	Annual	-1%	-1%
	1 SD	0%	0%
Normal	Irrigation Period	2%	1%
	Winter/Storage Period	-2%	-2%
	Annual	1%	0%
	1 SD	2%	3%
Dry	Irrigation Period	2%	2%
	Winter/Storage Period	-2%	-2%
	Annual	0%	0%
	1 SD	1%	1%

Irrigation period flows are similar for Alternative 4 with slightly lower flows at the start and end of the winter storage period and overlap in the middle of the season when Crescent Creek flows are maintained at 20 cfs (Figure 88). Alternative 4 flows are higher later in the irrigation season as stored water is released from Crescent Lake Reservoir.

Figure 88. The Little Deschutes River Hydrograph for the No-Action Alternative and Alternative 4 in Years 1–5 and Years 6–20 in Representative Normal (upper) and Dry (lower) Years at the LAPO Gauge

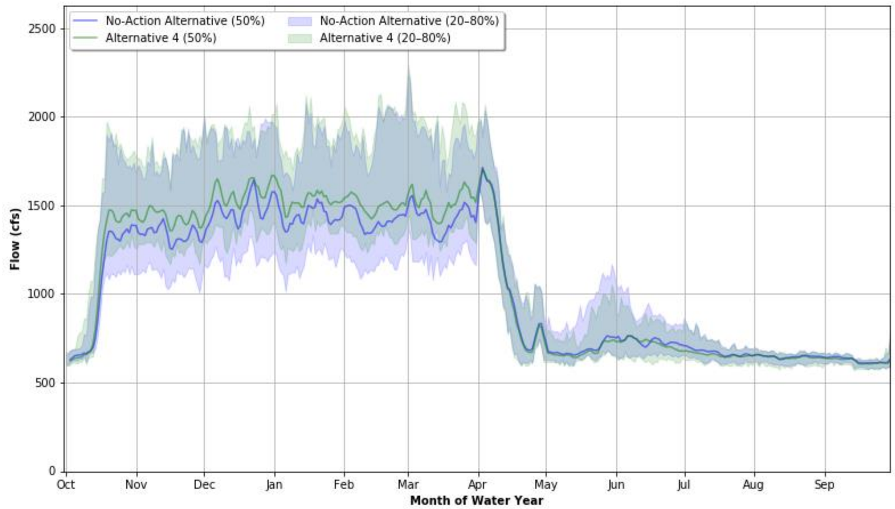




Deschutes River from Bend to Culver

There are no additional conservation measures for the Deschutes River between Bend and Culver. However, due to the effects of the accelerated flow regime, Alternative 4 flows at the Culver (CULO) gauge are slightly different relative to the no-action alternative (Figure 89) and proposed action. In both years 1 through 5 and years 6 through 20, Alternative 4 results in higher winter storage period flows and similar irrigation period flows relative to the no-action alternative. In years 6 through 20, differences are greater in the winter storage period and minor differences are more persistent (though minor) from mid-June through mid-July in the irrigation season. Alternative 4 has higher winter flows and similar irrigation period flows compared to the proposed action.

Figure 89. The Deschutes River Hydrograph for Years 1–5 (upper) and Years 6–20 (lower) for the No-Action Alternative and Alternative 4 Based on Modeled Flows at the CULO Gauge (Figures show the median flow and 20 to 80% flow range for the two alternatives.)



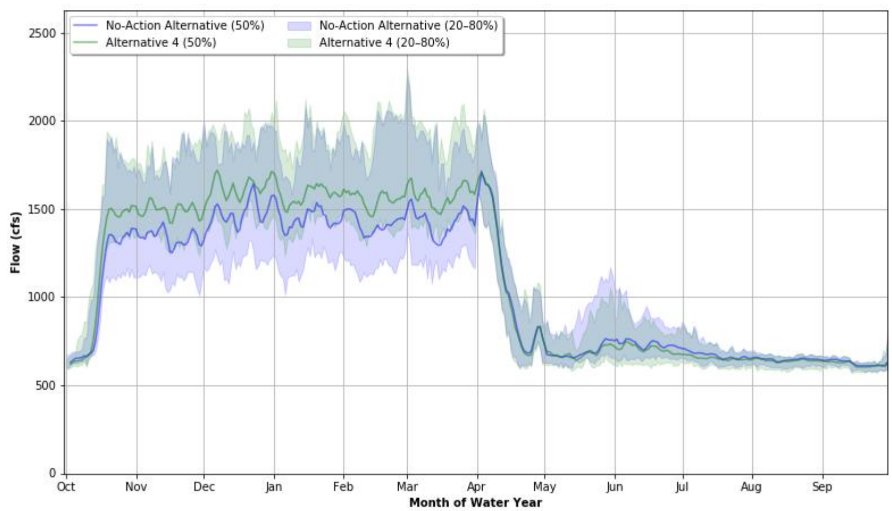


Table 58 includes a comparison of seasonal differences in minimum and maximum median flows based on CULO gauge data. Alternative 4 would have higher minimum and maximum median winter flows and higher maximum median irrigation period flows relative to the no-action alternative. Minimum median irrigation period flows are similar to the no-action alternative. The irrigation period maximum flows included in Table 58 include the month of October when surface water diversions begin to shut down for the winter. If October is excluded from the calculations, the maximum median daily flows for the irrigation period flows would be very similar to the minimum median daily flows.

Table 58. Comparison of Minimum and Maximum Median (50%) DAILY flows on the Deschutes River at the CULO Gauge by Season for the No-Action Alternative and Alternative 4 over the Permit Term

Alternative	Winter (Nov 1–Mar 31) Minimum (cfs)	Winter (Nov 1–Mar 31) Maximum (cfs)	Irrigation (Apr 1–Oct 31) Minimum (cfs)	Irrigation (Apr 1–Oct 31) Maximum (cfs)
No-Action	1,334.4	1,474.7	622.7	1,071.4
Alternative 4 (Years 1–5)	1,434.8	1,573.6	618.2	1,179.7
Alternative 4 (Years 6–20)	1,492.2	1,632.1	616.8	1,237.2

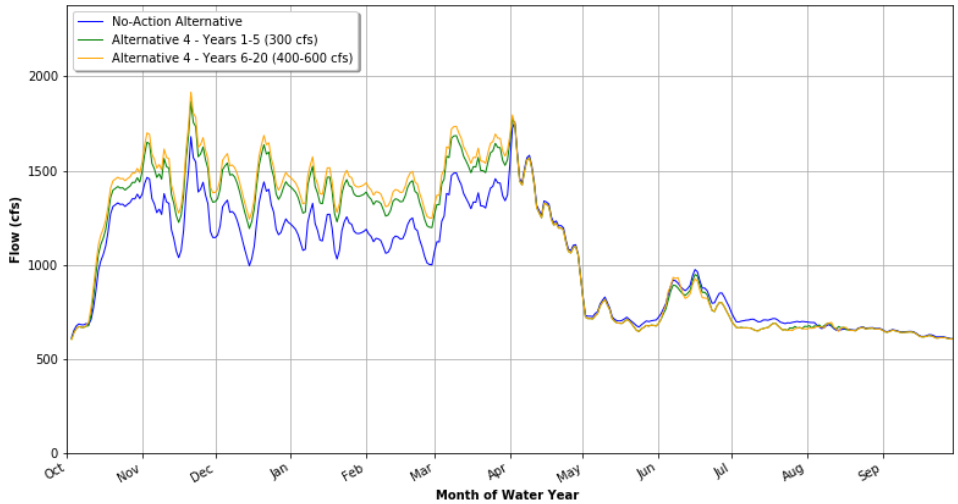
Total monthly streamflow volume (af) for representative wet, normal, and dry years was evaluated to assess changes in seasonal streamflow. Alternative 4 results are presented as the percent difference from the no-action alternative (Table 59). Winter storage and irrigation period flows increase relative to the no-action alternative in all three water year types with winter storage flow differences greatest in a dry year in the years 6 through 20 water management scenario. Irrigation period changes ae minor with the greatest positive change (2%) occurring in a dry year. Flow variability is also greatest in a dry year as winter storage period flows increase and irrigation period flows remain close to the same as the no-action alternative. Alternative 4 winter flows are higher and irrigation period flows are similar in years 6 through 20 compared to the proposed action years 21 through 30 flows.

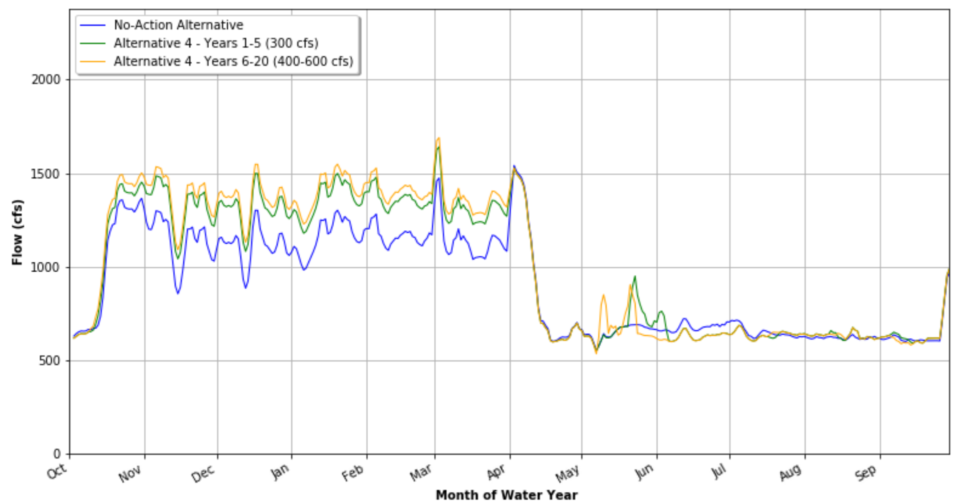
Table 59. Percent Differences in Streamflow Volume between the No-Action Alternative and Alternative 4 for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years at the CULO Gauge

Water Year Type	Time Period	Alternative 4 Years 1–5	Alternative 4 Years 6–20
Wet	Irrigation Period	-4%	0%
	Winter/Storage Period	1%	4%
	Annual	-1%	2%
	1 SD	6%	5%
Normal	Irrigation Period	0%	1%
	Winter/Storage Period	12%	16%
	Annual	6%	9%
	1 SD	23%	30%
Dry	Irrigation Period	2%	2%
	Winter/Storage Period	14%	20%
	Annual	9%	12%
	1 SD	30%	45%

Figure 90 includes the representative normal and dry year hydrographs for the CULO gauge under the no-action alternative and Alternative 4. Hydrographs for representative normal and dry years have similar patterns with the Alternative 4 scenarios having higher median flows during the winter storage season and similar flows to the no-action alternative during the irrigation period. There is a spike in streamflow that occurs from mid-May to early June in years 1 through 5, and in early to mid-May in years 6 through 20. The earlier flow increase in years 6 through 20 suggests the need to release more stored water to mitigate for lower streamflow earlier in the irrigation period under dry year conditions.

Figure 90. The Deschutes River Hydrograph for the No-Action Alternative and Alternative 4 in Years 1–5 and Years 6–20 in Representative Normal (upper) and Dry (lower) Years at the CULO Gauge

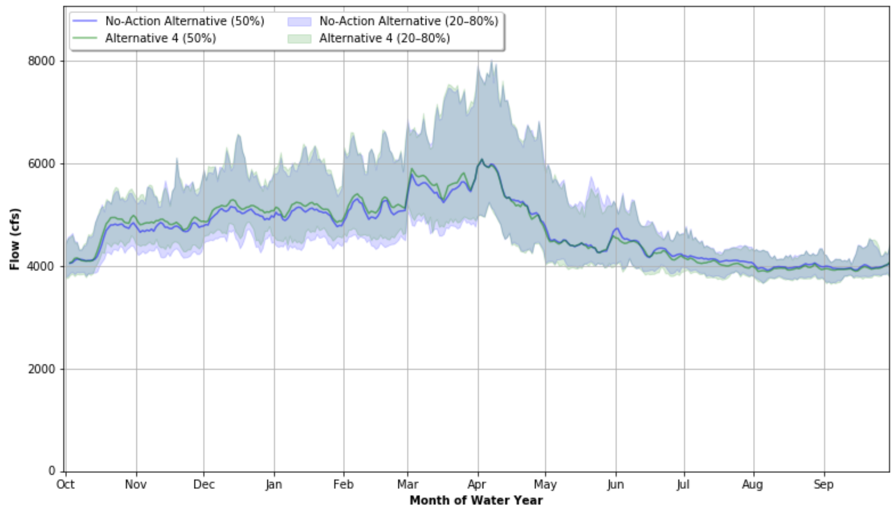




Deschutes River from Pelton Round Butte Dam to Madras

The Deschutes River at the Madras (MADO) gauge has similar median flows and flow variability for the no-action alternative and Alternative 3 (Figure 91). Like the other mainstem Deschutes River gauges, RiverWare output for the MADO also shows the influence of higher winter storage flows and slightly lower irrigation period flows. Storage period differences are greater in years 6 through 20 relative to years 1 through 5 of Alternative 4.

Figure 91. The Deschutes River Hydrograph for Years 1–5 (upper) and Years 6–20 (lower) for the No-Action Alternative and Alternative 4 Based on Modeled Flows at the MADO Gauge Downstream from Lake Billy Chinook (Figures show the median flow and 20 to 80% flow range for the two alternatives.)



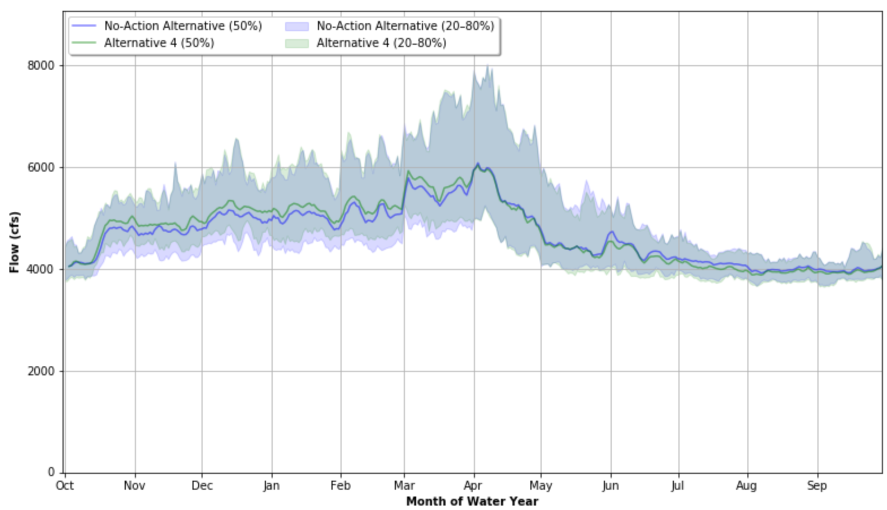


Table 60 includes a comparison of seasonal differences in minimum and maximum median flows based on MADO gauge data. Winter storage flows are approximately 2% greater and irrigation period flows are the same under Alternative 3 relative to the no-action alternative.

Table 60. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Deschutes River at the MADO Gauge by Season for the No-Action Alternative and Alternative 4 over the Permit Term

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	**Minimum (cfs)**	**Maximum (cfs)**	**Minimum (cfs)**	**Maximum (cfs)**
No-Action	4,725.5	5,503.7	3,966.8	5,366.1
Alternative 4 (Years 1–5)	4,830.6	5,633.4	3,937.1	5,339.8
Alternative 4 (Years 6–20)	4,860.2	5,662.2	3,927.2	5,336.3

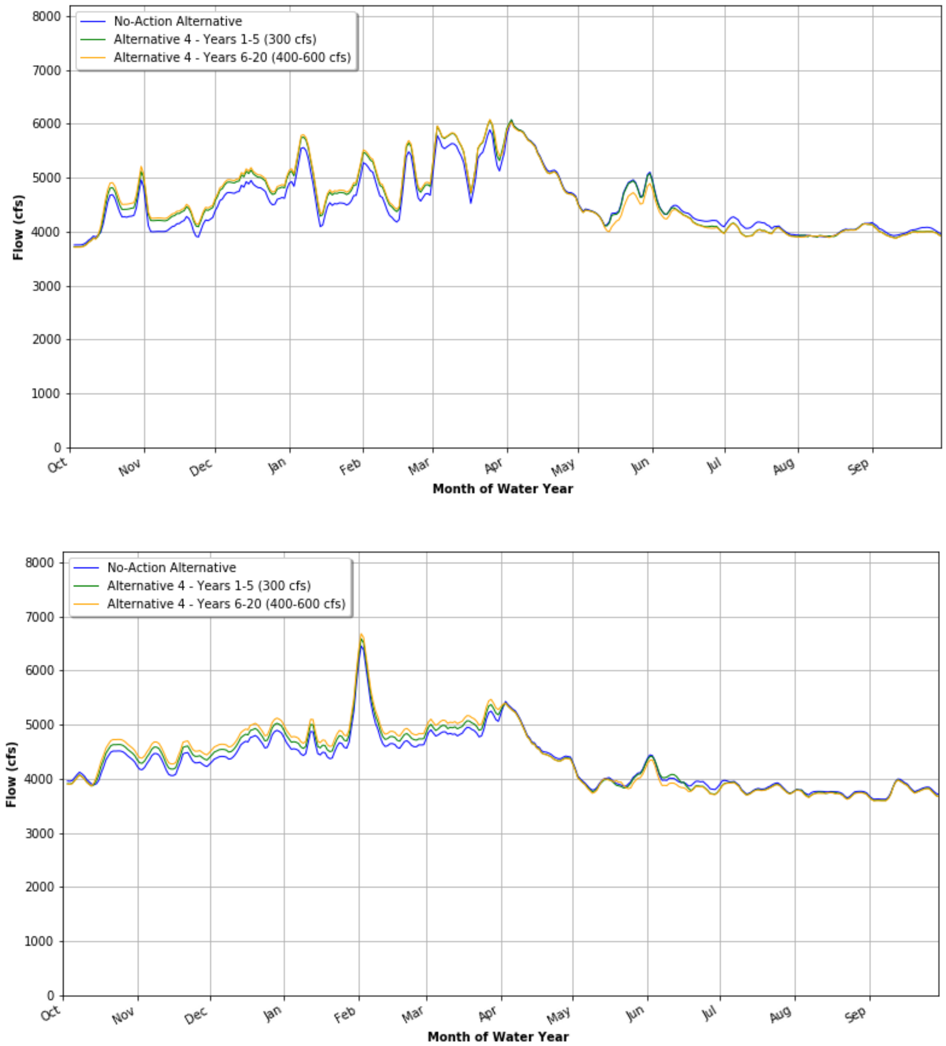
Total monthly streamflow volume (af) for representative wet, normal, and dry years was evaluated to assess changes in seasonal streamflow. Proposed action results were compared to the no-action alternative and proposed action results are reported as the percent difference from the no-action alternative (Table 61). Streamflow changes are minimal in wet and normal years over the permit term. Flows are more variable in dry years as minimum winter flows increase over the permit term. Alternative 4 flows in years 6 through 20 are similar to the proposed action flows in years 21 through 30.

Table 61. Percent Differences in Streamflow Volume between the No-Action Alternative and Alternative 4 for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years at the MADO Gauge

		Alternative 4	
Water Year Type	**Time Period**	**Years 1–5**	**Years 6–20**
Wet	Irrigation Period	0%	-1%
	Winter/Storage Period	1%	1%
	Annual	0%	0%
	1 SD	1%	1%
Normal	Irrigation Period	0%	0%
	Winter/Storage Period	2%	2%
	Annual	1%	1%
	1 SD	6%	7%
Dry	Irrigation Period	0%	0%
	Winter/Storage Period	3%	5%
	Annual	1%	2%
	1 SD	13%	23%

Figure 92 includes the representative normal and dry year hydrographs for the MADO gauge under the proposed action in years 1 through 5 and 6 through 20. Streamflow patterns are similar to the CRSO results with proposed action flows higher in the winter and lower or similar to the no-action alternative during the irrigation period. Flows are generally lower during the representative dry year.

Figure 92. The Deschutes River Hydrograph for the No-Action Alternative and Alternative 4 in Years 1–5 and Years 6–20 in Representative Normal (upper) and Dry (lower) Years at the MADO Gauge



Deschutes River Flood Flows

Alternative 4 results in a reduction of days exceeding respective flood flow thresholds for the WICO, BENO, and DEBO+TUMO gauges (when 2,000 cfs is applied as the DEBO+TUMO gauge data threshold) (Table 62). When the lower flood flow threshold of 1,400 cfs is used, three additional days exceed the flood threshold.

Table 62. Flood Flow Thresholds and Daily Flow Exceedance for the No-Action Alternative and Alternative 4 over the Permit-Term (Two flood flow thresholds are included for the DEBO+TUMO gauge data.)

Gauge	Flood Flow Threshold (cfs)	Average Number of Days of Flood Flow Threshold Exceedance per Year		
		No-Action	Alternative 4	
			Years 1–5	Years 6–20
WICO	1,600	2.3	1.4	0.8
BENO	2,000	27.4	19.3	17.7
DEBO+TUMO	1,400	26.8	29.9	29.2
DEBO+TUMO	2,000	1.9	1.3	1.2

Crooked River Outflow from Bowman Dam

Under Alternative 4, Conservation Measure CR-1 includes a storage season minimum instream flow of 80 cfs in the Crooked River. Increasing minimum flows from 300 cfs (years 1–5) up to between 400 and 600 cfs (years 6–20) on the Upper Deschutes River results in water delivery shortage for North Unit ID, which in turn requires North Unit ID to rely more heavily on Crooked River water. To meet North Unit ID demand, additional water is released from Prineville Reservoir and higher Crooked River flows are marked by elevated median flows from early-May through mid-June (Figure 93). Alterative 4 flows then decrease relative to the no-action alternative from mid-June through the end of September. Higher flows through May in years 6 through 20 are needed to meet the North Unit ID water demands resulting from the higher minimum winter storage season on the Upper Deschutes River.

Figure 93. The Crooked River Hydrograph for Years 1–5 (upper) and Years 6–20 (lower) for the No-Action Alternative and Alternative 4 Based on Modeled Flows at the PRVO Gauge (Figures show the median flow and 20 to 80% flow range for the two alternatives.)

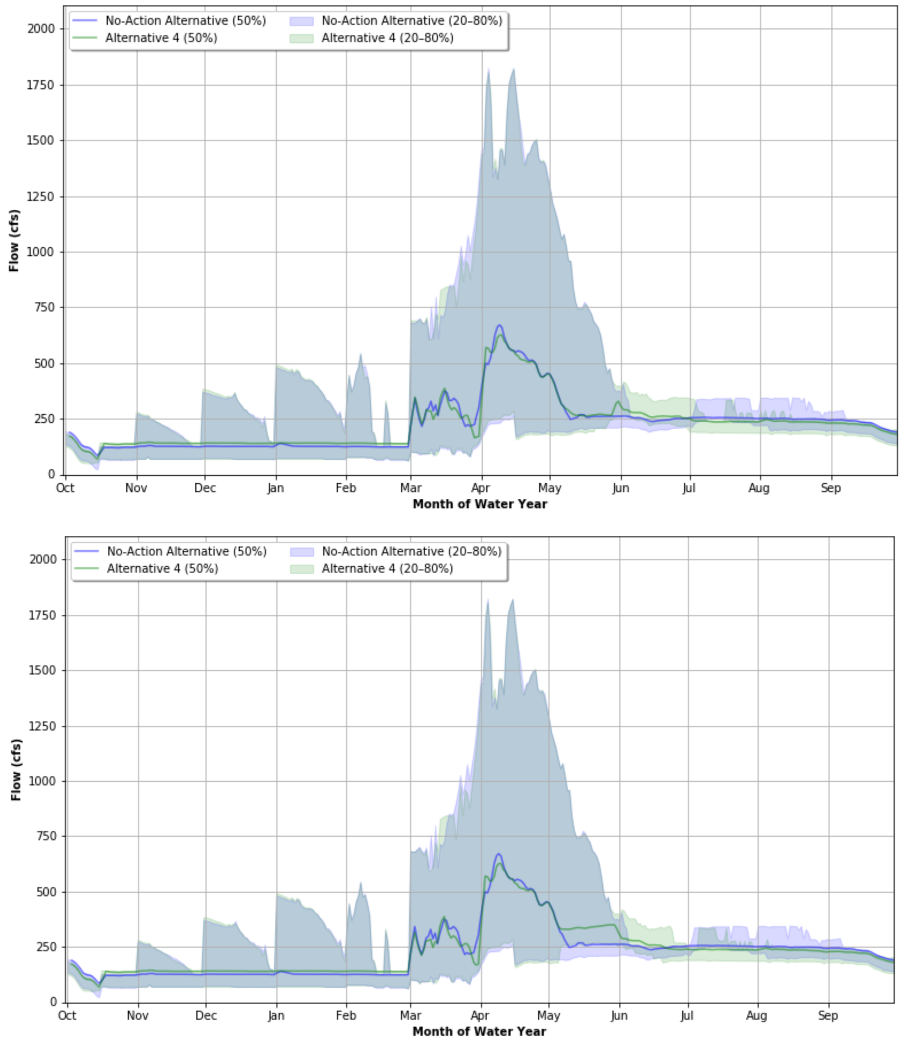


Table 63 includes a comparison of seasonal differences in minimum and maximum median flows based on PRVO gauge data. Flow differences are more pronounced during the winter storage period, when maximum flows decrease under Alternative 4. The flow reduction occurs in March and is related to additional reservoir filling related to excess storage capacity caused by the higher storage period flows relative to the no-action alternative. Additional reservoir filling reduces reservoir outflows to the Crooked River.

Table 63. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Crooked River at the PRVO Gauge by Season for the No-Action Alternative and Alternative 4 over the Permit Term)

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	Minimum (cfs)	Maximum (cfs)	Minimum (cfs)	Maximum (cfs)
No-Action	123.8	297.6	119.9	518.2
Alternative 4 (Years 1–5)	138.6	254.4	113.4	514.1
Alternative 4 (Years 6–20)	138.6	253.8	113.3	514.1

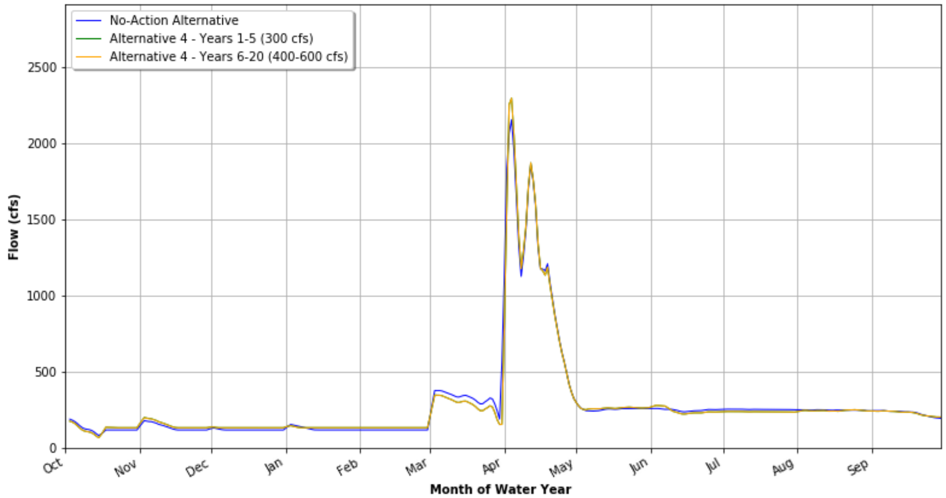
Total monthly streamflow volume (af) for representative wet, normal and dry years was evaluated to assess changes in seasonal streamflow. Alternative 4 results were compared to the no-action alternative and Alternative 4 results are reported as the percent difference from the no-action alternative (Table 64). Streamflow would experience minimal changes except in a dry year when winter storage period flows increase 21% due to the minimum 80 cfs instream flow. Flow variability also decreases in a dry year due to the higher storage period flows.

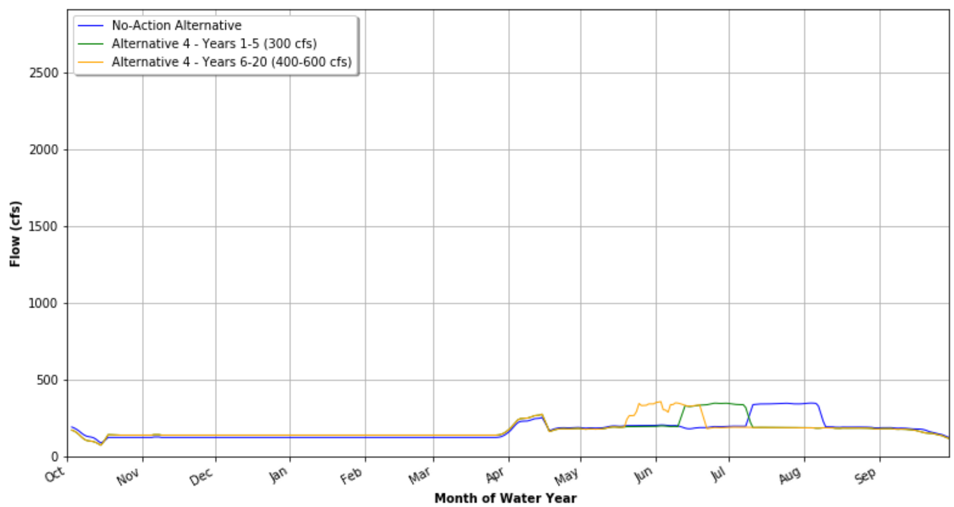
Table 64. Percent Differences in Streamflow Volume between the No-Action Alternative and Alternative 4 for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years at the PRVO Gauge

		Alternative 4	
Water Year Type	Time Period	Years 1–5	Years 6–20
Wet	Irrigation Period	0%	0%
	Winter/Storage Period	-1%	-2%
	Annual	-1%	-1%
	1 SD	-3%	-3%
Normal	Irrigation Period	0%	1%
	Winter/Storage Period	-3%	-3%
	Annual	0%	0%
	1 SD	2%	2%
Dry	Irrigation Period	-2%	-2%
	Winter/Storage Period	21%	21%
	Annual	4%	4%
	1 SD	-14%	-15%

Figure 94 includes the representative normal and dry year hydrographs for the PRVO gauge under Alternative 4 in years 1 through 5 and years 6 through 20. In a representative normal year, flows associated with Alternative 4 and the no-action alternative are very similar. In a representative dry year, month-long elevated flows occur from early July to early August under the no-action alternative. The higher flows occur from mid-June to mid-July in years 1 through 5 and from mid-May to mid-June in years 6 through 20 as flow is released to meet North Unit ID water demand.

Figure 94. The Crooked River Hydrograph for the No-Action Alternative and Alternative 4 in Years 1–5 and Years 6–20 in Representative Normal (upper) and Dry (lower) Years at the PRVO Gauge

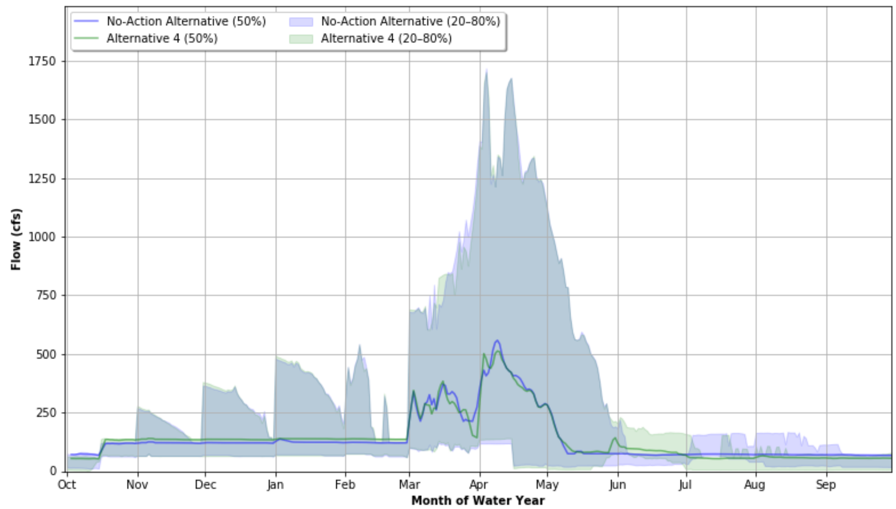




Crooked River from Bowman Dam to Highway 126 Crossing

Several diversions draw water from the Crooked River between Bowman Dam and the Highway 126 bridge (location of the CAPO gauge). Diversions including Rice Baldwin, Peoples, and the Crooked River Feed Canal are the primary diversions, smaller secondary diversions are also located in the reach. Comparative hydrographs for the no-action and Alternative 4 in years 1 through 5 and years 6 through 20 show slightly higher flows during the winter storage period and lower flows from late June through the end of September (Figure 95). The increased flows noted for the PRVO gauge in May, are also apparent at the CAPO gauge.

Figure 95. The Crooked River Hydrograph for Years 1–5 (upper) and Years 6–20 (lower) for the No-Action Alternative and Alternative 4 Based on Modeled Flows at the CAPO Gauge (Figures show the median flow and 20 to 80% flow range for the two alternatives.)



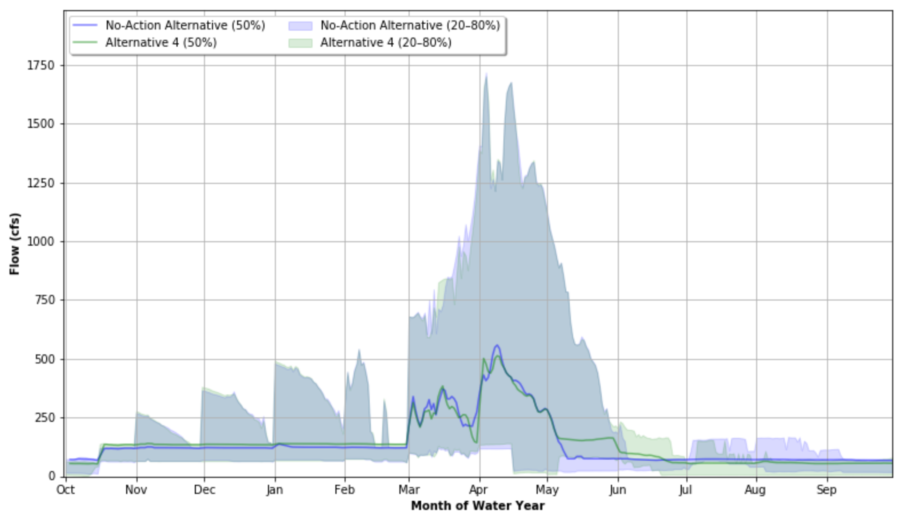


Table 65 includes a comparison of seasonal differences in minimum and maximum median flows based on CAPO gauge data. Minimum winter storage flows increase while maximum median flows decrease relative to the no-action alternative. Lower storage season peak flows are caused by reservoir filling in March, higher minimum flows are due to higher storage season minimum flows. During the irrigation season, Alternative 4 has lower minimum flows and similar maximum flows. The lower minimum flows are due to reservoir depletion caused by the higher storage season minimum flows.

Table 65. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Crooked River at the CAPO Gauge by Season for the No-Action Alternative and Alternative 4 over the Permit Term

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	**Minimum (cfs)**	**Maximum (cfs)**	**Minimum (cfs)**	**Maximum (cfs)**
No-Action	120.6	288.3	68.1	389.3
Alternative 4 (Years 1–5)	135.4	252.0	55.2	381.9
Alternative 4 (Years 6–20)	135.4	251.4	54.5	381.9

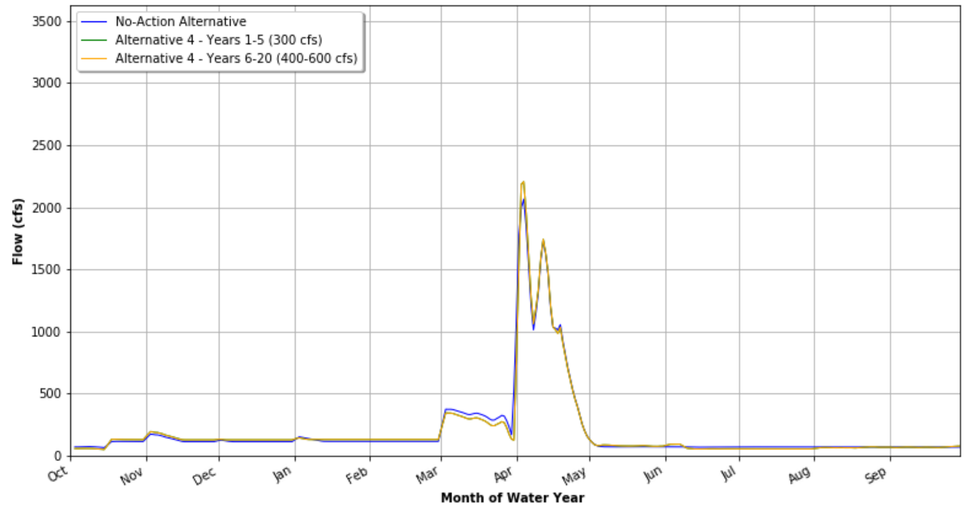
Total monthly streamflow volume (af) for representative wet, normal and dry years was evaluated to assess changes in seasonal streamflow (Table 66). Under Alternative 4, irrigation period flows increase 7% relative to the no-action alternative, but do not change between years 1 through 5 and years 6 through 20. In a representative dry year, irrigation flows would decrease 8% while winter storage period flows would increase 7%. Flow variability decreases in wet and normal years, but increases in dry years.

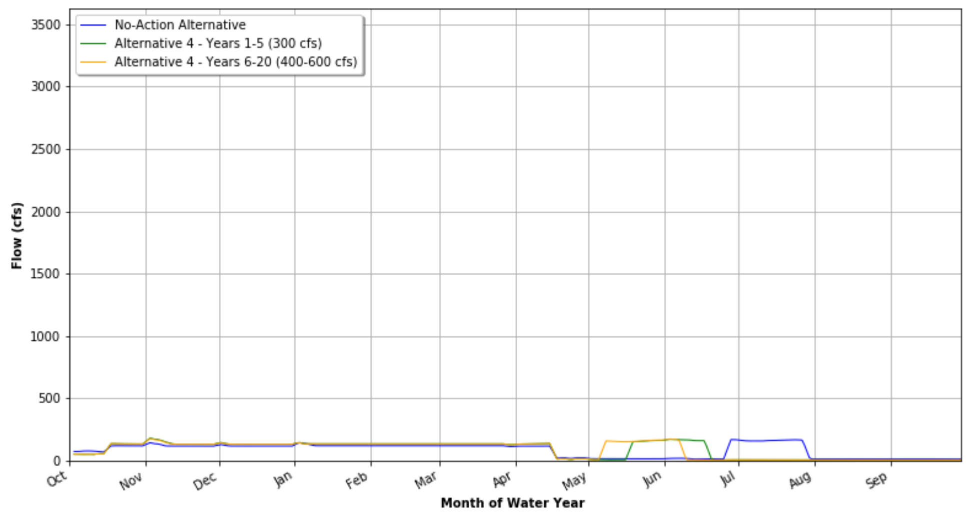
Table 66. Percent Differences in Streamflow Volume between the No-Action Alternative and Alternative 4 for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years at the CAPO Gauge

		Alternative 4	
Water Year Type	**Time Period**	**Years 1–5**	**Years 6–20**
Wet	Irrigation Period	-1%	0%
	Winter/Storage Period	-1%	-2%
	Annual	-1%	-1%
	1 SD	-4%	-4%
Normal	Irrigation Period	7%	7%
	Winter/Storage Period	1%	1%
	Annual	4%	4%
	1 SD	-5%	-5%
Dry	Irrigation Period	-8%	-8%
	Winter/Storage Period	7%	7%
	Annual	1%	1%
	1 SD	4%	12%

Figure 96 includes the representative normal and dry year hydrographs for the CAPO gauge under Alternative 4 in years 1 through 5 and years 6 through 20. The hydrographs reflect a similar pattern to the PRVO gauge. In a dry year, elevated flows are accelerated to earlier in the irrigation season in order to provide irrigation water to the North Unit ID pump station.

Figure 96. The Crooked River Hydrograph for the No-Action Alternative and Alternative 4 in Years 1–5 and Years 6–20 in Representative Normal (upper) and Dry (lower) Years at the CAPO Gauge

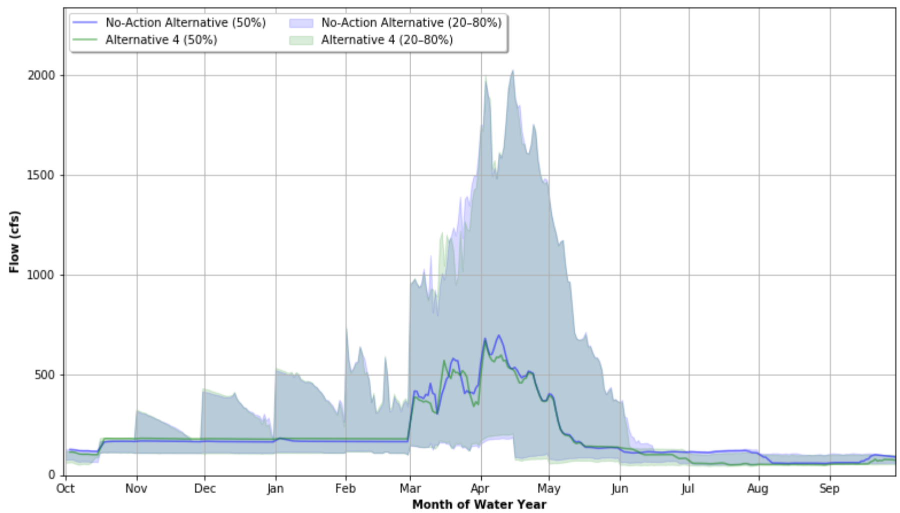




Crooked River from North Unit Irrigation District Pump Station to Smith Rock State Park

Crooked River streamflow at the Smith Rock gauge (CRSO) located downstream from the North Unit ID pump station is shown in hydrographs for the no-action alternative and Alternative 4 in years 1 through 5 and years 6 through 20 (Figure 97). The hydrographs are similar although median flows are lower from mid-June through early August as water is diverted by the North Unit ID pump station to meet water user demand. The difference between Alternative 4 and no-action alternative irrigation period flows increases in years 6 through 20 as more water is pumped at the North Unit ID pump station to meet water demand not met by the Upper Deschutes River. As under Alternative 3, releases of uncontracted storage from Prineville Reservoir would be protected instream year-round from Bowman Dam to Lake Billy Chinook.

Figure 97. The Crooked River Hydrograph for Years 1–5 (upper) and Years 6–20 (lower) for the No-Action Alternative and Alternative 4 Based on Modeled Flows at the CRSO Gauge (Figures show the median flow and 20 to 80% flow range for the two alternatives. Increased pumping at the North Unit ID pump station influences CRSO flows from June through August.)



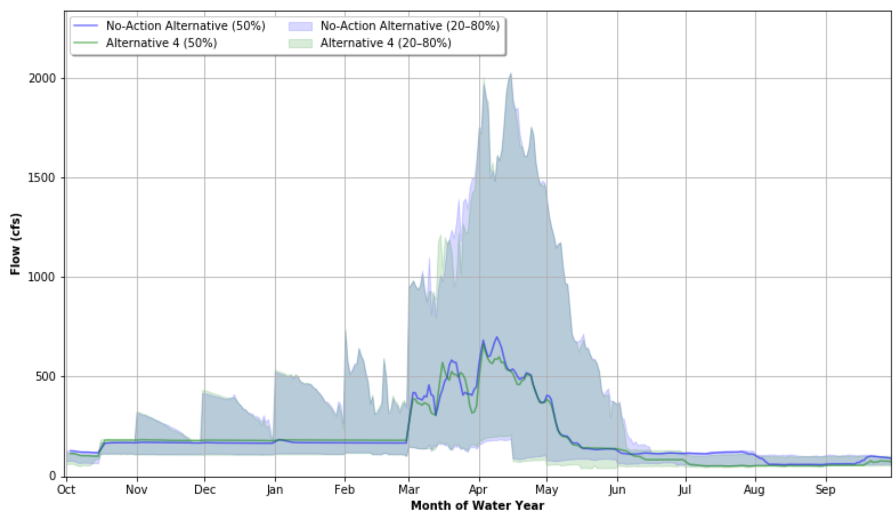


Table 67 includes a comparison of seasonal differences in minimum and maximum median flows based on CRSO gauge data. Minimum winter storage flows increase while maximum median flows decrease due to additional reservoir filling under Alternative 4. Alternative 4 has lower minimum flows and similar maximum flows. The lower minimum flows result from reduced storage, the maximum flows are reflective of flow releases to meet North Unit ID water demand.

Table 67. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Crooked River at the CRSO Gauge Downstream from the North Unit Irrigation District Pump Station by Season for the No-Action Alternative and Alternative 4

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	Minimum (cfs)	Maximum (cfs)	Minimum (cfs)	Maximum (cfs)
No-Action	166.1	413.9	59.2	511.7
Alternative 4 (Years 1–5)	179.7	388.0	51.9	510.0
Alternative 4 (Years 6–20)	179.2	387.1	51.9	509.7

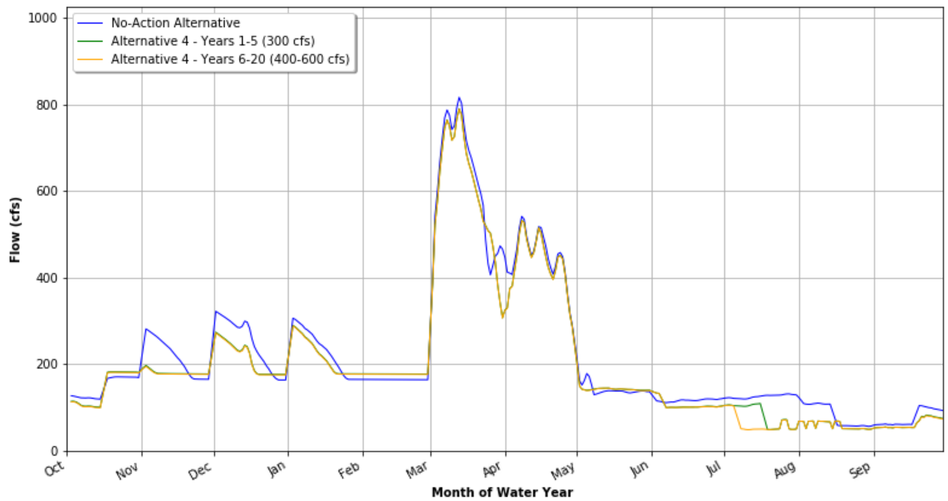
Total monthly streamflow volume (af) for representative wet, normal, and dry years were evaluated to assess changes in seasonal streamflow (Table 68). Compared to the no-action alternative, Alternative 4 irrigation period flows decrease in all water types with the greatest reduction in a normal year in years 6 through 20. Winter storage period flows only increase relative to the no-action alternative in a dry year. Flow variability only increases in a dry year due to the increased winter flows.

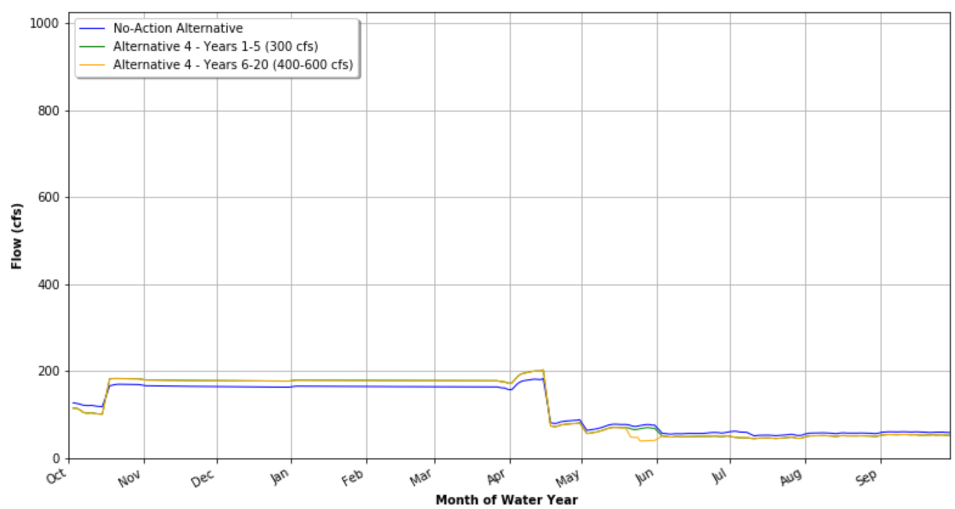
Table 68. Percent Differences in Streamflow Volume between the No-Action Alternative and Alternative 4 for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years at the CRSO Gauge

		Alternative 4	
Water Year Type	Time Period	Years 1–5	Years 6–20
Wet	Irrigation Period	-3%	-5%
	Winter/Storage Period	-2%	-2%
	Annual	-2%	-4%
	1 SD	-3%	-3%
Normal	Irrigation Period	-9%	-11%
	Winter/Storage Period	0%	-1%
	Annual	-4%	-5%
	1 SD	-2%	-1%
Dry	Irrigation Period	-4%	-6%
	Winter/Storage Period	14%	13%
	Annual	6%	5%
	1 SD	15%	16%

Figure 98 presents the representative normal and dry year hydrographs for the CRSO gauge under Alternative 4. The North Unit ID pump station flow effects occur in mid-July to mid-August in a normal year. In a dry year, the pump station effects are limited to late June due to the overall low flow effects of a dry year.

Figure 98. The Crooked River Hydrograph for the No-Action Alternative and Alternative 4 in Years 1–5 and Years 6–20 in Representative Normal (upper) and Dry (lower) Years at the CRSO Gauge

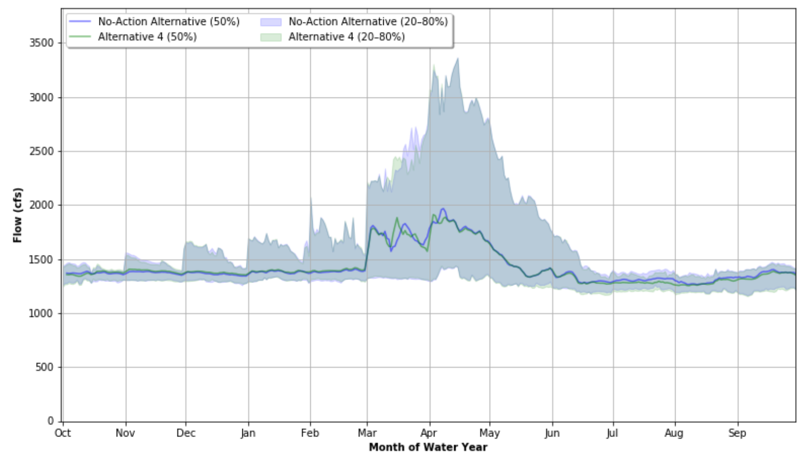




Crooked River from Smith Rock State Park to Opal Springs Dam

There are minor differences between no-action alternative and Alternative 4 flows at the CROO gauge downstream from Opal Springs Dam. Substantial groundwater inputs in this reach mask water management-related changes to Crooked River flows. Compared to the no-action alternative, there is a slight decrease in streamflow from mid-June through early August in years 6 through 20 of Alternative 4 (Figure 99). Otherwise, there are minor differences in the median flow values over the hydrograph.

Figure 99. The Crooked River Hydrograph for Years 1–5 (upper) and Years 6–20 (lower) for the No-Action Alternative and Alternative 4 Based on Modeled Flows at the CROO Gauge Downstream from Opal Springs Dam (Figures show the median flow and 20 to 80% flow range for the two alternatives.)



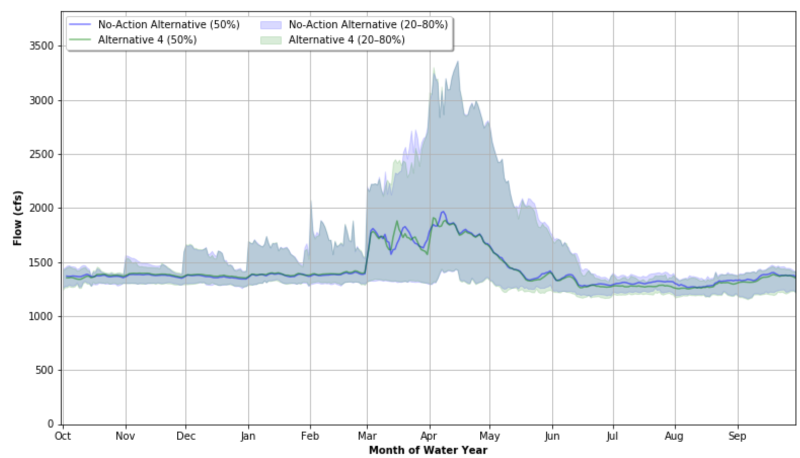


Table 69 includes a comparison of seasonal differences in minimum and maximum median flows based on CROO gauge data. The no-action alternative and Alternative 4 have similar minimum and maximum median flows (less than 2% differences) in the winter and summer suggesting the influence of groundwater inputs.

Table 69. Comparison of Minimum and Maximum Median (50%) Daily Flows on the Crooked River at the CROO Gauge by Season for the No-Action Alternative and Alternative 4 over the Permit Term

	Winter (Nov 1–Mar 31)		Irrigation (Apr 1–Oct 31)	
Alternative	**Minimum (cfs)**	**Maximum (cfs)**	**Minimum (cfs)**	**Maximum (cfs)**
No-Action	1,361.2	1,698.6	1,291.0	1,777.3
Alternative 4 (Years 1–5)	1,372.6	1,671.8	1,274.0	1,765.9
Alternative 4 (Years 6–20)	1,372.0	1,671.8	1,271.2	1,764.8

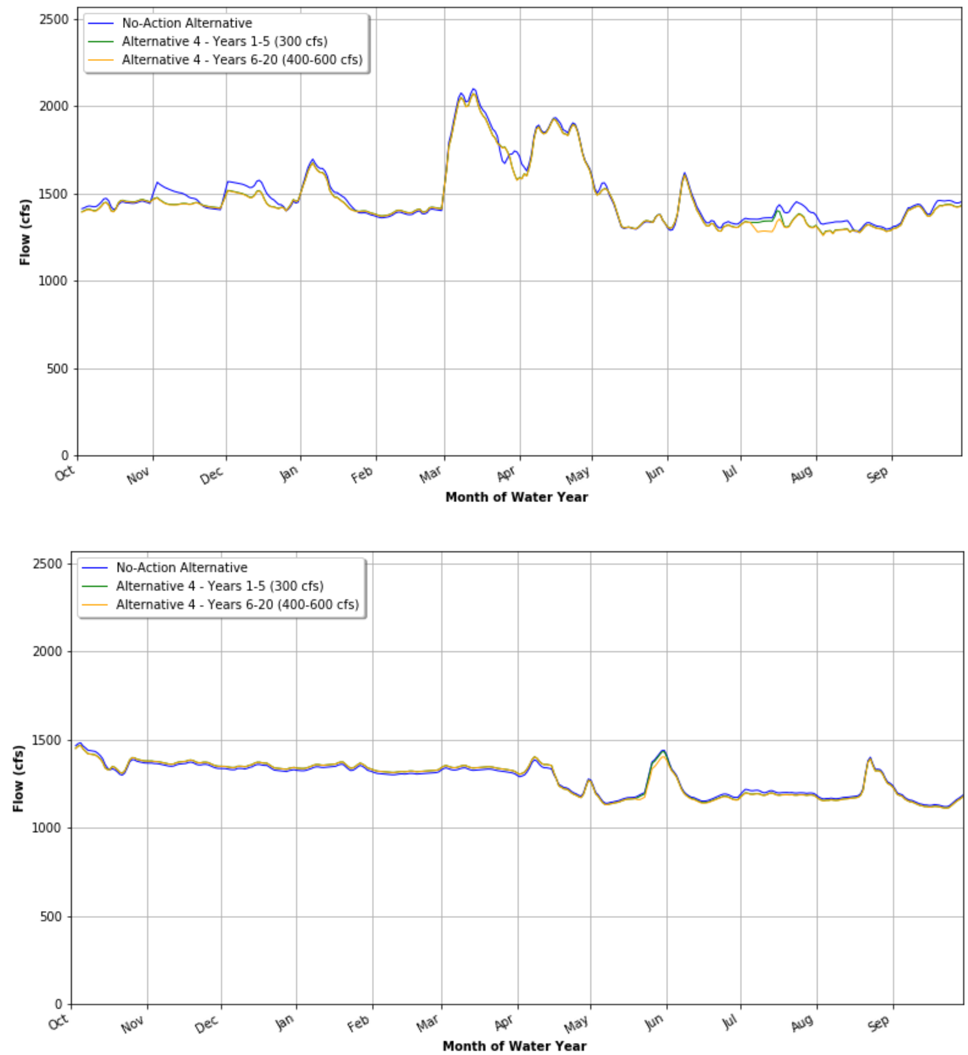
There are small differences in streamflow volumes in all water year types and over the permit term (Table 70). Differences relate to reduced winter storage flows as excess flow above minimum flow targets is stored in Prineville Reservoir, and the North Unit ID pump station diverts water to compensate for the effects of minimum flow targets on the Upper Deschutes River. The influence of the North Unit ID pump station diversion is less influential at the CROO gauge due to the large volume of groundwater inputs between the pump station and the CROO gauge.

Table 70. Percent Differences in Streamflow Volume between the No-Action Alternative and Alternative 4 for the Irrigation Period (April 1 to October 31), Winter Storage Period (November 1 to March 31), and the Entire Year for Representative Wet, Normal, and Dry Years at the CROO Gauge

		Alternative 4	
Water Year Type	**Time Period**	**Years 1–5**	**Years 6–20**
Wet	Irrigation Period	-1%	-2%
	Winter/Storage Period	-1%	-1%
	Annual	-1%	-1%
	1 SD	-2%	-3%
Normal	Irrigation Period	-1%	-2%
	Winter/Storage Period	0%	0%
	Annual	-1%	-1%
	1 SD	-3%	-2%
Dry	Irrigation Period	0%	-1%
	Winter/Storage Period	1%	1%
	Annual	0%	0%
	1 SD	11%	12%

Figure 100 includes the representative normal and dry year hydrographs for the CROO gauge under Alternative 4 in normal and dry years. Similar to the preceding analyses, there are minimal flow differences between the no-action alternative and Alternative 4 largely due to the volume of groundwater inputs in the reach.

Figure 100. The Crooked River Hydrograph for the No-Action Alternative and Alternative 4 in Years 1–5 and Years 6–20 in Representative Normal (upper) and Dry (lower) years at the CROO Gauge



Crooked River Flood Flows

Additional conservation measures associated with Alternative 4 result in minimal flow changes that do not alter the magnitude of the base flood or more frequent flood flows that cause shallow flooding. Like the no-action alternative, Alternative 4 results in 4 days per year of flows exceeding the CAPO gauge 2,500 cfs flood threshold. Alternative 4 is therefore not anticipated to increase the frequency of shallow floodplain inundation relative to the no-action alternative.

WR-5: Affect Groundwater Recharge

Effects under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action. There would be no meaningful effect on the regional groundwater system compared to the no action alternative.

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Personal Communications

Giffin, Jeremy (a). District 11 Watermaster, Oregon Water Resources Department, Bend, OR. January 28, 2018—Email with Owen McMurtrey, GSI Water Solutions, Inc., regarding surface water regulation in the Deschutes basin.

Giffin, Jeremy (b). District 11 Watermaster, Oregon Water Resources Department, Bend, OR. January 29, 2018—Meeting with Owen McMurtrey, GSI Water Solutions, Inc., regarding surface water regulation in the Deschutes basin.

Gorman, Kyle, Manager, Oregon Water Resources Department, Bend, OR. November 27, 2018—email with Troy Brandt, River Design Group, Inc., regarding surface water flooding in the Deschutes Basin.

Johnson, Jennifer, PE, Hydrologic Engineer, U.S. Bureau of Reclamation, Boise, ID. June 13, 2019—email with Troy Brandt, River Design Group, Inc. regarding RiverWare model period.

La Marche (a), Jonathan, Hydrologist, Oregon Water Resources Department, Bend, OR. October 9, 2018—Meeting with Bruce Brody-Heine, GSI Water Solutions, Inc., regarding surface water–groundwater interactions across entire basin.

La Marche (b), Jonathan, Hydrologist, Oregon Water Resources Department, Bend, OR. February 1, 2019—Phone call with Bruce Brody-Heine, GSI Water Solution, regarding surface water–groundwater interactions in Tumalo and Ochoco Creeks.

La Marche (c), Jonathan, Hydrologist, Oregon Water Resources Department, Bend, OR. November 27, 2018—email with Troy Brandt, River Design Group, Inc., regarding surface water flooding in the Deschutes Basin.

Appendix 3.4-A

Vegetation and Wildlife Technical Supplement

Appendix 3.4-A
Plant and Wildlife Technical Supplement

Purpose

This appendix addresses the following topics.

- The approach and results of screening to determine which plant and wildlife species to address in the effects analysis.
- Delineation and description of stream reaches used in the plant and wildlife effects analysis.
- Analysis of RiverWare outputs.

Plant and Wildlife Species Screening

Special-Status Plants

Special-status plants and fungi were determined through reference to the following sources.

- Species listed by the Oregon Department of Agriculture as threatened, endangered, or candidates for such listing. These species are listed by name in Oregon Administrative Rules (OAR) 603-703-0070 and are listed by county in a searchable database (Oregon Department of Agriculture 2018a).
- Plants listed as special status species on the U.S. Forest Service (USFS) Region 6 special-status species list, filtered to include only species potentially present in Deschutes National Forest (U.S. Forest Service 2019).
- Plants identified by USFS as potentially present in riparian areas within the Deschutes Basin, and sensitive to hydrologic changes.

The results of these searches are as follows.

- Plant species listed by Oregon Department of Agriculture as potentially present in Crook, Deschutes, or Jefferson Counties: *Astragalus peckii* and *Botrychium pumicola*.
- Plant and fungal species listed by the USFS as potentially present in Region 6, which includes the Deschutes National Forest: *Anastrophyllum minutum, Blepharostoma arachnoideum, Brachydontium olympicum, Campylium stellatum, Cephaloziella spinigera, Conostomum tetragonum, Encalypta brevipes, Entosthodon fascicularis, Gymnomitrion concinnatum, Haplomitrium hookeri, Harpanthus flotovianus, Jungermannia polaris, Lophozia gillmanii, Marsupella sparsifolia, Nardia japonica, Polytrichastrum sexangulare* var. *vulcanicum, Preissia quadrata, Pseudocalliergon trifarium, Rivulariella gemmipara, Schistidium cinclidodonteum, Schofieldia monticola, Splachnum sphaericum, Trematodon asanoi, Tritomaria exsecta, Gastroboletus vividus, Helvella crassitunicata, Pseudorhizina californica, Rhizopogon alexsmithii, Texosporium sancti-jacobi, Tholurna dissimilis, Agoseris elata, Arnica viscosa, Astragalus peckii, Botrychium pumicola, Calamagrostis breweri, Carex capitata, Carex diandra, Carex lasiocarpa,*

Carex livida, Carex retrorsa, Carex vernacula, Castilleja chlorotica, Cheilanthes feei, Collomia mazama, Cyperus acuminatus, Cyperus lupulinus ssp. *lupulinus, Diphasiastrum complanatum, Elatine brachysperma, Eucephalus gormanii, Gentiana newberryi* var. *newberryi, Heliotropium curassavicum, Lipocarpha aristulata, Lobelia dortmanna, Lycopodiella inundata, Muhlenbergia minutissima, Ophioglossum pusillum, Penstemon peckii, Pilularia americana, Pinus albicaulis, Potamogeton diversifolius, Rorippa columbiae, Rotala ramosior, Scheuchzeria palustris* ssp. *americana, Schoenoplectus subterminalis,* and *Utricularia minor*.

Potential presence of special-status plants in the study area was determined through reference to the collections database maintained by the Consortium of Pacific Northwest Herbaria (2018). This is a comprehensive regional database listing the full collection catalogs of all major herbaria based in Washington, Oregon, and Idaho, and some neighboring areas. Potential presence of special-status plants in the study area was also determined using a GIS shapefile provided by Deschutes National Forest, listing occurrences of special-status plants on the forest. This shapefile was filtered to only identify occurrences within the study area. None of the Oregon or USFS Region 6 listed species was found to have ever been observed in the study area.

Invasive Plants

Potential invasive plants in the study area were determined through reference to the following sources.

- Species listed by the Oregon Department of Agriculture as invasive in (Oregon Department of Agriculture 2018b). The distribution of these weeds in the study area was analyzed using the Weedmapper database (Oregon Department of Agriculture 2018c).
- Plants known to be invasive in Deschutes and Ochoco National Forests, and Crooked River National Grassland, were identified using a GIS shapefile of invasive plant occurrences provided by Deschutes National Forest. This shapefile was filtered to only identify occurrences within the study area, representing a total of 1,750 records. Species recorded within the study area include *Bromus tectorum* (cheatgrass), *Cardaria draba* (whitetop), *Cardaria pubescens* (hairy whitetop), *Centaurea* sp. (knapweed), *Centaurea biebersteinii* (spotted knapweed), *Centaurea diffusa* (diffuse knapweed), *Centaurea solstitialis* (yellow star-thistle), *Centaurea stoebe* ssp. *micranthos* (spotted knapweed), *Cirsium arvense* (Canada thistle), *Cirsium vulgare* (bull thistle), *Convolvulus arvensis* (field bindweed), *Cytisus scoparius* (Scotch broom), *Elymus repens* (quackgrass), *Euphorbia esula* (leafy spurge), *Hieracium aurantiacum* (orange hawkweed), *Hypericum perforatum* (common St. Johnswort), *Iris pseudacorus* (paleyellow iris), *Isatis tinctoria* (Dyer's woad), *Kochia scoparia* (burningbush), *Lepidium* (pepperweed), *Leucanthemum vulgare* (oxeye daisy), *Linaria dalmatica* (Dalmatian toadflax), *Linaria vulgaris* (butter and eggs), *Melilotus officinalis* (sweetclover), *Myriophyllum spicatum* (Eurasian watermilfoil), *Onopordum acanthium* (Scotch cottonthistle), *Phalaris arundinacea* (reed canarygrass), *Salsola kali* (Russian thistle), *Senecio jacobaea* (stinking willie), *Solanum triflorum* (cutleaf nightshade), *Taeniatherum caput-medusae* (medusahead), *Tribulus terrestris* (puncturevine), and *Verbascum thapsus* (common mullein).

The Oregon Department of Agriculture classifies weeds as A, B, or T weeds, defined as follows (Oregon Department of Agriculture 2018b).

- **A Listed Weed (A):** A weed of known economic importance that occurs in the state in small enough infestations to make eradication or containment possible; or is not known to occur, but its presence in neighboring states make future occurrence in Oregon seem imminent. Recommended action: Infestations are subject to eradication or intensive control when and where found.

- **B Listed Weed (B):** A regionally abundant weed of economic importance that may have limited distribution in some counties. Recommended action: Limited to intensive control at the state, county, or regional level as determined on a site-specific, case-by-case basis. Where implementation of a fully integrated statewide management plan is not feasible, biological control (when available) is be the primary control method.
- **T Designated Weed (T):** A focal species for prevention and control by the Oregon Noxious Weed Control Program. Action against these weeds will receive priority. T-designated noxious weeds are determined by the Oregon State Weed Board, which directs the Oregon Department of Agriculture to develop and implement a statewide management plan. T-designated noxious weeds are species selected from either the A or B list.

USFS does not have a weed classification system, but all listed weeds are subject to control.

The great majority of invasive plant species potentially present in the study area are habitat generalists that may occur in riparian or wetland settings, but are also commonly found in varied upland settings, including both forest and nonforest communities. As such the proposed action has limited potential to affect their distribution. However, several of the less common species have a riparian or wetland association, and reed canarygrass is a very common species that has riparian and wetland associations. This analysis therefore particularly addresses potential effects of the proposed action on reed canarygrass, while acknowledging that similar affects will accrue to other riparian- and wetland-associated invasive plants. The analysis also focuses on the potential for the proposed action and alternatives to alter site vulnerability to the invasion and persistence of invasive weeds by changing hydrological factors that influence the availability of bare soil substrates where weeds can readily establish. Alternatives that reduce seasonal hydrologic fluctuations, flooding, and sedimentation would tend to develop persistent native-dominated plant communities that have reduced presence of invasive weeds. Alternatives that increase seasonal hydrologic fluctuations, flooding, and sedimentation would tend to develop areas of exposed unvegetated soil or sediment that are highly vulnerable to weed infestation.

Special-Status Wildlife

An inventory of special-status wildlife species potentially present in the study area was created through reference to the following sources.

- A special-status species list published by the Oregon Department of Fish and Wildlife (ODFW), listing all special-status species potentially present in the East Cascades ecoregion as defined by the Oregon Conservation Strategy; this ecoregion includes the entire study area (Oregon Department of Fish and Wildlife 2016).
- A special-status species list provided by Deschutes National Forest in response to a query as to which special-status species should be assessed in this EIS (U.S. Forest Service 2016).
- A special-status species list provided by the Prineville District, U.S. Bureau of Land Management (Ashton pers. comm.).

These species lists included many different listing classifications. Some of these special-status species are imperiled, but many others are not rare and have large, healthy populations in the study area. The special-status classification codes used in the EIS are defined in Table 1.

Table 1. Special-Status Species Classifications Defined

Classification	Definition
BG	A species protected under the Bald and Golden Eagle Protection Act.
BLM	A species identified by BLM as a species of concern for this EIS.
DBC	Species identified by Deschutes National Forest as Birds of Conservation Concern, referencing a larger FWS list (U.S. Fish and Wildlife Service 2008).
DCS	Species identified by Deschutes National Forest as part of the Conservation Strategy for the East Slope of the Cascade Mountains.
DNF	Species identified by the Deschutes National Forest part of the Northwest Forest Plan.
DO	Species identified by the Deschutes National Forest as Other Required Species.
DS	Species identified by the Deschutes National Forest as Regional Forester Sensitive
FE	A species listed as endangered by FWS. An endangered species is defined in the ESA as a species "in danger of extinction throughout all or a significant portion of its range."
FT	A species listed as threatened by FWS. A threatened species is defined in the ESA as a species "likely to become endangered within the foreseeable future throughout all or a significant portion of its range."
FPT	A species that FWS has proposed for listing as threatened.
MIS	A species identified by Deschutes National Forest as a Management Indicator Species. Management Indicators are defined in FSM 2620.5-1 as "Plant and animal species, communities, or special habitats selected for emphasis in planning, and which are monitored during forest plan implementation in order to assess the effects of management activities on their populations and the populations of other species with similar habitat needs which they may represent" (U.S. Forest Service 1991).
SC	A species that is being reviewed by ODFW for as a candidate for listing as threatened or endangered on the state Threatened and Endangered Species List (OAR 625-100-040(1).
ST	A species listed by ODFW as threatened. *Threatened* means an animal that could become endangered in the near future within all or a portion of its range (OAR 625-100-0001(3)).
SS	A species listed as an Oregon Sensitive Species. *Sensitive* refers to wildlife species, subspecies, or populations that are facing one or more threats to their populations, habitat quantity or habitat quality or that are subject to a decline in number of sufficient magnitude such that they may become eligible for listing on the state Threatened and Endangered Species List (OAR 625-100-040(1)).
SSC	A species listed as an Oregon Sensitive Species-Critical. These sensitive species are also of particular conservation concern. Sensitive-Critical species have current or legacy threats that are significantly affecting their abundance, distribution, diversity, and/or habitat (Oregon Department of Fish and Wildlife 2016).

EIS = environmental impact statement; FWS = U.S. Fish and Wildlife Service; ESA = Endangered Species Act; OAR = Oregon Administrative Rules; ODFW = Oregon Department of Fish and Wildlife

The inventory of special-status wildlife species potentially present in the study area was screened according to two criteria.

1. Is the species likely to occur in the study area?
2. Does the species have a primary association with aquatic, wetland, or riparian habitats?

Criterion 1 was resolved by reference to online databases of species occurrence. The principal sources used were eBird.org for birds, and VertNet.org for all other vertebrate species. The eBird (2018) site is a "citizen science" site that maintains records of sightings of birds; most records have been acquired since 2001. The database is very complete for species occurring in the United States. VertNet.org is a database frequently used by vertebrate biologists researching specimen collections, especially within the United States, and is frequently cited in peer-reviewed publications in vertebrate biology. Published literature was also used for some species and was the sole source used to address Criterion 1 for invertebrate species. Species that have never been recorded anywhere in the study area were assumed to not occur in the study area and are not otherwise analyzed in the EIS. Species that have been recorded in the study area were additionally assessed under Criterion 2.

Criterion 2 was resolved by reference to published literature addressing all special-status species that have been recorded anywhere in the study area. For most species, this review used the online database NatureServe.org (2018), which is a standard database recommended by the U.S. Fish and Wildlife Service (FWS) and widely referenced in conservation analyses. For some species, NatureServe data were not sufficient to assess likely habitat associations of the species where it occurs within the study area, and published literature was referenced.

All species found to pass both criteria are addressed in the EIS.

Table 2 lists all species evaluated and the outcome of evaluation under the two criteria. Descriptions of the columns listed in Table 2 are as follows.

- **Taxonomic group:** Each species is assigned to the invertebrates, or to a class of vertebrates (amphibians, reptiles, birds, or mammals).
- **Species common and scientific names:** Scientific names correspond to the usage of the listing authority (FWS, USFS, or ODFW).
- **Species status:** Uses the classification codes defined in Table 1.
- **Criterion 1:** Whether the species has been recorded in the study area. If yes, additionally listed as *low, moderate,* or *high. Low* indicates the species has occasionally been recorded, typically with years between successive records. Often such infrequent records indicate a migratory or accidental occurrence. *Moderate* indicates the species has frequently been recorded in at least some portions of the study area, suggesting the presence of a persistent population of the species. *High* indicates the species is abundant in at least some portions of the study area, suggesting a large population and possibly a significant ecological role.
- **Criterion 2:** Whether the species has a primary association with aquatic, wetland, or riparian habitats; yes or no.
- **Determination:** either a negligible impact risk, meaning the species is not otherwise addressed in this EIS; or a potential impact risk, meaning the species is addressed in Chapter 3, *Affected Environment and Environmental Consequences*, of this EIS.
- **Rationale**: The justification underlying the determination.

Table 2. Species Evaluated for Inclusion in the EIS

Taxonomic Group	Species Common Name	Species Scientific Name	Status[a]	Criterion 1	Criterion 2	Determination	Rationale
Amphibian	Cascades frog	*Rana cascadae*	FSSS, SS	Low	Yes	Potential impact risk	Potentially in hydrologically connected waters in upper elevations of watershed.
Amphibian	Columbia spotted frog	*Rana luteiventris*	DS	No	Yes	Negligible impact risk	Not known to occur in study area: nearest occurrences are east, in Great Basin ecoregion.
Amphibian	Cope's giant salamander	*Dicamptodon copei*	SS	No	Yes	Negligible impact risk	Not known to occur in study area; occurs at higher elevations than study area.
Amphibian	Western toad	*Anaxyrus boreas*	SS	High	Yes	Potential impact risk	Uses riverine and reservoir habitats, and is known to occur in study area.
Bird	American peregrine falcon	*Falco peregrinus anatum*	DBC, DS, MIS	Moderate	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Bald eagle	*Haliaeetus leucocephalus*	BG, DBC, DS, MIS, SS	Moderate	Yes	Potential impact risk	Commonly forages in riparian forests.
Bird	Black swift	*Cypseloides niger*	DBC	Low	No	Negligible impact risk	The rare occurrences in the Deschutes Basin do not show association with riparian or wetland habitats.
Bird	Black-chinned sparrow	*Spizella atrogularis*	DBC	No	No	Negligible impact risk	Not known to occur in study area. Nearest known occurrences are south of Upper Klamath Lake.
Bird	Black-crowned rosy finch	*Leucostichte atrata*	DBC	No	No	Negligible impact risk	Not known to occur in study area. Nearest known occurrences are in southeastern Oregon.
Bird	Black-throated sparrow (BR and OW only)	*Amphispiza bilineata*	DO	Low	No	Negligible impact risk	No primary association with habitat subject to impacts and rare in study area (most

Taxonomic Group	Species Common Name	Species Scientific Name	Status[a]	Criterion 1	Criterion 2	Determination	Rationale
							occurrences are to the east, in the Basin and Range ecoregion).
Bird	Bobolink (GB and OW only)	*Dolychonix ozyvorus*	DO	Low	No	Negligible impact risk	No primary association with habitat subject to impacts and rare in study area (most occurrences are to the east, in the Basin and Range ecoregion).
Bird	Brewer's sparrow	*Spizella breweri*	DBC, DO	Moderate	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Brown creeper	*Certhia americana*	DCS	High	Yes	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Bullock's oriole	*Icterus bullockii*	DO	High	Yes	Potential impact risk	Uses riparian habitat and is known to occur in study area.
Bird	Burrowing owl	*Athene cunicularia*	DO	Low	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Calliope hummingbird	*Selasphorus calliope*	DBC	Moderate	Yes	Potential impact risk	Uses riparian (and upland) habitat and is known to occur in study area.
Bird	Caspian tern	*Hydroprogne caspia*	SS	Moderate	Yes	Potential impact risk	Forages on larger, fish-bearing waters.
Bird	Chipping sparrow	*Spizella passerina*	DCS	High	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Clark's nutcracker	*Nucifraga columbiana*	DCS	High	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Cooper's hawk	*Accipiter cooperii*	MIS	High	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Dusky grouse	*Dendragapus obscurus*	DCS	No	No	Negligible impact risk	No primary association with habitat subject to impacts, and not known to occur in study area; nearest occurrences are east, in Ochoco Mountains.

Taxonomic Group	Species Common Name	Species Scientific Name	Status[a]	Criterion 1	Criterion 2	Determination	Rationale
Bird	Ferruginous hawk	*Buteo regalis*	DBC, DO	Moderate	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Flammulated owl	*Psiloscops flammeolus*	DBC, DCS, DNF, SS	Low	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Golden eagle	*Aquila chrysaetos*	BG, DBC, MIS, SS	Moderate	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Grasshopper sparrow	*Ammodrammus savannarum*	DO	No	No	Negligible impact risk	No primary association with habitat subject to impacts, and not known to occur in study area: nearest occurrences are south, in Klamath area.
Bird	Gray flycatcher	*Empidonax wrightii*	DO	Moderate	Yes	Potential impact risk	Uses riparian (and upland) habitat and is known to occur in study area.
Bird	Great blue heron	*Ardea herodias*	MIS	High	Yes	Potential impact risk	Commonly forages near water bodies and nests in riparian or wetland forests.
Bird	Great gray owl	*Strix nebulosa*	BLM, DNF, MIS, SS	Low	No	Negligible impact risk	No primary association with habitat subject to impacts, and occurs at higher elevations than study area.
Bird	Greater (western) sage grouse	*Centrocercus urophasianus phaeios*	DBC, DO, DS	Moderate	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Greater sandhill crane	*Antigone canadensis tabida*	DCS, SS	Moderate	Yes	Potential impact risk	May forage or roost in wetlands in areas with long sight lines.
Bird	Green-tailed towhee	Pipio chlorulus	DBC	Moderate	Yes	Potential impact risk	Uses riparian habitat and is known to occur in study area.
Bird	Green-winged teal	*Anas crecca*	MIS	High	Yes	Potential impact risk	Uses lake and river habitat and is known to occur in study area.
Bird	Hairy woodpecker	*Dryobates villosus*	MIS	High	No	Negligible impact risk	No primary association with habitat subject to impacts.

Taxonomic Group	Species Common Name	Species Scientific Name	Status[a]	Criterion 1	Criterion 2	Determination	Rationale
Bird	Hermit thrush	*Catharus guttatus*	DCS	High	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Lark sparrow	*Chondestes grammacus*	DO	Moderate	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Lazuli bunting	*Passerina amoena*	DO	Moderate	Yes	Potential impact risk	Uses riparian habitat and is known to occur in study area.
Bird	Lesser scaup	*Aythya affinis*	MIS	Moderate	Yes	Potential impact risk	Uses lake and river habitat and is known to occur in study area.
Bird	Loggerhead shrike	*Lanius ludovicianus*	DBC, DO	Moderate	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Long-billed curlew	*Numenius americanus*	DBC, SS	Moderate	Yes	Potential impact risk	Associated with wetland and riparian habitats.
Bird	Mallard	*Anas platyrhynchos*	MIS	High	Yes	Potential impact risk	Uses lake, river, and wetland habitat and is known to occur in study area.
Bird	Marbled godwit	*Limosa fedoa*	DBC	Low	Yes	Potential impact risk	Uses lake (including reservoir) habitat and is known to occur in study area.
Bird	Neotropical migrant birds	(not applicable)	BLM	High	Yes	Potential impact risk	Many neotropical migrant birds have a primary association with riparian habitat; some also use wetland, lake, and river habitat; many species are known to occur in the study area.
Bird	Northern flicker	*Colaptes auratus*	MIS	High	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Northern goshawk	*Accipiter gentilis atricapillus*	BLM, MIS, SS	Low	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Northern pintail	*Anas acuta*	MIS	Moderate	Yes	Potential impact risk	Uses lake and river habitat and is known to occur in study area.
Bird	Northern spotted owl	*Strix occidentalis caurina*	MIS, FT, ST	Low	No	Negligible impact risk	No primary association with habitat subject to impacts.

Taxonomic Group	Species Common Name	Species Scientific Name	Status[a]	Criterion 1	Criterion 2	Determination	Rationale
Bird	Northern waterthrush	*Parkesia noveboracensis*	BLM, DS	Low	Yes	Negligible impact risk	Occurrences in study area are upstream and at higher elevations than the affected waters.
Bird	Olive-sided flycatcher	*Contopus cooperi*	DCS, SSC	Moderate	Yes	Potential impact risk	Uses riparian habitats and is known to occur in study area.
Bird	Osprey	*Pandion haliaetus*	MIS	Moderate	Yes	Potential impact risk	Forages on fish-bearing waters and is known to occur in study area.
Bird	Pileated woodpecker	*Dryocopus pileatus*	MIS	Moderate	No	Negligible impact risk	No primary association with habitat subject to impacts, and primarily occurs at higher elevations than study area.
Bird	Pinyon jay	*Gymnorhinus cyanocephalus*	DBC	High	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Prairie falcon	*Falco mexicanus*	DO	Moderate	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Pygmy nuthatch	*Sitta pygmaea*	DCS, DNF	High	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Red-tailed hawk	*Buteo jamaicensis*	MIS	High	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Sage sparrow	*Artemisiospiza nevadensis*	DBC, DO	Low	No	Negligible impact risk	No primary association with habitat subject to impacts, and most occurrences in central Oregon have been east of study area.
Bird	Sage thrasher	*Oreoscoptes montanus*	DBC, DO	Low	No	Negligible impact risk	No primary association with habitat subject to impacts, and most occurrences in central Oregon have been east of study area.
Bird	Sharp-shinned hawk	*Accipiter striatus*	MIS	Low	No	Negligible impact risk	No primary association with habitat subject to impacts.

Taxonomic Group	Species Common Name	Species Scientific Name	Status[a]	Criterion 1	Criterion 2	Determination	Rationale
Bird	Sharp-tailed grouse	*Tympanuchus phasianellus*	DO	No	No	Negligible impact risk	Not known to occur in study area: nearest occurrences are far east, in Columbia Basin and Wallowa Mountains.
Bird	Snowy plover	*Charadrius nivosus*	DBC	Low	Yes	Negligible impact risk	Rarely recorded in study area, and not at waters potentially affected by any of the alternatives.
Bird	Swainson's hawk	*Buteo swainsoni*	SS	Low	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Tricolored blackbird	*Agelaius tricolor*	DBC, DS	Low	Yes	Potential impact risk	Uses wetland and riparian habitat and is known to occur in study area.
Bird	Tule goose	*Anser albifrons elgasi*	DS, MIS	Low	No	Negligible impact risk	The rare occurrences in the Deschutes Basin do not show association with riparian or wetland habitats.
Bird	Virginia's warbler	*Oreothlypis virginiae*	DBC, DO	No	Yes	Negligible impact risk	Not known to occur in study area; nearest occurrences far to south and east.
Bird	Western grebe	*Aechmophorus occidentalis*	MIS	Moderate	Yes	Potential impact risk	Uses lake and river habitat and is known to occur in study area.
Bird	White-headed woodpecker	*Picoides albolarvatus*	DBC, DCS, DNF, DS, MIS, SSC	Low	No	Negligible impact risk	No primary association with habitat subject to impacts.
Bird	Willow flycatcher	*Empidonax traillii*	DBC, DO	Moderate	Yes	Potential impact risk	Uses riparian habitat and is known to occur in study area.
Bird	Wood duck	*Aix sponsa*	MIS	Moderate	Yes	Potential impact risk	Uses lake and river habitat and is known to occur in study area.
Bird	Yellow rail	*Coturnicops noveboracensis*	DBC, DS, SSC	Low	Yes	Potential impact risk	USFS states species is present in study area (Turner pers. comm.).
Bird	Yellow warbler	*Setophaga petechia*	DO	High	Yes	Potential impact risk	Uses riparian habitat and is known to occur in study area.

Taxonomic Group	Species Common Name	Species Scientific Name	Status[a]	Criterion 1	Criterion 2	Determination	Rationale
Bird	Yellow-billed cuckoo	Coccyzus americanus	DBC, DO, FT	No	Yes	Negligible impact risk	Not known to occur in study area.
Bird	Yellow-breasted chat	*Icteria virens*	DO	Low	Yes	Potential impact risk	Uses riparian and wetland habitat and is known to occur in study area.
Invertebrate	Crater Lake tightcoil	*Pristiloma crateris*	DNF, DS	Moderate	Yes	Potential impact risk	Known to occur in streams within the study area.
Invertebrate	Evening field slug	*Deroceras hesperium*	DNF	Low	Yes	Potential impact risk	Duncan (2005) indicates it may occur in forested, perennially wet areas within the study area.
Invertebrate	Johnson's hairstreak	*Callophrys [Mitoura] johnsoni*	DS	No	No	Negligible impact risk	No primary association with habitat subject to impacts and not known to occur in study area.
Invertebrate	Silver-bordered fritillary	*Boloria selene atrocostalis*	DS	Low	Yes	Negligible impact risk	Not known to occur in study area (U.S. Forest Service 2015).
Invertebrate	Western bumblebee	*Bombus occidentalis*	DS, MIS	Low	No	Negligible impact risk	Not known to occur in study area – found at higher elevations immediately to the west (Turner 2015).
Mammal	American marten	*Martes americana*	MIS	No	Yes	Negligible impact risk	Not known to occur in study area.
Mammal	American pika	*Ochotona princeps*	SS	Low	No	Negligible impact risk	No primary association with habitat subject to impacts.
Mammal	California myotis	*Myotis californicus*	SS	Moderate	No	Negligible impact risk	No primary association with habitat subject to impacts.
Mammal	Elk	*Cervus canadensis*	BLM, MIS	Moderate	Yes	Potential impact risk	Seasonal association with riparian and some wetland habitats in study area.
Mammal	Fringed myotis	*Myotis thysanodes*	DS, SS	Moderate	Yes	Potential impact risk	Forages and may roost in riparian areas.
Mammal	Gray wolf	*Canis lupus*	BLM, FE, FSSS	No	No	Negligible impact risk	No primary association with habitat subject to impacts and not known to occur in study area.

Taxonomic Group	Species Common Name	Species Scientific Name	Status[a]	Criterion 1	Criterion 2	Determination	Rationale
Mammal	Hoary bat	*Lasiurus cinereus*	SS	No	Yes	Negligible impact risk	Not known to occur in study area.
Mammal	Long-legged myotis	*Myotis volans*	SS	Moderate	Yes	Potential impact risk	Forages and may roost in riparian areas.
Mammal	Mule deer	*Odocoileus hemionus*	BLM, MIS	Moderate	Yes	Potential impact risk	Seasonal association with riparian and some wetland habitats in study area.
Mammal	Mule deer	*Odocoileus hemionus*	BLM, MIS	Moderate	Yes	Potential impact risk	Seasonal association with riparian habitats in study area.
Mammal	Pacific fisher	*Pekania pennanti (pennantia)*	DS	Low	Yes	Potential impact risk	Associated with riparian habitats, although no recent records in the study area.
Mammal	Pacific marten	*Martes caurina*	SS	Low	Yes	Potential impact risk	Associated with riparian habitats, although no recent records in the study area.
Mammal	Pallid bat	*Antrozous pallidus*	DS, SS	Moderate	Yes	Potential impact risk	Forages in riparian areas.
Mammal	Sierra Nevada red fox	*Vulpes vulpes necator*	DS, SS	Low	No	Negligible impact risk	No primary association with habitat subject to impacts.
Mammal	Silver-haired bat	*Lasionycteris noctivagans*	SS	Low	Yes	Potential impact risk	Forages in riparian areas.
Mammal	Spotted bat	*Euderma maculatum*	DS, SS	No	Yes	Negligible impact risk	Not known to occur in study area.
Mammal	Townsend's big-eared bat	*Corynorhinus townsendii*	DS, MIS, SS	Low	Yes	Potential impact risk	Forages in riparian areas.
Mammal	Wolverine	*Gulo gulo*	MIS, FTP, ST	Low	No	Negligible impact risk	No primary association with habitat subject to impacts, and occurs at higher elevations than study area.
Mollusk	Shiny tightcoil	*Pristiloma wascoense*	DS	Low	No	Negligible impact risk	No primary association with habitat subject to impacts.

Taxonomic Group	Species Common Name	Species Scientific Name	Status[a]	Criterion 1	Criterion 2	Determination	Rationale
Reptile	California mountain kingsnake	*Lampropeltis zonata*	FSSS, SS	Low	Yes	Negligible impact risk	Not known to occur in study area.
Reptile	Western painted turtle	*Chrysemys picta bellii*	SSC	No	Yes	Negligible impact risk	Not known to occur in study area, and occurs at lower elevations than study area.
Reptile	Western pond turtle	*Actinemys marmorata*	SSC	Low	Yes	Potential impact risk	Known to occur in study area (Wray pers. comm.).
Bird	Redhead	*Aythya americana*	MIS	Moderate	Yes	Potential impact risk	Uses lake and river habitat and is known to occur in study area.
Bird	Ring-necked duck	*Aythya collaris*	MIS	High	Yes	Potential impact risk	Uses lake and river habitat and is known to occur in study area.
Bird	Canvasback	*Aythya valisneria*	MIS	Moderate	Yes	Potential impact risk	Uses lake and river habitat and is known to occur in study area.
Bird	Canada goose	*Branta canadensis*	MIS	High	Yes	Potential impact risk	Uses lake, river, and wetland habitat and is known to occur in study area.
Bird	Bufflehead	*Bucephala albeola*	DS, MIS	Moderate	Yes	Potential impact risk	Commonly forages on fish-bearing water bodies.
Bird	Common goldeneye	*Bucephala clangula*	MIS	Moderate	Yes	Potential impact risk	Uses lake and river habitat and is known to occur in study area.
Bird	Barrow's goldeneye	*Bucephala islandica*	MIS	Moderate	Yes	Potential impact risk	Uses lake and river habitat and is known to occur in study area.
Bird	Trumpeter swan	*Cygnus buccinator*	SS	Moderate	Yes	Potential impact risk	Associated with wetland and riparian habitats and known to occur in study area.
Bird	Common loon	*Gavia immer*	MIS	High	Yes	Potential impact risk	Uses lake habitat, including reservoirs in study area.
Bird	Harlequin duck	*Histrionicus histrionicus*	DS, MIS	Low	Yes	Potential impact risk	Forages and nests along high-energy mountain streams.
Bird	Hooded merganser	*Lophodytes cucullatus*	MIS	Moderate	Yes	Potential impact risk	Uses lake and river habitat and is known to occur in study area.

Taxonomic Group	Species Common Name	Species Scientific Name	Status[a]	Criterion 1	Criterion 2	Determination	Rationale
Bird	American wigeon	*Mareca americana*	MIS	High	Yes	Potential impact risk	Uses lake and river habitat and is known to occur in study area.
Bird	Gadwall	*Mareca strepera*	MIS	Moderate	Yes	Potential impact risk	Uses lake and river habitat and is known to occur in study area.
Bird	Common merganser	*Mergus merganser*	MIS	High	Yes	Potential impact risk	Uses lake and river habitat and is known to occur in study area.
Bird	Ruddy duck	*Oxyura jamaicensis*	MIS	Moderate	Yes	Potential impact risk	Uses lake and river habitat and is known to occur in study area.
Bird	American white pelican	*Pelecanus erythrorhynchos*	SS	Moderate	Yes	Potential impact risk	Habitat includes larger rivers, lakes, and reservoirs.
Bird	Horned grebe	*Podiceps auritus*	DS, MIS	Moderate	Yes	Potential impact risk	Forages on streams and lakes.
Bird	Red-necked grebe	*Podiceps grisegena*	MIS, SSC	Moderate	Yes	Potential impact risk	Uses lake and river habitat.
Bird	Eared grebe	*Podiceps nigricollis*	DBC, MIS	Moderate	Yes	Potential impact risk	Uses lake and river habitat and is known to occur in study area
Bird	Pied-billed grebe	*Podilymbus podiceps*	MIS	Moderate	Yes	Potential impact risk	Uses lake and river habitat and is known to occur in study area.
Bird	Northern shoveler	*Spatula clypeata*	MIS	Moderate	Yes	Potential impact risk	Uses lake and river habitat and is known to occur in study area.
Bird	Cinnamon teal	*Spatula cyanoptera*	MIS	High	Yes	Potential impact risk	Uses lake and river habitat and is known to occur in study area.
Bird	Blue-winged teal	*Spatula discors*	MIS	Moderate	Yes	Potential impact risk	Uses lake, river, and wetland habitat and is known to occur in study area.
Bird	Downy woodpecker	*Dryobates pubescens*	MIS	High	Yes	Potential impact risk	Commonly forages in riparian forests and is known to be common in study area.
Bird	Lewis's woodpecker	*Melanerpes lewis*	DBC, DCS, DO, DS, MIS, SSC		Yes	Potential impact risk	Commonly forages in forests with recent burn mortality.

Taxonomic Group	Species Common Name	Species Scientific Name	Status[a]	Criterion 1	Criterion 2	Determination	Rationale
Bird	Black-backed woodpecker	*Picoides arcticus*	DCS, DNF, MIS, SS	Moderate	Yes	Potential impact risk	Commonly nests and forages near water bodies.
Bird	American three-toed woodpecker	*Picoides dorsalis*	MIS, SS	Moderate	Yes	Potential impact risk	Commonly forages in riparian forests.
Bird	Red-naped sapsucker	*Sphyrapicus nuchalis*	DCS, DO, MIS	Moderate	Yes	Potential impact risk	Uses riparian (and upland) habitat and is known to occur in study area.
Bird	Red-breasted sapsucker	*Sphyrapicus ruber*	MIS	Moderate	Yes	Potential impact risk	Uses riparian (and upland) habitat and is known to occur in study area.
Bird	Williamson's sapsucker	*Sphyrapicus thyroides*	DBC, DCS, MIS	Moderate	Yes	Potential impact risk	Uses riparian (and upland) habitat and is known to occur in study area.

[a] Classification codes are defined in Table 1.

Species Guilds

Species selected for analysis in the EIS were assigned to guilds, defined for the purposes of this analysis as groups of species having similar life history requirements for their principal use of riparian and wetland vegetation communities in the study area. Table 3 identifies and defines the guilds, and identifies the species included in each guild.

Table 3. Species Guilds Used in the Wildlife Analysis

Guild	Guild definition and component species
Elk–deer	Large ungulates that seasonally forage in both forest and nonforest riparian habitats, and in some (shallow water, firm bottom) wetlands: Elk, mule deer (Oregon Compass 2018).
Fish-eater	Bird and mammal species that primarily forage on fishes and thus are sensitive to the available extent of fish-bearing waters, regardless of vegetation community: American white pelican, bald eagle, Barrow's goldeneye, bufflehead, Caspian tern, common goldeneye, common loon, common merganser, eared grebe, harlequin duck, hooded merganser, horned grebe, osprey, Pacific fisher, Pacific marten, pied-billed grebe, red-necked grebe, western grebe.
Forest	Birds that primarily or exclusively forage, roost, and breed in riparian forests: American three-toed woodpecker, black-backed woodpecker, Bullock's oriole, calliope hummingbird, downy woodpecker, green-tailed towhee, lazuli bunting, Lewis's woodpecker, red-breasted sapsucker, red-naped sapsucker, Williamson's sapsucker, yellow warbler.
Generalist	Birds, a toad, and land snails that extensively use habitat outside the study area but are also potentially associated with a variety of riparian and wetland habitats: Crater Lake tightcoil, evening field slug, great blue heron, neotropical migrant birds, western toad.
Insect-eater	Bird and bat species that forage on airborne insects; may forage over or in riparian or wetland vegetation or open water, and typically roost, rest or breed in riparian forest: Gray flycatcher, olive-sided flycatcher, willow flycatcher, yellow-breasted chat, fringed myotis, long-legged myotis, pallid bat, silver-haired bat, Townsend's big-eared bat.
Open–wetland	Birds that extensively use habitat outside the study area but in the study area are mainly associated with unforested wetlands and wet agricultural areas: Canada goose, greater sandhill crane, long-billed curlew, marbled godwit, tricolored blackbird, trumpeter swan.
Shallow-water	Water birds that primarily forage on vegetation and benthic invertebrates in wetlands and shallow water areas of streams, lakes, and reservoirs, and largely roost and nest in those areas as well: American wigeon, blue-winged teal, canvasback, cinnamon teal, gadwall, green-winged teal, lesser scaup, mallard, northern pintail, northern shoveler, redhead, ring-necked duck, ruddy duck, wood duck, yellow rail.
Wetland–aquatic	A largely aquatic amphibian that primarily occurs in cold, shallow ponds and wetlands in Crescent Creek, the Cascades frog; and a largely aquatic reptile that primarily occurs in warmer, slow-moving waters in the Deschutes River from Bend to the Columbia River, the western pond turtle.

River Reach Delineation

The large and environmentally diverse study area was subdivided for the purposes of the effects analysis by separating it into river reaches. The demarcation of river reaches was performed according to the following principles.

- Reaches identified by FWS (2017, 2019).
- Reaches identified by Courter et al. (2014).
- Reach breaks located at dams and major diversions.
- Each reservoir containing one or more reaches.
- Reaches selected to have relatively uniform topography, channel conditions, hydrological gain or loss characteristics, and riparian and wetland vegetation.

The 47 reaches so designated are illustrated in Figure 1 and described in Table 4. The list of wildlife species potentially occurring in the study area, and their distribution in the river reaches, is shown in Table 5.

Figure 1. River Reaches in the Wildlife Study Area—Sheet 1

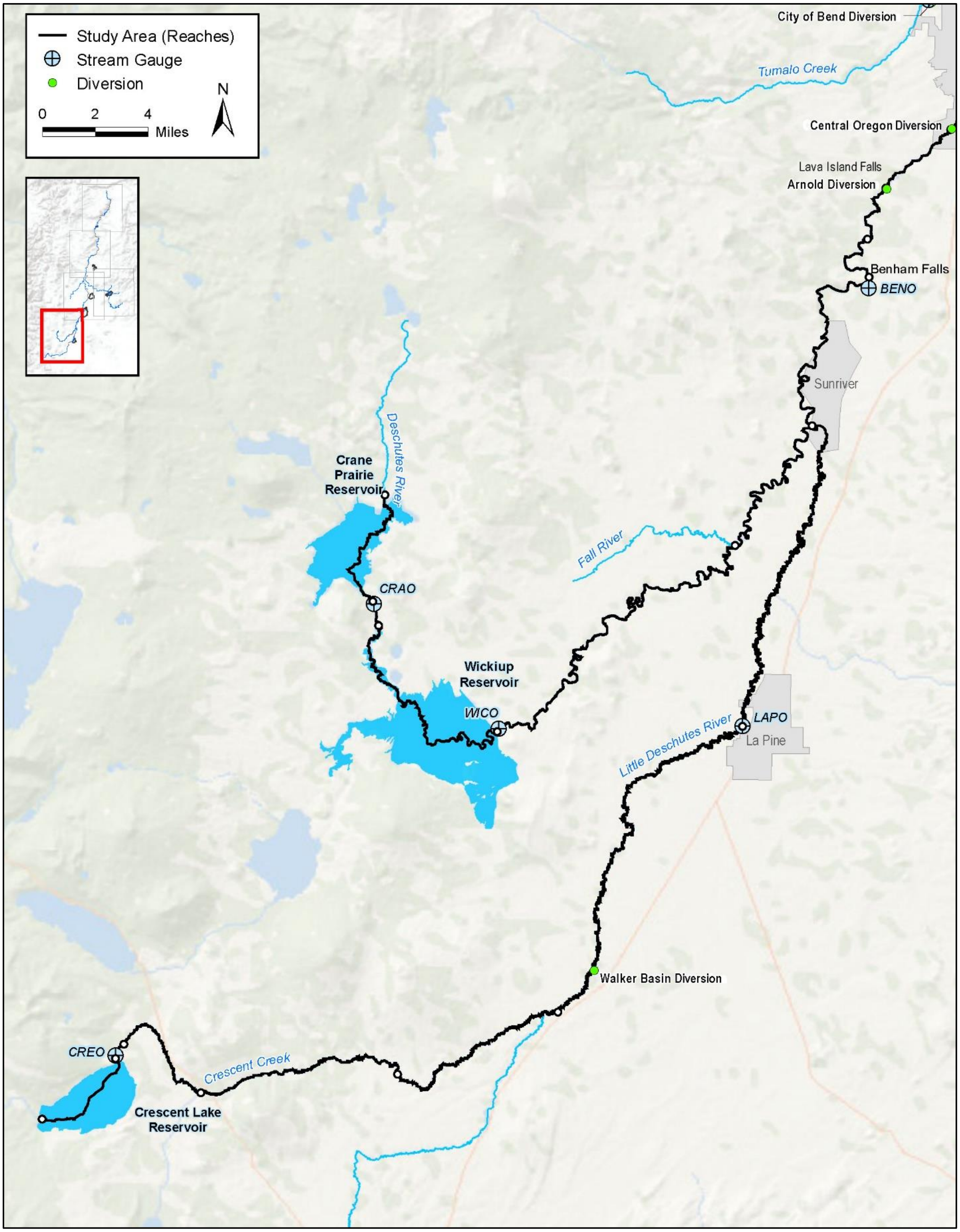

Figure 1. River Reaches in the Wildlife Study Area—Sheet 2

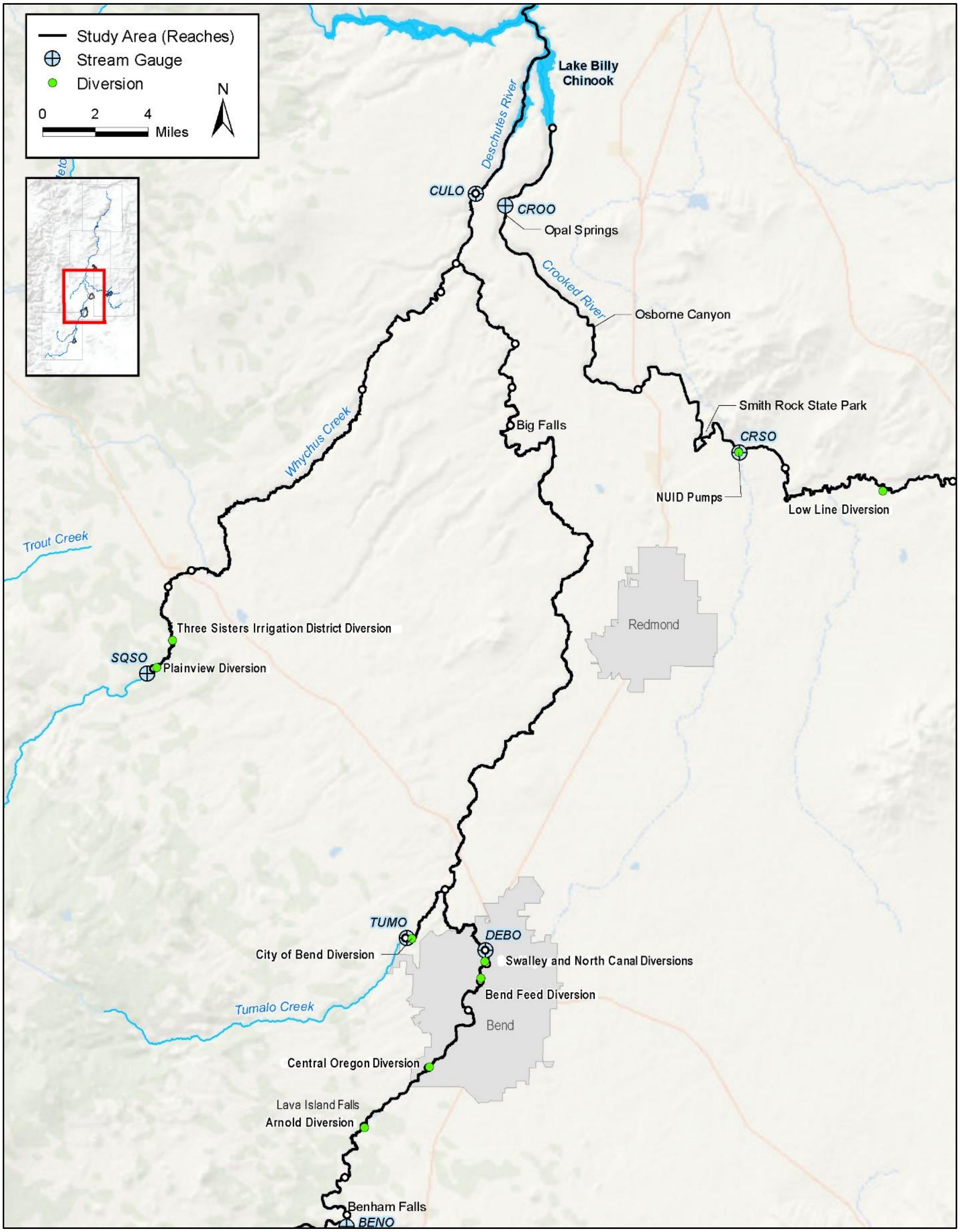

Figure 1. River Reaches in the Wildlife Study Area—Sheet 3

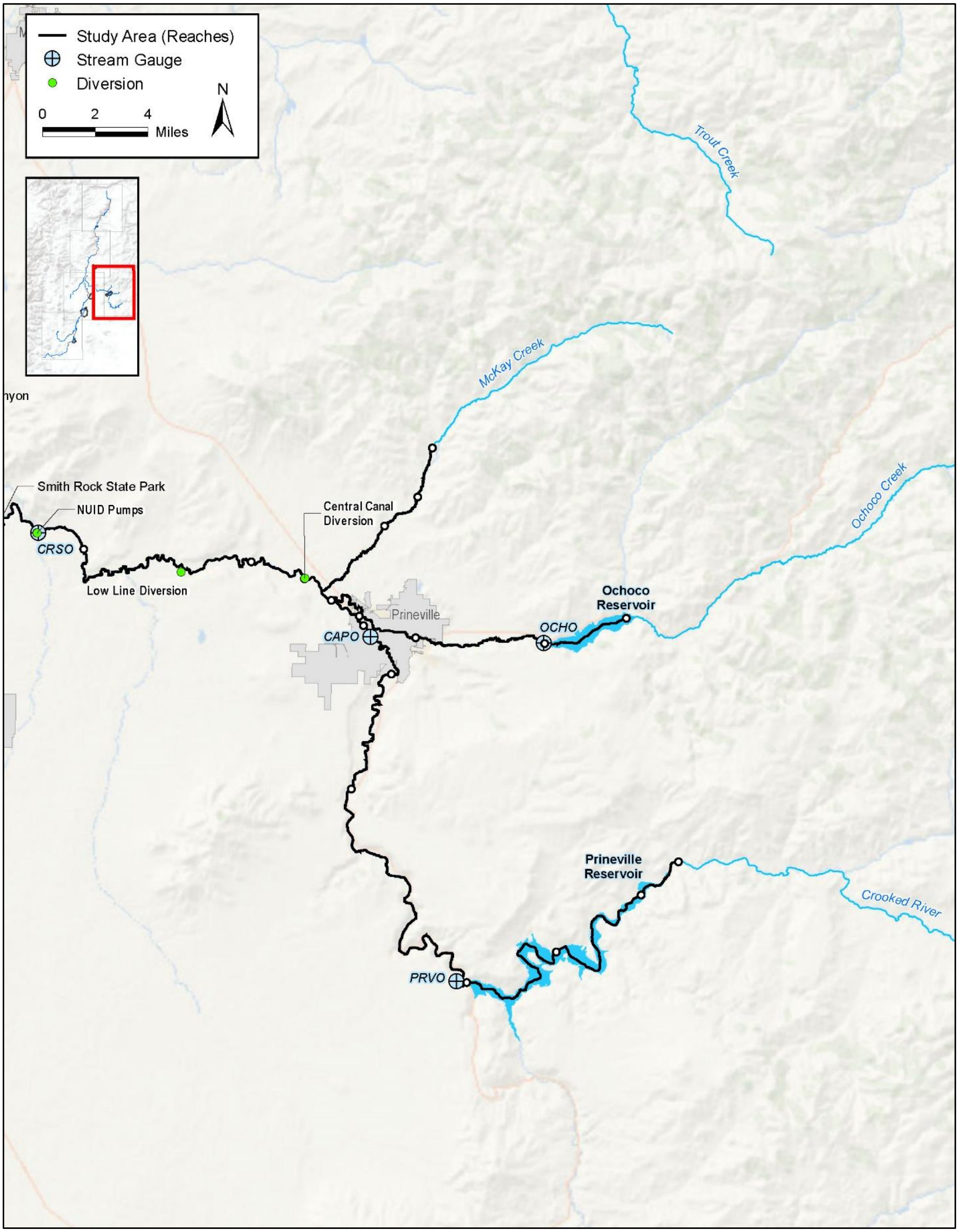

Figure 1. River Reaches in the Wildlife Study Area—Sheet 4

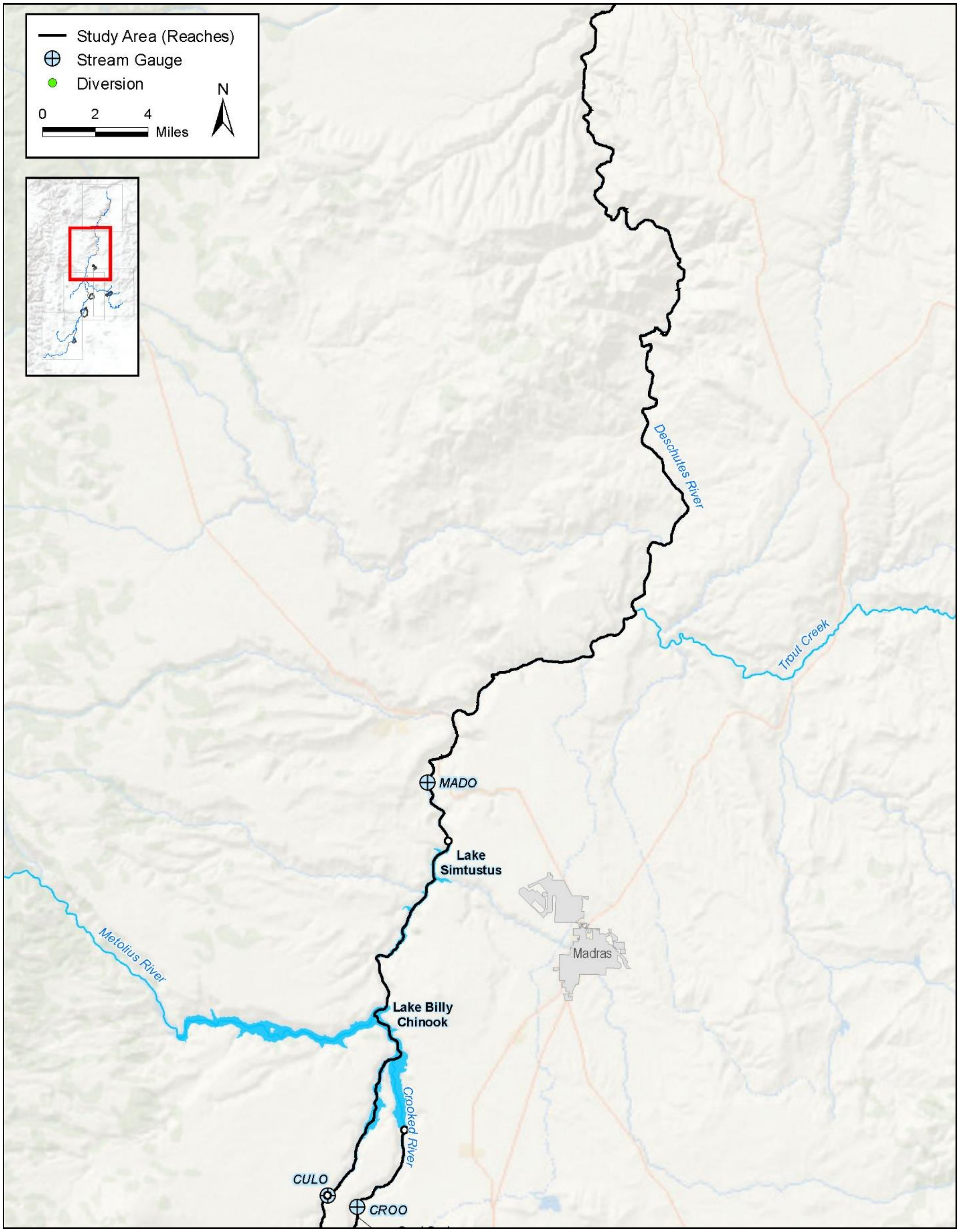

Figure 1. River Reaches in the Wildlife Study Area—Sheet 5

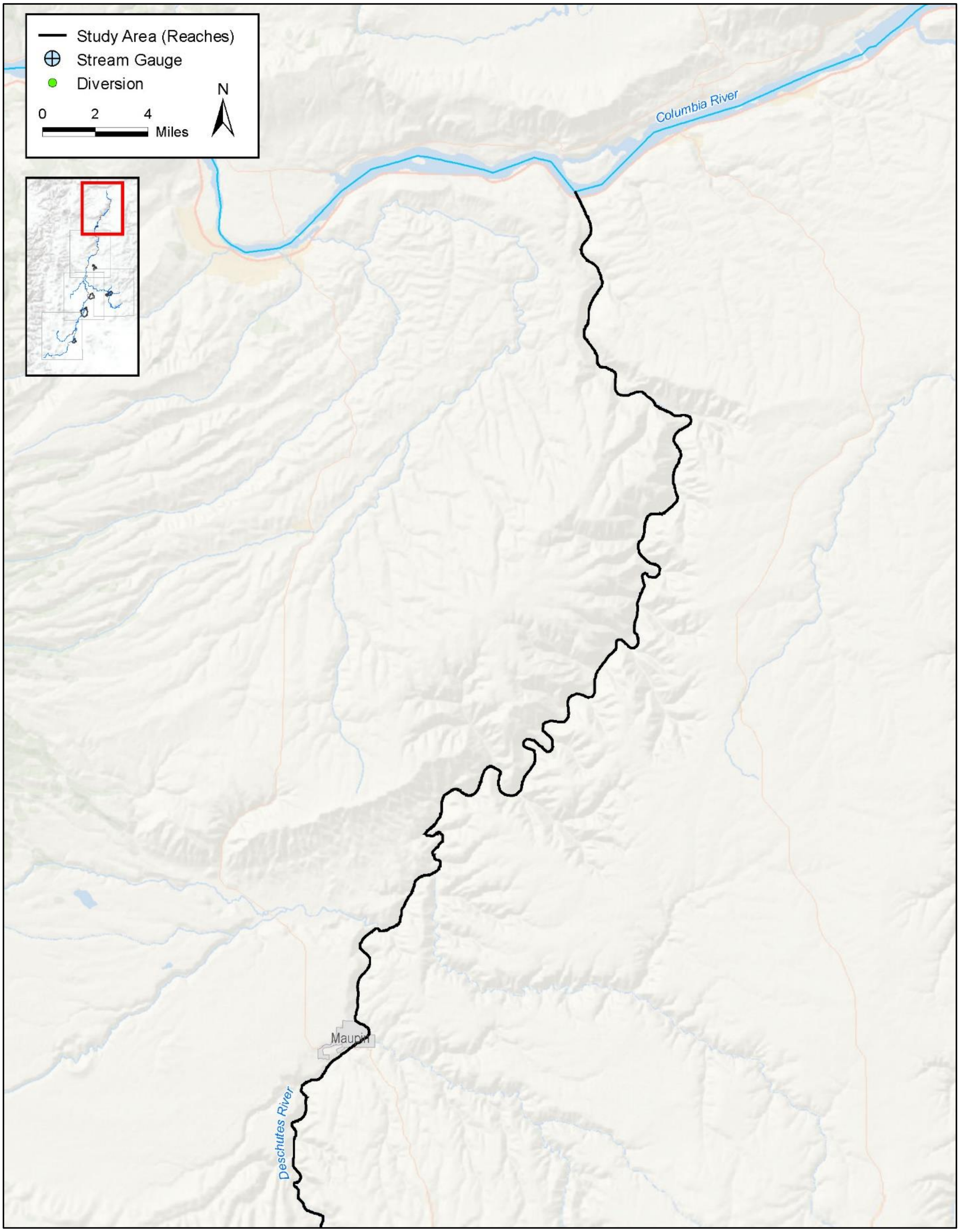

Table 4. Study Area Reaches

River	Reach	Length (mi)	Description
Crescent–Little Deschutes	CLD-1	29.3	CLD-1 and CLD-2 are along the Little Deschutes River. CLD-1 has a low-gradient underfit stream with glide morphology in an unforested wetland/riparian vegetation corridor with a total width of 328 to 984 feet.
Crescent–Little Deschutes	CLD-2	29.2	Same as CLD-1, but upstream of the LAPO gauge.
Crescent–Little Deschutes	CLD-3	12.6	CLD-3 to CLD-6 are along Crescent Creek. The Little Deschutes River upstream of here would not be affected by the proposed action and alternatives. CLD-3 has the same morphology as CLD-1, but is upstream of the Walker Basin Canal diversion.
Crescent–Little Deschutes	CLD-4	11.0	River is a meandering underfit stream with glide morphology in an unforested wetland/riparian vegetation corridor with a total width of 164 to 328 feet.
Crescent–Little Deschutes	CLD-5	5.9	CLD-5 has a low-gradient meandering stream within a mostly unforested riverine wetland corridor with a total width of 164 to 328 feet, flanked by ponderosa pine-dominated upland forest. At the upper end of CLD-5, the channel is constricted by development.
Crescent–Little Deschutes	CLD-6	0.9	A pool-riffle streamflows through a mostly unforested riverine wetland wetland/riparian vegetation corridor with a total width of 99 to 164 feet, flanked by ponderosa pine-dominated upland forest.
Crescent–Little Deschutes	CLD-7	4.5	Crescent Lake is a reservoir that has no riparian or wetland vegetation except in three large embayments (the inflow stream and two slack water areas) that support mixed wetland and riparian vegetation.
Crooked	Cro-1	15.0	River is tightly confined in deep canyon with no wetlands and almost no riparian vegetation. Lower end is at Deschutes River confluence in Lake Billy Chinook. Consistent with reach C-1 of Courter et al. (2014).
Crooked	Cro-2	9.4	Partly in a deep canyon, but has a 33- to 99-foot-wide riparian zone on each bank of the river. The riparian vegetation is supported by a groundwater inflow. No wetlands. Consistent with reach C-2 of Courter et al. (2014).
Crooked	Cro-3	2.3	Same as Cro-2 but is upstream of the NUID pumps.
Crooked	Cro-4	11.7	Unconfined, flanked almost continuously by irrigated agriculture. The river with its riparian zone is mostly 115 feet wide but in places is several times wider between the cultivated fields.
Crooked	Cro-5	3.0	Same as Cro-4 but is above the Low Line Canal diversion.
Crooked	Cro-6	1.6	Same as Cro-4 but is above the Central Canal diversion.
Crooked	Cro-7	1.8	Same as Cro-4 but is above the Ochoco Creek confluence.
Crooked	Cro-8	3.2	River is flanked by intensive development; there is negligible riparian or wetland vegetation. Consistent with lower part of reach C-4 of Courter et al. (2014).
Crooked	Cro-9	6.8	Same as Cro-3, except some areas have steep desert upland on one side and irrigated agriculture on the other. Consistent with upper part of reach C-4 of Courter et al. (2014).

River	Reach	Length (mi)	Description
Crooked	Cro-10	14.4	River is mostly in an open canyon with riparian vegetation about 33 feet wide on each bank, locally wider (on point bars). There are some small areas of agriculture (hayfields). Consistent with reach C-5 of Courter et al. (2014).
Crooked	Cro-11	7.3	Lower Prineville Reservoir, which has no riparian or wetland vegetation.
Crooked	Cro-12	6.9	Upper Prineville Reservoir, where seasonally exposed areas have some riparian or wetland vegetation.
Crooked	Cro-13	2.2	The headwaters of Prineville Reservoir have a large wetland and benches or bars with shrub and herb riparian and wetland vegetation. This is upper limit of potential project effects on the Crooked River.
Deschutes	Des-1	104.6	A desert canyon extends from the Columbia River up to the base of Pelton Dam. There is negligible groundwater inflow, outflow, or tributary contributions. There are very few wetlands, and riparian vegetation extends in a narrow band 0 to 197 feet wide, with an average total width (both river banks combined) of 61 feet.
Deschutes	Des-2	17.1	The reach includes the Regulating Reservoir, Lake Simtustus, and Lake Billy Chinook. There is negligible riparian or wetland vegetation. The Crooked River joins the Deschutes in Des-2.
Deschutes	Des-3	3.0	River has pool-riffle and step-pool morphology, and is confined within a canyon that experiences active groundwater inflow at or above the river surface elevation for most of its length, and which is the primary hydrology source for riparian and wetland vegetation found in this reach.
Deschutes	Des-4	37.1	Same as Des-3 but is above the Whychus Creek confluence.
Deschutes	Des-5	4	Same as Des-3 but is above the Tumalo Creek confluence.
Deschutes	Des-6	0.6	Same as Des-3 but is above the DEBO gauge.
Deschutes	Des-7	0.9	River is confined variously by lava flows, development, and topography, with limited but locally important riparian or aquatic vegetation. River channel has a mixed pool-riffle, step-pool and glide morphology with occasional cascades. The largest diversion on the Deschutes River (North Unit ID and others) is located at the break between Des-6 and Des-7.
Deschutes	Des-8	1.8	Same as Des-7, but is above the Bend Feed Canal diversion.
Deschutes	Des-8a	3.4	Same as Des-8. Reach Des-8a is designated for consistency with the FWS (2017, 2019) analysis, which placed a reach break at the Colorado Avenue bridge.
Deschutes	Des-9	3.7	River has glide morphology with some waterfalls related to lava flows. There are locally important riverine wetlands and floodplain riparian vegetation, mostly located on river bars. The Central Oregon Canal diversion is at the break between Des-8a and Des-9.

River	Reach	Length (mi)	Description
Deschutes	Des-10	3.1	River has low gradient, glide morphology due to ancient damming by a lava flow at Lava Island Falls, which is the break between Des-9 and Des-10, and is the site of the Arnold Canal diversion. Some extensive wetland complexes flank the river or its former cut-off meanders; these include a mix of aquatic, wetland, and riparian vegetation, mostly in herbs and shrubs but locally in hardwood and mixed forest.
Deschutes	Des-10a	3.1	Similar to Des-10, but moving upstream through the reach, the river gradually becomes steeper and more confined with fewer and smaller associated wetlands.
Deschutes	Des-11	11.4	Same as Des-10a but is above the BENO gauge.
Deschutes	Des-12	11.0	Same as Des-10a but is above the Little Deschutes River confluence.
Deschutes	Des-12a	21.7	Same as Des-10a but is above the Fall River confluence.
Deschutes	Des-13	13.1	Wickiup Reservoir has little riparian/wetland vegetation, but it develops some localized herbaceous vegetation during draw-down. Uppermost Des-13 is less often inundated and has substantial areas of both herb and shrub wetland and riparian vegetation
Deschutes	Des-14	1.2	Pool-riffle reach with narrow bands of riparian vegetation, mostly located on point bars.
Deschutes	Des-15	6.5	Crane Prairie Reservoir has locally extensive riparian/wetland vegetation on its margins and at its head. This is the upper limit of potential project effects on the Deschutes River.
McKay	MK-1	3.8	Unconfined low-gradient stream through cultivated fields. The riparian corridor width varies from 15 to 328 feet depending on how much land is left uncultivated along the stream. Vegetation is mostly herbs with some shrubs. Consistent with reach MK-1 of Courter et al. (2014).
McKay	MK-2	1.9	Similar to MK-1, with some areas of predominately shrub or tree vegetation. Consistent with reach MK-2 of Courter et al. (2014).
McKay	MK-3	2.0	Similar to MK-2 with a somewhat steeper channel that is seasonally dry. Consistent with reach MK-3 of Courter et al. (2014).
Ochoco	Och-1	2.5	Creek is unconfined, flanked almost continuously by irrigated agriculture. Combined width of aquatic and riparian vegetation averages 115 feet. Och-1, Och-2, and Och-3 are combined into one reach, O-1, by Courter et al. (2014).
Ochoco	Och-2	2.6	Creek is in developed city of Prineville, has riparian trees, but is essentially all developed as parks or residential. No wetlands.
Ochoco	Och-3	6.0	Is largely the same as Reach 1, but somewhat more heterogeneous with some desert upland and some residential areas and parks, and aquatic/riparian corridor width 20 to 30 meters.
Ochoco	Och-4	3.6	The Ochoco Reservoir shoreline has negligible riparian or wetland vegetation.
Tumalo	Tum-1	2.8	Creek has no wetlands. Width of riparian vegetation is 33 feet, average, on each side of creek. Riparian growth may be supported by groundwater inflow. The upper limit of Tum-1 is the Tumalo Diversion, the upper limit of potential proposed action and alternatives effects.

River	Reach	Length (mi)	Description
Whychus	Why-1	1.6	Creek has pool-riffle and step-pool morphology, and is confined within a canyon that experiences active groundwater inflow at or above the river surface elevation for most of its length, and which is the primary hydrology source for riparian and wetland vegetation found in this reach. That vegetation which has an average width of about 66 feet along each streambank. Consistent with Courter et al. (2014) reach W-1.
Whychus	Why-2	6.3	Creek is tightly confined in a canyon with a riparian vegetation width of about 20 feet along each streambank. There is little evidence of groundwater inflow. Includes lowermost portion of reach W-2 of Courter et al. (2014).
Whychus	Why-3	12.9	Creek is unconfined or loosely confined with a riparian vegetation width of 66 to 164 feet along each streambank. There is evidence of domestic pasturage, local evidence of groundwater inflow, and local areas of wetlands, irrigated agriculture, and exurban development. The floodplain includes oxbows and other alluvial features. The upper limit of Why-3 coincides with limit of reach W-2 of Courter et al. (2014).
Whychus	Why-4	1.3	Creek is in Sisters, an area of intensive suburban development with negligible riparian and no wetland vegetation. Consistent with reach W-3 of Courter et al. (2014).
Whychus	Why-5	4.1	Channel is confined, pool-riffle, flowing within conifer (ponderosa pine mostly) forest with an average riparian vegetation width of 20 feet along each streambank. There are no wetlands or nonforest areas. Consistent with reach W-4 of Courter et al. (2014). The upper limit of Why-5 is the Plainview diversion, the headward limit of potential project effects.

ID = Irrigation District; FWS = U.S. Fish and Wildlife Service.

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Table 5. Correspondence between Species and Reaches in the Study Area

Guild	Species	Reaches																																																		Source(s) & Comment
		Des-1	Des-2	Des-3	Des-4	Des-5	Des-6	Des-7	Des-8	Des-8a	Des-9	Des-10	Des-10a	Des-11	Des-12	Des-12a	Des-13	Des-14	Des-15	Why-1	Why-2	Why-3	Why-4	Why-5	Cro-1	Cro-2	Cro-3	Cro-4	Cro-5	Cro-6	Cro-7	Cro-8	Cro-9	Cro-10	Cro-11	Cro-12	Cro-13	Och-1	Och-2	Och-3	Och-4	Tum-1	CLD-1	CLD-2	CLD-3	CLD-4	CLD-5	CLD-6	CLD-7	MK-1	MK-2	MK-3	
Elk-Deer	Elk	X	X	X	X	X				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											X	X	X					X	X	X	X	X	X	X	X			X	Oregon Compass (2018) identified as important winter range.
Elk-Deer	Mule deer	X	X	X	X															X	X	X	X	X	X	X							X	X	X	X	X					X									X	X	Oregon Compass (2018) identified as important winter range.
Fish-eater	Bald eagle, Barrow's goldeneye, bufflehead, common goldeneye, common merganser, osprey, pied-billed grebe	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	eBird (2018) indicates species is very common in study area.
Fish-eater	Hooded merganser	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							X	X	X	X	X					X	X	X	X	X	X	X	X	X	X	X	eBird (2018) indicates species is very common, especially in the Deschutes River basin above Bend.
Fish-eater	American white pelican, Caspian tern, common loon, eared grebe, horned grebe, red-necked grebe		X														X		X																X	X					X												eBird (2018) indicates species is almost exclusively at reservoirs.
Fish-eater	Harlequin duck																X		X																																		eBird (2018) indicates species is rare: only 3 records, seen at Crane Prairie and Wickiup.
Fish-eater	Western grebe		X											X			X		X																X	X					X												eBird (2018) indicates species is largely limited to reservoirs and at wetlands near Sunriver.
Fish-eater	Pacific fisher, Pacific marten										X	X	X	X	X	X	X	X	X				X	X																			X	X	X	X	X	X	X				NatureServe (2018) provides county occurrence data and habitat descriptors (conifer forest).
Forest	Bullock's oriole, calliope hummingbird, Downy woodpecker, Lewis's woodpecker, red-breasted sapsucker, red-naped sapsucker, yellow warbler	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	eBird (2018) indicates species is very common in both hardwood and conifer forests throughout study area.
Forest	American Three-toed Woodpecker, black-backed woodpecker, green-tailed towhee, Williamson's sapsucker					X	X	X	X	X	X	X	X	X	X	X	X	X	X				X	X																			X	X	X	X	X	X	X				eBird (2018) indicates species is generally associated with conifer forest.
Forest	Lazuli Bunting	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							X	X	X	X	X					X	X	X	X	X	X	X	X	X	X	X	eBird (2018) indicates species is common, but sporadic across study area.
Generalist	Great blue heron, western toad	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	eBird (2018) indicates heron is very common in study area. Large toad aggregations reported from Crane Prairie Reservoir (Wray pers. Comm. 2019) but NatureServe (2018) indicates western toad is reported from counties throughout study area.
Generalist	Neotropical migrant birds	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	USFS (2016) provides no definition of "neotropical migrants" but assuming this is a reference to songbirds, they are assumed to be ubiquitous.
Generalist	Evening field slug										X	X	X	X	X	X	X	X	X					X																			X	X	X	X	X	X	X				Duncan (2005) states it occurs at "perennially wet meadows in forested habitats."
Generalist	Crater Lake Tightcoil																																																				Analysis for this species appears in the aquatic species section.
Insect-eater	Gray flycatcher	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	eBird (2018) indicates species is very common in study area.
Insect-eater	Yellow-breasted Chat	X	X	X	X	X	X	X	X	X	X	X													X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X												eBird (2018) indicates species is uncommon and, in study area, found at low elevations.
Insect-eater	Olive-sided flycatcher, willow flycatcher					X	X	X	X	X	X	X	X	X	X	X	X	X	X				X	X																			X	X	X	X	X	X	X				eBird (2018) indicates species is generally associated with conifer forest.
Insect-eater	Pallid bat, Townsend's big-eared bat	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	NatureServe (2018) habitat descriptors.

Guild	Species	Reaches																																																			Source(s) & Comment
		Des-1	Des-2	Des-3	Des-4	Des-5	Des-6	Des-7	Des-8	Des-8a	Des-9	Des-10	Des-10a	Des-11	Des-12	Des-12a	Des-13	Des-14	Des-15	Why-1	Why-2	Why-3	Why-4	Why-5	Cro-1	Cro-2	Cro-3	Cro-4	Cro-5	Cro-6	Cro-7	Cro-8	Cro-9	Cro-10	Cro-11	Cro-12	Cro-13	Och-1	Och-2	Och-3	Och-4	Tum-1	CLD-1	CLD-2	CLD-3	CLD-4	CLD-5	CLD-6	CLD-7	MK-1	MK-2	MK-3	
Insect-eater	Long-legged myotis, silver-haired bat										X	X	X	X	X	X	X	X	X				X	X																			X	X	X	X	X	X	X				NatureServe (2018) provides county occurrence data and habitat descriptors (conifer forest).
Insect-eater	Fringed myotis																																											X	X	X	X	X	X				NatureServe (2018) county occurrence data.
Open-wetland	Canada goose	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	eBird (2018) indicates species is very common in study area.
Open-wetland	Tricolored blackbird																								X	X	X	X	X	X	X	X						X	X	X	X									X	X	X	eBird (2018) indicates species is strongly concentrated on Ochoco and McKay creeks, and the Crooked River below Prineville.
Open-wetland	Trumpeter swan											X	X	X			X		X									X	X	X	X				X	X		X		X	X												eBird (2018) indicates species is uncommon, with sightings in agricultural land west of Prineville, at various reservoirs, and in wetlands northwest of Sunriver.
Open-wetland	Marbled godwit																X																		X	X																	eBird (2018) indicates species is rare, with sightings at Wickiup and Prineville Reservoirs.
Open-wetland	Greater sandhill crane																X		X																																		eBird (2018) shows no greater sandhill cranes in study area, but sandhill cranes not identified to subspecies have many records at Crane Prairie and Wickiup.
Open-wetland	Long-billed curlew																X																																				eBird (2018) indicates species is rare, with a few occurrences at Wickiup and Ochoco Reservoirs.
Shallow-water	American wigeon, green-winged teal, mallard, ring-necked duck	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	eBird (2018) indicates species is very common in study area.
Shallow-water	Blue-winged teal, wood duck			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	eBird (2018) indicates species is occasional in almost all of the study area upstream of Lake Billy Chinook.
Shallow-water	Canvasback		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	eBird (2018) indicates species is occasional in all of the study area except in reach Des-1.
Shallow-water	Cinnamon teal, gadwall, ruddy duck		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	eBird (2018) indicates species is very common, but almost exclusively at reservoirs.
Shallow-water	Lesser scaup, northern pintail, northern shoveler		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							X	X	X	X	X					X	X	X	X	X	X	X	X	X	X	X	eBird (2018) indicates species is very common, but primarily at reservoirs.
Shallow-water	Redhead											X	X	X			X		X									X	X	X	X				X	X		X		X	X												eBird (2018) indicates species is uncommon, with sightings at reservoirs in in wetlands northwest of Sunriver.
Shallow-water	Yellow rail																		X																																		Turner (pers. comm. 2019) states species occurs in Big Marsh, which is upstream of Des-15.
Wetland-aquatic	Western pond turtle	X	X	X	X	X	X	X	X																																												Based on description by Wray (pers. comm. 2019).
Wetland-aquatic	Cascades frog																																														X	X	X				Based on description by Harrington (pers. comm. 2019).

Codes:
X = Species is potentially present in reach
[empty] = Species is not potentially present in reach, except as an occasional visitor (e.g., a migrant found in unsuitable habitat)

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Appendix 3.4-B
Oregon Spotted Frog Technical Supplement

Appendix 3.4-B
Oregon Spotted Frog Technical Supplement

Introduction

This appendix addresses the following topics.

- Background material for the Oregon spotted frog affected environment.
- Delineation and description of stream reaches used in the impact analysis.
- Approach and results of the reach-level and site-specific analyses of impacts.

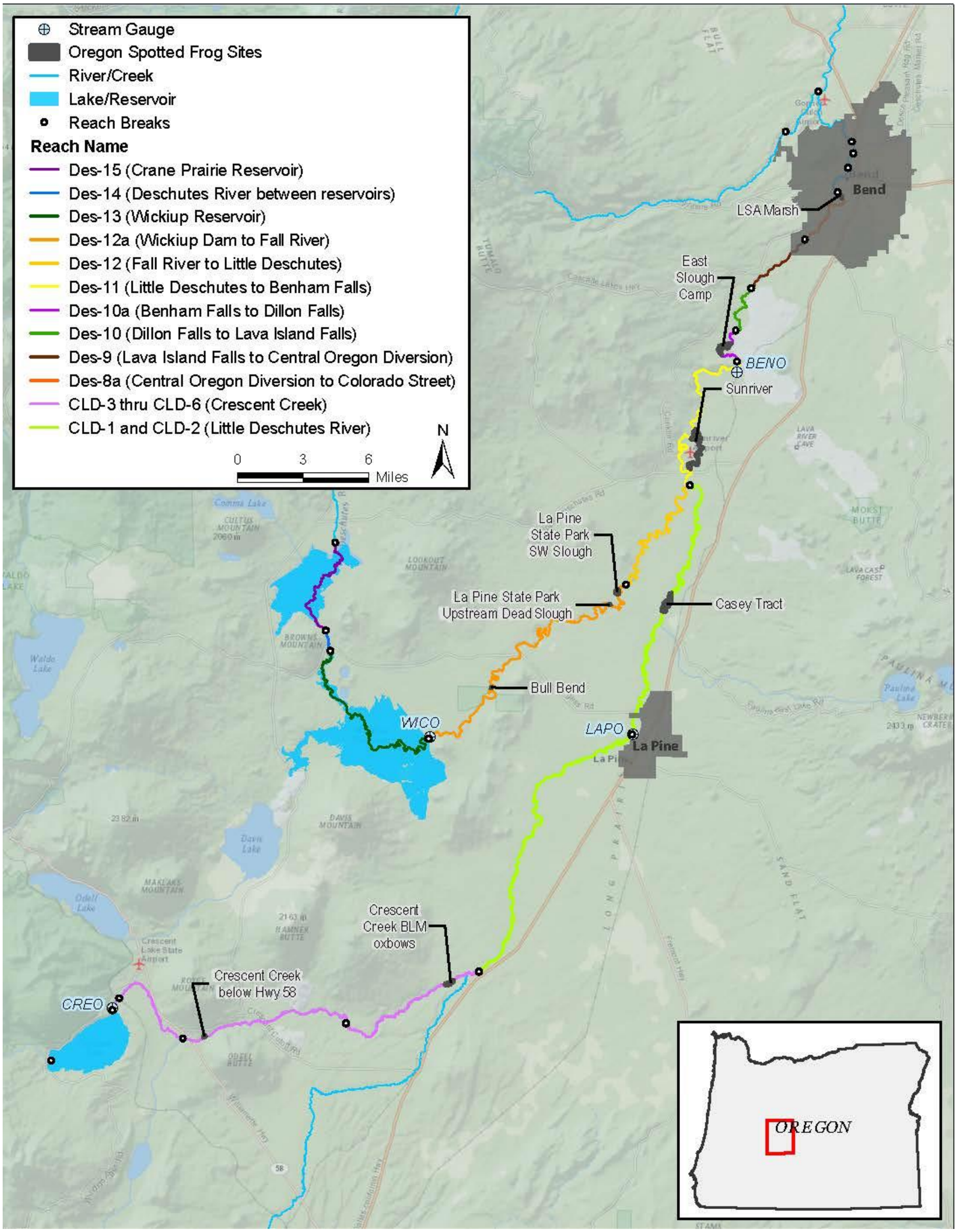
Methods

This analysis utilizes the RiverWare model to predict the volume of water flowing through the system throughout the year for each alternative. As discussed in the Deschutes Project Biological Opinion (BiOp) (U.S. Fish and Wildlife Service 2017, 2019), certain volumes of water flowing through the system result in water elevations that are known to inundate wetland vegetation that is also habitat for Oregon spotted frogs. The Deschutes Project BiOp and photographic records not associated with the BiOp provide baseline information on the vegetation community at some sites and inform the analysis of how the modeled flows, correlated water elevations, and the predicted inundation patterns under each alternative may affect Oregon spotted frog habitat components and seasonal availability. The analysis focuses on a daily time scale during Oregon spotted frog breeding, summer rearing, fall (pre-winter), and overwintering periods to assess how the modeled volumes of water flowing through the system may affect Oregon spotted frog habitat during these key life history periods. It is important to note that this analysis does not reach the site-specific depth of the analysis presented in the Deschutes Project BiOp; the goal of this analysis is to complete a system-level comparison of the alternatives in the study area to inform the assessment of environmental consequences on the Oregon spotted frog.

Defining the Study Area

The study area for this analysis includes the portion of the Deschutes Basin that is occupied by Oregon spotted frog and would potentially be affected by the alternatives. The study area extends from Crane Prairie Reservoir down the Upper Deschutes River to the LSA Marsh in Bend, Oregon, which is the lowest occupied site directly influenced by flows in the Deschutes River system (Figure 1). The study area also includes Crescent Creek downstream from the outlet of Crescent Lake to the confluence with the Little Deschutes River, and the Little Deschutes from this confluence downstream to the Deschutes River.

Figure 1. Oregon Spotted Frog Study Area Reaches and Sites (Occupied and Breeding)



Stream and River Reach Delineation

To facilitate the effects analysis, the study area was divided into 12 stream and river reaches (Figure 1). These reaches overlap with the known distribution of the species. There are 10 reaches in the Upper Deschutes River (between Crane Prairie Reservoir and Bend) and 2 reaches in the Crescent Creek and the Little Deschutes River portion of the study area.

The study area reaches are described in Table 1.

Table 1. Description of Study Area Reaches

River	Reach	Length (mi)	Description
Little Deschutes	CLD-1 and CLD-2	58.5	CLD-1 to CLD-2 are along the Little Deschutes River. CLD-1 extends for 29.3 miles and has a low-gradient underfit stream with glide morphology in an unforested wetland/riparian vegetation corridor with a total width of 328 to 984 feet. CLD-2 has the same morphology as CLD-1, but upstream of the LAPO gauge.
Crescent-Creek	CLD-3 through CLD-6	30.4	CLD-3 through CLD-6 are along Crescent Creek. The Little Deschutes River upstream of here would not be affected by the alternatives. CLD-3 has the same morphology as CLD-1, but extends for 12.6 miles upstream of the Walker Basin Canal. CLD-4 is an 11.0-mile-long section where creek is a meandering underfit stream with glide morphology in an unforested wetland/riparian vegetation corridor with a total width of 164 to 328 feet. CLD-5 has a low-gradient meandering stream for 5.9 miles within a mostly unforested riverine wetland corridor with a total width of 164 to 328 feet, flanked by ponderosa pine-dominated upland forest. At the upper end of CLD-5, the channel is constricted by development. The upper 0.9 mile of the reach (CLD-6) is a pool-riffle stream that flows through a mostly unforested riverine wetland wetland/riparian vegetation corridor with a total width of 99 to 164 feet, flanked by ponderosa pine-dominated upland forest.
Deschutes	Des-8a	3.4	River is confined variously by lava flows, development, and topography, with limited but locally important riparian or aquatic vegetation. River channel has a mixed pool-riffle, step-pool and glide morphology with occasional cascades. Reach Des-8a is designated for consistency with the U.S. Fish and Wildlife Service (2017, 2019) analysis, which placed a reach break at the Colorado Avenue bridge.
Deschutes	Des-9	3.7	River has glide morphology with some waterfalls related to lava flows. There are locally important riverine wetlands and floodplain riparian vegetation, mostly located on river bars. The Central Oregon Canal diversion is at the break between Des-8a and Des-9.
Deschutes	Des-10	3.1	River has low gradient, glide morphology due to ancient damming by a lava flow at Lava Island Falls, which is the break between Des-9 and Des-10, and is the site of the Arnold Canal diversion. Some extensive wetland complexes flank the river or

River	Reach	Length (mi)	Description
			its former cut-off meanders; these include a mix of aquatic, wetland and riparian vegetation, mostly in herbs and shrubs but locally in hardwood and mixed forest.
Deschutes	Des-10a	3.1	Similar to Des-10, but moving upstream through the reach, the river gradually becomes steeper and more confined with fewer and smaller associated wetlands.
Deschutes	Des-11	11.4	Same as Des-10a but is above the BENO gauge.
Deschutes	Des-12	11.0	Same as Des-10a but is above the Little Deschutes River confluence.
Deschutes	Des-12a	21.7	Same as Des-10a but is above the Fall River confluence.
Deschutes	Des-13 (Wickiup Reservoir)	13.1	Wickiup Reservoir has some riparian/wetland vegetation, and it develops some localized herbaceous vegetation during draw-down. Uppermost Des-13 is less often inundated and has substantial areas of both herb and shrub wetland and riparian vegetation.
Deschutes	Des-14	1.2	Pool-riffle reach with narrow bands of riparian vegetation, mostly located on point bars.
Deschutes	Des-15 (Crane Prairie Reservoir)	6.5	Crane Prairie Reservoir has locally extensive riparian/wetland vegetation on its margins and at its head. This is the upper limit of potential effects on the Deschutes River.

Site Selection

The following criteria were used to select sites for the site-specific analysis:

- Sites that represent the geographic extent of Oregon spotted frog occupancy in the study area.
- Sites that are known Oregon spotted frog breeding locations.
- Sites with varying levels of connectivity to the river system; sites with greater connectivity would more closely track the flows in the main channel whereas water levels in disconnected sites can behave with varying degrees of independence from mainstem flows.
- Sites with varying groundwater and other surface water inputs.
- Sites proximal to the stream gauges; flow modeling would be more accurate for these sites if they are connected to the main stream/river channel.
- Sites with multiple data resources.

The site-specific analysis includes 11 sites (Table 2). Some reaches included more than one site, and other sites were left out of the site-specific analysis because the range of sites selected capture variability within the criteria listed above.

Table 2. Oregon Spotted Frog Sites Included in the Site-Specific Analysis

Site	Reach	Description
Crane Prairie Reservoir	Des-15	Reservoir; occupied breeding
Wickiup Reservoir	Des-13	Reservoir; occupied breeding
Bull Bend	Des-12a	River; occupied
La Pine State Park (Dead Slough)	Des-12a	Oxbow; occupied breeding
La Pine State Park (SW Slough)	Des-12a	Oxbow; occupied breeding
Sunriver	Des-11	Limited connection; occupied breeding
East Slough Camp (complex)	Des-10a	Varied connectivity; occupied breeding
LSA Marsh	Des-8a	Riparian wetland; occupied breeding
RM 21.9 (Wetlands A and B below Hwy 58)	CLD-4	Riparian wetland; occupied breeding
RM 1.7 (BLM oxbows)	CLD-3	Riparian wetland; occupied breeding
Casey Tract	CLD-1	Occupied breeding

Life History Timeframes

The analysis assessed the effects among the alternatives by comparing how the differing flow regimes might affect the following four key life history periods of the Oregon spotted frog:

- Breeding (March 15 through April 30): During this period the egg masses are sensitive to changes in water levels that can result in less favorable conditions for development (exposure to predation, risk of desiccation).
- Rearing (April 1 through August 31): During this period frog eggs hatch and tadpoles develop throughout the summer, finally metamorphosing into juvenile frogs.
- Pre-wintering (September 1 through October 15): Juveniles and adults may move from wetlands associated with breeding and rearing to overwintering sites if habitat conditions do not support these life history periods in the same location.
- Overwintering (October 16 through March 14): Frogs remain relatively inactive during the winter and they are vulnerable to exposure via desiccation, suffocation, and/or freezing.

Relating Flow to Oregon Spotted Frog Habitat Impacts

The amount of water flowing through the Upper Deschutes River system affects the quality of the aquatic habitat used by Oregon spotted frogs based on time of year and the corresponding key life history periods described previously. General patterns of habitat sensitivity to flow include:

- Breeding and rearing habitats are supported in sites where flow volumes are sufficient to ensure emergent vegetation remains inundated with water during the breeding and rearing seasonal periods.
- During breeding, stable water elevation is important as egg masses develop. Egg masses are vulnerable to mortality through desiccation or predation if changing water levels move them to unsuitable habitat or strand them.
- During rearing, mobile tadpoles and metamorphic frogs can tolerate more water level fluctuation than egg masses. Flows need to maintain inundation of vegetation to provide cover.

- During the pre-winter, as juveniles and adults move from inundated wetland sites to overwintering locations in springs and creeks with refugia (e.g., mud banks, vegetation mats), and often with well-oxygenated flowing water, the distance traveled should be minimized. Inundation of vegetation early in this period provides shelter to Oregon spotted frogs from predation. As water levels drop, the amount of water level change to which Oregon spotted frogs are exposed is also important to their successful movement and survival.
- Although Oregon spotted frogs may relocate during the overwintering period, water level stability protects sedentary individuals from exposure and freezing.

Approach for Reach-Level and Site-Level Impact Analysis

RiverWare (Zagona et al. 2001) output and stream gauge flow data were related to Oregon spotted frog site conditions in some reaches within the study area by assessing the amount of flow and patterns of change in flow depicted in modeled hydrographs, relative to flow thresholds that reflect some of the habitat sensitivity patterns described above. The reach-level and site-level impact assessments relied on the flow thresholds presented in Table 3 as well as the hydrographs presented in the *Environmental Consequences* section.

Unless otherwise noted, hydrographs in this analysis present the fully implemented alternatives, meaning the flows predicted under each alternative when operating at their highest minimum instream fall and winter flow below Wickiup Dam.

- Proposed action starting in year 21 through year 30 of the permit term: 400 cfs.
- Alternative 3 starting in year 11 through year 30: 400–500 cfs.
- Alternative 4 starting in year 6 through year 20: 400–600 cfs.

Although Alternative 3 targets the higher minimum flow (500 cfs) in above-normal and wet years, the model used the same assumption for release of flows in excess of the minimum for the proposed action in above-normal and wet years.[1] Therefore, the hydrographs presented for the proposed action and Alternative 3 at these flows (400 cfs and 400 to 500 cfs, respectively) are the same.

With some exceptions (e.g., Des-8a and Sunriver in Des-11), the flow thresholds below were developed by the U.S. Fish and Wildlife Service (FWS) and are also presented in the Deschutes Project Biological Opinion (U.S. Fish and Wildlife Service 2017: Table 32; 2019). FWS developed the thresholds by comparing the flow measured at gauges in the rivers or streams to the timing and duration of inundation patterns observed at sites. For sites associated with a gauge, when the flow threshold in Table 3 is observed at the gauge, the associated sites experience inundation levels that are deep enough to partially submerge emergent vegetation in the site, thereby providing sufficient cover and habitat function to support Oregon spotted frogs, particularly during breeding.

[1] Although the proposed action does not include the commitment to target the higher flow, typical operations practice is to release more water during above-normal and wet years. The RiverWare model required an assumption for how flows in excess of the minimum would be managed. The same equation for managing flows was applied to the proposed action and Alternative 3 to maintain comparative model outputs.

Table 3. Flow Thresholds

Reach	Site	Associated Gauge	Flow Threshold (cfs)
Des-12a (Wickiup Dam to Fall River)		WICO	900
	Bull Bend	WICO	900
	La Pine State Park (Dead Slough)	WICO	900
	La Pine State Park (SW Slough)	WICO	900
Des-12 (Fall River to Little Deschutes)		WICO	900
Des-11 (Little Deschutes to Benham Falls)		WICO	900
	Sunriver	WICO/BENO	1,580/1,900
Des-10a (Benham Falls to Dillon Falls)		BENO	1,200
	East Slough Camp (complex)	BENO	1,200–1,600
Des-10 (Dillon Falls to Lava Island Falls)		BENO	1,200–1,500
Des-9 (Lava Island Falls to Central Oregon Diversion)		Modified from BENO *RiverWare Internode: Siphon2COIDInflow*	(none)
Des-8a (Central Oregon Diversion to Colorado Street)	LSA Marsh	Modified from BENO *RiverWare Internode: Siphon2COIDOutflow*	1,200
CLD-3 through CLD-6 (Crescent Creek)	Wetlands A and B BLM Oxbows	CREO	(none)
CLD-1 and CLD-2(Little Deschutes River)	Casey Tract	LAPO	(none)

In addition to the wetland inundation thresholds in Table 3, the analysis applied some reach-specific flow thresholds to assess other site conditions which do not represent wetland vegetation inundation but allow comparison of other physical attributes that are likely to affect habitat over time. An example of this is the flow threshold describing when water flow switches from flowing toward the wetlands to toward the river. These thresholds are described by reach in the *Environmental Consequences* section.

For reservoirs, RiverWare-modeled storage volumes (acre-feet [af]) and associated reservoir pool elevations (feet) were compared among the alternatives. The assessment relied on water elevation and storage volume targets or ranges described in the Deschutes Project Biological Opinion (U.S. Fish and Wildlife Service 2017, 2019). These are detailed in the specific reach analysis sections for Crane Prairie and Wickiup reservoirs (Des-15 and Des-13).

Analysis of effects on general vegetation growth patterns within the study area considered the following growing season information. The growing season typically covers the period of time between the last and first freeze dates of a year. Based on data collected from 1971 through 2002 (Detweiler 2016), the median last frost date, or the beginning of the growing season for Bend, Oregon, is June 20, and the growing season extends to the median first frost date of September 2 (day 337 of water year). La Pine, Oregon also experiences its last frost on June 20, but the first frost typically happens on September 8 (day 343 of the water year). The growing season is approximately 11 weeks long and overlaps with the rearing period for Oregon spotted frogs.

Analysis of Other Threats to the Species

The assessment qualitatively addresses how proposed changes to the water management of the system may secondarily affect other known threats to the species in the study area. Primarily these threats include the proliferation of invasive species such as reed canarygrass (*Phalaris arundinacea*), which can affect the quality of the emergent vegetation at breeding sites, and nonnative predatory species such as the bullfrog (*Lithobates catesbeianus*), brown bullhead catfish (*Ictalurus nebulosus*), brown trout (*Salmo trutta*), and three-spined stickleback (*Gasterosteus aculeatus*).

Considerations of the Upper Deschutes River Conservation Fund

Alternatives 3 and 4 include Conservation Measure DR-2: Upper Deschutes River Conservation Fund. The fund would be used to support conservation measures for restoration and/or habitat maintenance activities and/or benefit the covered species within the Deschutes River. This measure is not included in the proposed action or no-action alternative. The effects of Conservation Measure DR-2 are not quantifiable; however, the assessment of environmental consequences considers it qualitatively because the measure could be used to support habitat restoration actions designed to respond to trends of either decreasing Oregon spotted frog habitat loss or degradation, or Oregon spotted frog declining populations if they are detected by the monitoring program during the permit period.

Comparing the Alternatives

This assessment compared how well the proposed action, Alternative 3, and Alternative 4 would perform relative to the no-action alternative and identified which alternative or group of alternatives would result in the most favorable conditions for Oregon spotted frogs and their habitat.

The RiverWare model was used to assess the performance of the alternatives by comparing the predicted number of days of habitat inundation during the following periods.

- Breeding, Oregon spotted frog’s most sensitive life history period.
- Pre-winter, when frogs choose an overwintering site.
- Overwintering, when frogs are relatively inactive, comparing day counts of habitat inundation during rearing when frogs are most mobile.

The analysis focuses on the full implementation stage for each alternative, because conditions affecting the Oregon spotted frog would be at their most beneficial or adverse level of effect at this stage. The proposed action and Alternatives 3 and 4 have different time frames, listed below, for when they would operate at their highest minimum instream fall and winter flow below Wickiup Dam. The analysis also considers the length of time needed to reach full implementation as well as the duration at which the alternative would operate at full implementation when considering the overall effect of the alternative over its permit term.

- Proposed action: years 21 through 30.
- Alternative 3: years 11 through 30.
- Alternative 4: years 6 through 20.

If differences in the extent of habitat inundation were noted among the life history periods, the time required to reach full implementation (highest flow level) and duration of the full implementation timeframe were considered. Longer time needed to reach full implementation or shorter duration at full implementation would extend the negative effects of ongoing threats to the species as they exist under the current condition.

The hydrographic patterns at full implementation of each alternative, including modeled flow changes, within-year, and then year-to-year variation among the alternatives, were also considered. If alternatives performed similarly, the effect of the Conservation Measure DR-2 was considered, which is only included in Alternatives 3 and 4.

Effects of the proposed action and alternatives on Oregon spotted frog would be considered adverse if they directly or indirectly result in habitat conditions likely to cause a decline in the distribution, abundance, diversity, and productivity of Oregon spotted frog.

Affected Environment

Biology of the Species

The Oregon spotted frog (*Rana pretiosa*) was listed as threatened under the Endangered Species Act (ESA) on August 29, 2014 (79 FR 41657). Critical habitat was designated on May 11, 2016 (81 FR 29336). Oregon spotted frogs have historically ranged from British Columbia to northeastern California, occupying 31 subbasins (Hayes 1997, McAllister and Leonard 1997). Currently, the Oregon spotted frog occupies 15 subbasins from southwestern British Columbia to at least southern Oregon (70 FR 51662-51663: Table 1). The spotted frog is likely extirpated from northeastern California (Hayes 1997). Within the study area, spotted frogs occupy two subbasins: the Upper Deschutes River and the Little Deschutes River. These subbasins are aquatically connected, unlike other subbasins in Oregon.

Oregon spotted frogs reach maturity by 1 to 3 years of age, varying by sex, elevation, and latitude. At lower elevations, breeding occurs in February or March while at higher elevations, it occurs between early April and early June (Leonard et al. 1993). Egg masses are laid communally, in groups of up to several hundred (Licht 1971, Nussbaum et al. 1983, Cook 1984, Hayes et al. 1997, Engler and Friesz 1998). Females deposit their eggs in shallow water such as temporary pools, gradually receding shorelines, benches of seasonal lakes and marshes, and in wet meadows. Egg-laying sites tend to be only temporarily wet but are connected to permanently wetted areas through surface water. Eggs are often deposited in low and sparse aquatic vegetation situated to take advantage of solar exposure that warms the surrounding water. Due to the specific needs for ovipositional habitat and a limited flexibility to switch sites, Oregon spotted frogs may be especially affected by modification of existing egg-laying sites (Hayes 1994).

Eggs typically hatch within 3 weeks and tadpoles move into rearing habitat, such as streams, ponds, and wetlands. The tadpoles graze on plant tissue, bacteria, algae, detritus, and carrion. Tadpole survival is greatly affected by predation and is increased as tadpoles grow and with access to mature aquatic vegetation for cover (Licht 1974). Tadpoles metamorphose into froglets in their first summer.

Adult Oregon spotted frogs show a high affinity for aquatic habitat. They prefer perennially deep pools with moderate amounts of native vegetation, including grasses, sedges, and rushes, although they may also occupy mixes of reed canarygrass and native vegetation (Watson et al*.* 2003; McAllister and Leonard 1997). Reed canarygrass can reduce the quality of breeding habitat as it proliferates over time (Kapust et al. 2012). Aquatic plants are used by adults for basking and cover.

Oregon spotted frogs are generally limited in their dispersal movements, averaging between 1,312 feet (400 meters) to 2,600 feet (800 meters) throughout the year, however individuals have been shown to disperse up to 1.7 miles (2.7 kilometers) (Cushman and Pearl 2007; Hallock and Pearson 2001; Watson et al*.* 1998). Frequency of movement is positively correlated with pool proximity (Watson et al. 2003). Spotted frogs in the Sunriver population routinely make annual migrations of 1,640 to 4,265 feet (500 to 1,300 meters) between a major egg-laying complex and an overwintering site. A recent study (Pearl et al. 2018) including some sites from the Upper Deschutes found that most frogs moved less than 250 meters during the fall, although some showed greater movement distances depending on habitat type. Those using ditches moved farther, up to 1,145 meters over the tracking period. Due to limited dispersal distance, all life history types are exhibited in the study area.

Limited dispersal distances and low habitat connectivity are thought to contribute to the low genetic diversity found in Oregon spotted frogs (Blouin et al. 2010). Blouin et al. (2010) demonstrated that gene flow is much higher if populations are less than 10 kilometers apart. FWS considers spotted frog habitat connected for the purposes of genetic exchange when occupied/suitable habitats fall within a maximum movement distance of 3.1 miles (5 kilometers) (U.S. Fish and Wildlife Service 2013).

For overwintering, adults generally require flowing streams for well-oxygenated water (Tattersall and Ultsch 2008) and refugia from predators and freezing (Watson et al. 2003). Where cold winters tend to ice over ponds, spotted frogs have been observed to remain active during the first month of freezing, appear dormant during January and February, and gradually increase activity by mid-March, even when ice cover remains (Hayes et al. 2001). Oregon spotted frogs have been observed using "semi-terrestrial" overwintering habitats, such as interstices in lava rock, beaver channels, and flooded beaver lodges along the Deschutes River in central Oregon (Pearl et al. 2018). Overwintering sites may contain multiple frogs, underscoring the importance of these habitat features for spotted frogs (Pearl et al. 2018).

Status in the Study Area

The proposed action would affect two subbasins: the Upper Deschutes from Bend to Crane Prairie Reservoir and the Little Deschutes Basin, including the Little Deschutes up to its confluence with

Crescent Creek and Crescent Creek to Crescent Lake. Both subbasins include several riverine, palustrine, and lacustrine wetland locations known to be occupied by Oregon spotted frogs.

A *metapopulation* is a group of populations experiencing a measurable amount of gene flow. The Oregon spotted frogs within the study area belong to the Central Cascades metapopulation (Blouin et al. 2010). In the study area, patches of habitat conducive to Oregon spotted frog breeding are separated from each other by areas that are not suitable for breeding but may support other uses by Oregon spotted frogs (e.g., dispersal, foraging). For the purpose of this analysis, an Oregon spotted frog site is defined as a habitat patch where breeding has been confirmed (breeding site), or an area where multiple Oregon spotted frogs have been detected (occupied site). Occupied sites and breeding sites within the study area are shown on Figure 1. Additional sites may exist but have not yet been identified; private lands, in particular, have had few surveys.

Above Wickiup Dam on the Upper Deschutes River, Crane Prairie Reservoir contains several breeding sites. The Deschutes River Arm and the southeast bay of Wickiup Reservoir are each known to support Oregon spotted frogs. Along the mainstem Deschutes River from below Wickiup Dam to the confluence with the Little Deschutes River, there are six known breeding sites, in two of which only occasional breeding has been detected. From below the confluence with the Little Deschutes River to Bend, there are six breeding sites (one of which is occasional) and one recently identified site with only juveniles detected (U.S. Fish and Wildlife Service 2017, 2019).

There are nine breeding sites that are monitored by FWS along the Little Deschutes River downstream of its confluence with Crescent Creek. The middle Little Deschutes, from Crescent Creek to the confluence with Long Prairie Creek, has three of these sites. The lower Little Deschutes, from Long Prairie Creek to the confluence with the Deschutes River, contains the other six. In 2011 and 2012, breeding counts found that spotted frogs were distributed throughout the entire reach of the Little Deschutes River, downstream of Crescent Creek (U.S. Fish and Wildlife Service 2017). Crescent Creek contains five known breeding sites. Surveys in 2011 and 2012 found Oregon spotted frogs distributed throughout 25 of the 30 miles of the reach. No Oregon spotted frogs were detected within 5 miles downstream of Crescent Lake Dam (U.S. Fish and Wildlife Service 2017, 2019).

Within the study area occupied site connectivity with the river and its associated flows are varied. Some sites are closely connected to the river (e.g., Bull Bend) whereas others function relatively independently from the fluctuations in the river flows (e.g., Sunriver, Old Mill/Casting Pond). Both the Sun River (which hosts the Sunriver occupied breeding site) and the Old Mill/Casting Pond are human-made so their independence from river flow fluctuations is probably the most extreme among the known Oregon spotted frog sites in the study area. In addition, groundwater inputs, and site-specific characteristics such as site topography, elevation, and substrate are known to affect the extent and timing of site-specific responses to changes in river flow (U.S. Fish and Wildlife Service 2017, 2019).

Threats to Oregon Spotted Frogs in the Deschutes Basin

In the 2014 Final Rule determining the ESA threatened species status of Oregon spotted frog (79 FR 51657), FWS identified threats to Oregon spotted frogs in the Deschutes Basin. Specifically, in the Upper Deschutes River Subbasin threats include wetland loss, reed canarygrass, shrub encroachment, and hydrological changes (water management). In the Little Deschutes River Subbasin, threats include habitat loss and/or modification due to land conversions (primarily agriculture), hydrologic changes (e.g., dams, ditches, and water control structures), shrub encroachment, invasive reed canarygrass, and introduced predators (bullfrogs and cold water fish).

Environmental Consequences

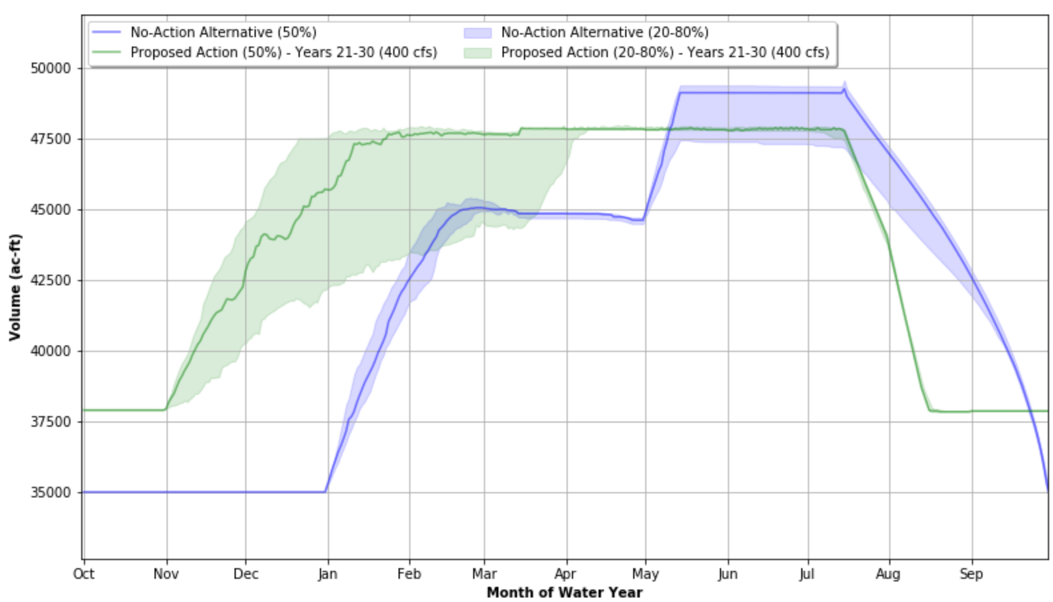
Reach Des-15: Crane Prairie Reservoir

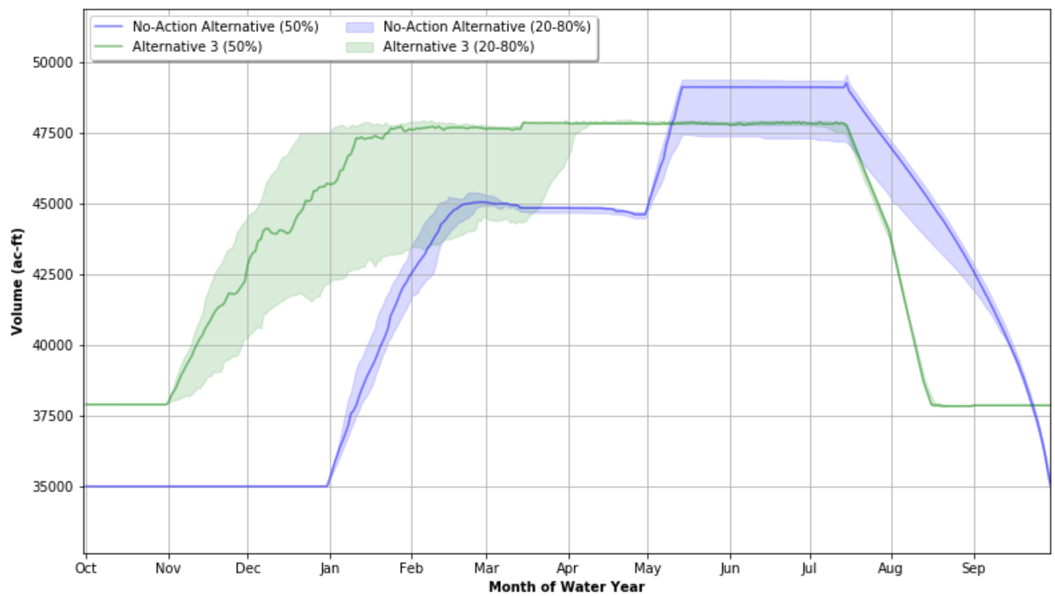
Crane Prairie Reservoir is occupied by Oregon spotted frog, and it supports breeding at several locations. Due to the relatively large breeding population recorded at this site, Crane Prairie is a key site for maintaining the species in the Upper Deschutes Basin.

In the Deschutes Project Biological Opinion (U.S. Fish and Wildlife Service 2017, 2019), FWS found that storage volumes between 45,000 and 50,000 af ensure quality breeding habitat for Oregon spotted frogs because at these storage volumes the upper edge of the reservoir pool remains within the existing emergent vegetation.

Figure 2 depicts daily water volume hydrographs generated for Crane Prairie Reservoir (CRA) using RiverWare for the no-action alternative, the proposed action, Alternative 3, and Alternative 4. The hydrographs in Figure 2 represent a visual comparison of the storage volumes expected under the different alternatives at their full implementation. Volumes are the same under the proposed action and Alternative 3.

Figure 2. Water Volume (acre-feet) in Crane Prairie Reservoir Modeled using RiverWare for the Proposed Action (top), Alternative 3 (middle) and Alternative 4 (bottom) at their Highest Winter Flow Scenarios





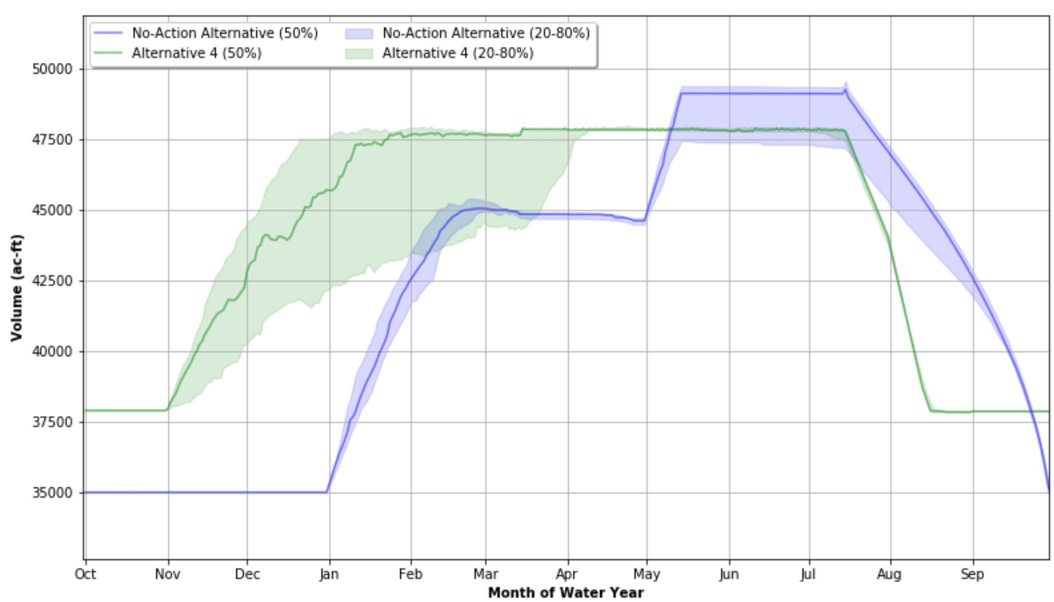


Table 4 and Table 5 provide comparisons among the alternatives of storage volume (af) and water elevation (feet) available in Crane Prairie during each of the key Oregon spotted frog life history periods. Data were calculated from the 20% (low flow years), 50% (median flow years), and 80% (high flow years) daily values for the 29-year model period, averaged over the key life history period days of the water year

Table 4. Crane Prairie Reservoir Water Storage Volumes under Each Alternative during Key Oregon Spotted Frog Seasons

	Dry Years			Median Years			Wet Years		
Crane Prairie Reservoir	No-Action Alternative (ac-ft)	Proposed Action/ Alternative 3 % of No-Action	Alternative 4 % of No-Action	No-Action Alternative (ac-ft)	Proposed Action/ Alternative 3 % of No-Action	Alternative 4 % of No-Action	No-Action Alternative (ac-ft)	Proposed Action/ Alternative 3 % of No-Action	Alternative 4 % of No-Action
Breeding	44,638	105%	102%	44,787	107%	107%	44,843	107%	107%
Rearing	45,809	100%	100%	47,098	97%	97%	47,324	97%	97%
Pre-winter	37,826	100%	100%	38,011	100%	100%	38,154	99%	99%
Overwintering	38,233	109%	109%	38,477	115%	115%	38,799	117%	117%

Table 5. Crane Prairie Reservoir Water Elevations under Each Alternative during Key Oregon Spotted Frog Seasons (feet)

	Dry Years			Median Years			Wet Years		
Crane Prairie Reservoir	No-Action Alternative	Proposed Action/ Alternative 3 difference from No-Action	Alternative 4 difference from No-Action	No-Action Alternative	Proposed Action/ Alternative 3 difference from No-Action	Alternative 4 difference from No-Action	No Action Alternative	Proposed Action/ Alternative 3 difference from No-Action	Alternative 4 difference from No-Action
Breeding	4,442.71	-0.49	-0.49	4,442.74	-0.67	-0.67	4,442.75	-0.67	-0.67
Rearing	4,442.96	0.01	0.01	4,443.25	0.27	0.27	4,443.30	0.30	0.30
Pre-winter	4,441.19	-0.02	-0.02	4,441.23	0.02	0.02	4,441.26	0.05	0.05
Overwintering	4,441.27	-0.75	-0.75	4,441.33	-1.32	-1.32	4,441.40	-1.43	-1.43

Breeding Sites

The proposed action, Alternative 3, and Alternative 4 would provide quality breeding habitat by maintaining the reservoir volume within the range targeted by FWS (2017) whereas the no-action alternative would maintain levels slightly below the targeted volume during all years. Alternative 3 and the proposed action would be slightly more effective during dry years than Alternative 4.

Effects

At Crane Prairie reservoir, from an operation standpoint the proposed action, Alternative 3, and Alternative 4 are indistinguishable, but they vary as a group from the no-action alternative.

Based on the storage volume calculations (Table 4):

- During all types of years (wet, dry, normal [median]), the no-action alternative provides about the same volume of water as the proposed action, Alternative 3, and Alternative 4 during rearing and pre-winter, but less water during breeding and much less during overwintering.
- The proposed action, Alternative 3, and Alternative 4 show similar performance, and all outperform the no-action alternative.

Based on the storage elevation calculations (Table 5):

- The no-action alternative, the proposed action, Alternative 3 and Alternative 4 perform similarly, although the no-action alternative provides slightly lower water elevations than the proposed action and Alternative 3 in winter and during the breeding seasons of normal (median) and wet years.
- All alternatives perform similarly, although the no-action alternative provides slightly lower water elevations than the other alternatives in winter, and during breeding, and pre-winter of dry years.

From the hydrographs (Figure 2):

- The pool elevation and storage volume would be held at a consistent level with vegetation inundated throughout the breeding season under all alternatives.
- During pre-winter, the proposed action, Alternative 3, and Alternative 4 the volume of water in the reservoir would decrease but not be reduced below approximately 37,870 af, which is higher than the no-action alternative minimum storage level (35,000 af). This would make it easier for Oregon spotted frog to access overwintering sites because of the shorter travel distances between breeding and overwintering sites.
- Under the proposed action, Alternative 3, and Alternative 4, volume would be prevented from decreasing below 37,870 af during the winter. Smaller volume fluctuation would be expected to support OSF by increasing stability of a key abiotic component (water) that supports the vegetation community.
- The rate of fill would be smoothed, as water volumes increase between Nov 1 and April 1 (or earlier) and be held at an upper volume of 48,000 af. There would not be a jump in volume after May 1 for the proposed action, Alternative 3, and Alternative 4, as seen in the no-action

alternative. The smoothing of the hydrograph would positively affect Oregon spotted frogs by maintaining a more stable water interface with the vegetation. Under the proposed action, Alternative 3, and Alternative 4, Oregon spotted frogs would experience fewer changes in volume and avoid a volume change that happens during the rearing period under the no-action alternative.

Summary Conclusion

Table 8 summarizes the overall results of this comparison of each alternative to the no-action. The proposed action, Alternative 3, and Alternative 4 would similarly improve Oregon spotted frog habitat and support the species compared to the no-action alternative.

Reach Des-14

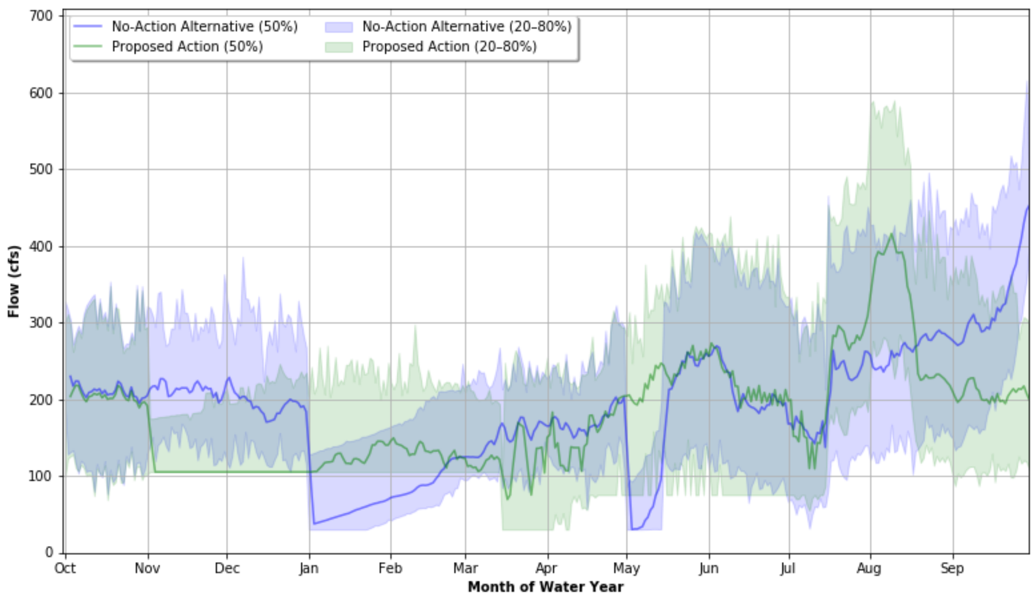
Oregon spotted frogs are known to occupy this short stretch of the Deschutes River between Crane Prairie Reservoir and Wickiup Reservoir; however, records of egg mass observation indicate the single confirmed breeding site appears to fail during most if not all years (U.S. Fish and Wildlife Service 2017, 2019). Oregon spotted frog egg masses were again detected within this area of the reach during 2019 (O'Reilly pers. comm. [a]) Aside from potentially supporting breeding, the reach provides connectivity between Crane Prairie and Wickiup Reservoirs.

RiverWare Results

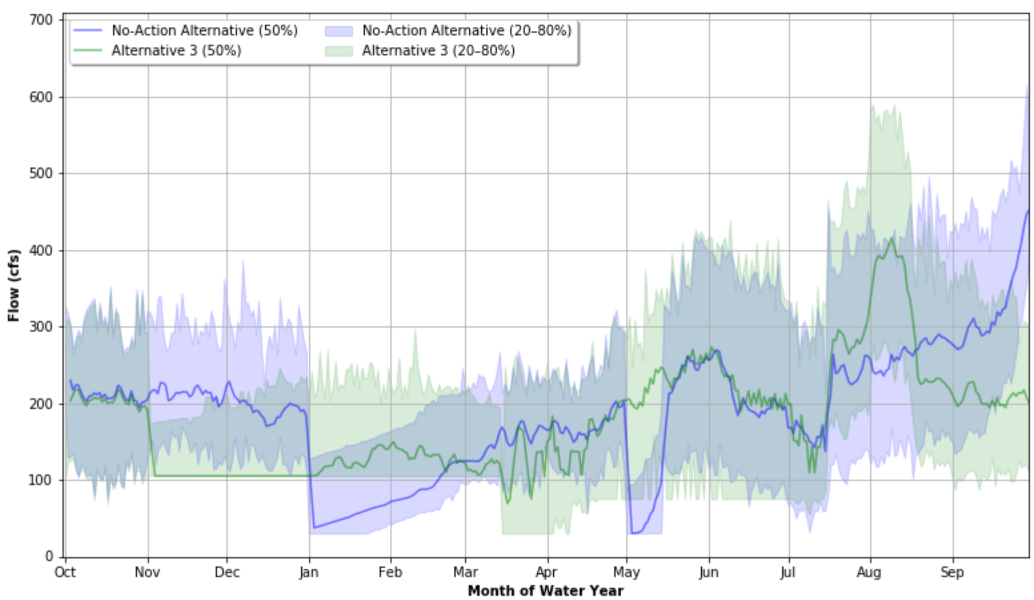
Figure 3 depicts daily Deschutes River flow hydrographs generated for the CRAO gauge location using RiverWare for all alternatives. The hydrographs in Figure 3 represent a visual comparison of the river flows expected under the different alternatives at the full implementation stage.

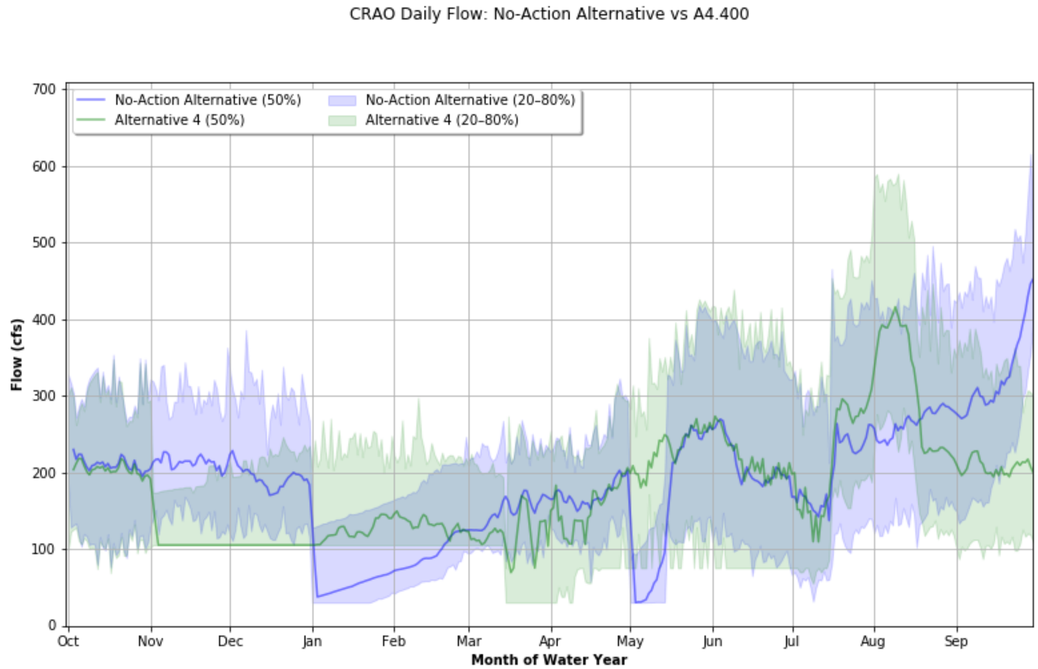
Figure 3. Deschutes River Flow Modeled Using RiverWare at the CRAO Gauge for the No-Action Alternative Compared to the Proposed Action (top), Alternative 3 (middle), and Alternative 4 (bottom), at their Full Implementation

CRAO Daily Flow: no-action alternative vs proposed action 400 cfs



CRAO Daily Flow: No-Action Alternative vs A3.400





For each alternative, the graphs present the median modeled flow (50%; solid line) and a band capturing the 20% through 80% modeled flows, meaning the flows expected to occur 20% to 80% of the time.

Effects

The analysis for this reach was completed by comparing the RiverWare results for the CRAO gauge which is located on the Deschutes River just downstream from Crane Prairie Reservoir. It is important to note that the known breeding site located within this reach is heavily influenced by water level management in Wickiup Reservoir. The 2018 annual monitoring results for this wetland indicated that when Wickiup Reservoir storage exceeds approximately 179,000 af there is a surface connection as the water in the reservoir backs up into Reach Des-14 and inundates this site (U.S. Department of the Interior et al. 2019). Wickiup continues to influence this wetland with sub-surface flow when Wickiup storage volume exceeds 140,000 af. Therefore, although this section provides a reach-level comparison of the alternatives based on the RiverWare modeling, it does not capture the site-specific conditions where Wickiup management affects the lower portions of the reach, including the vicinity of the known breeding site.

From the RiverWare hydrographs (Figure 3), this reach experiences erratic flows throughout the year due to the operational maintenance of water elevation in Crane Prairie Reservoir.

Breeding

- Flow fluctuates throughout the breeding period under the no-action alternative and this pattern is amplified under the proposed action, Alternative 3, and Alternative 4.

The no-action alternative would outperform the fully implemented proposed action, Alternative 3, and Alternative 4; however, all alternatives offer erratic flow patterns.

Rearing

- Flow patterns continue to display erratic swings but they are most extensive under the no-action alternative as indicated by the large drop in flow during May.

All three of the fully implemented proposed action, Alternative 3, and Alternative 4 would outperform the no-action alternative; however, all alternatives experience flow changes that are not conducive to supporting Oregon spotted frog habitat.

Pre-Winter

- From the hydrographs (Figure 3), flows modeled for the fully implemented proposed action, Alternative 3, and Alternative 4 experience a similar decrease in flow through the pre-winter season. The no-action alternative experiences a much larger flow fluctuation during the pre-winter.

The proposed action, Alternative 3, and Alternative 4 would perform similarly and would be much more stable compared to the no-action alternative. The less drastic change in inundation water elevation may mean fewer frogs would select poor overwintering sites that end up disconnected or above the waterline. This more stable pattern could lead to an increase in the use of this reach by Oregon spotted frogs at least for dispersal and during overwintering. The proposed action lacks Conservation Measure DR-2, which would fund activities to restore and maintain habitat to benefit the covered species within the Deschutes River, including Oregon spotted frog. For these reasons, the fully implemented Alternative 3 and Alternative 4 would outperform the proposed action and no-action alternative.

Overwintering

From the hydrographs (Figure 3), flows under the proposed action, Alternative 3 and Alternative 4 maintain a more stable flow pattern during winter than the no-action alternative. Stability in flow would protect overwintering Oregon spotted frogs and could result in an increased use of the reach for overwintering. Full implementation of the proposed action, Alternative 3, and Alternative 4 would outperform the no-action alternative. The proposed action lacks Conservation Measure DR-2, which would fund activities to restore and maintain habitat to benefit the covered species within the Deschutes River, including Oregon spotted frog. For these reasons, the fully implemented Alternative 3 and Alternative 4 would outperform the proposed action and no-action alternative.

Summary Conclusion

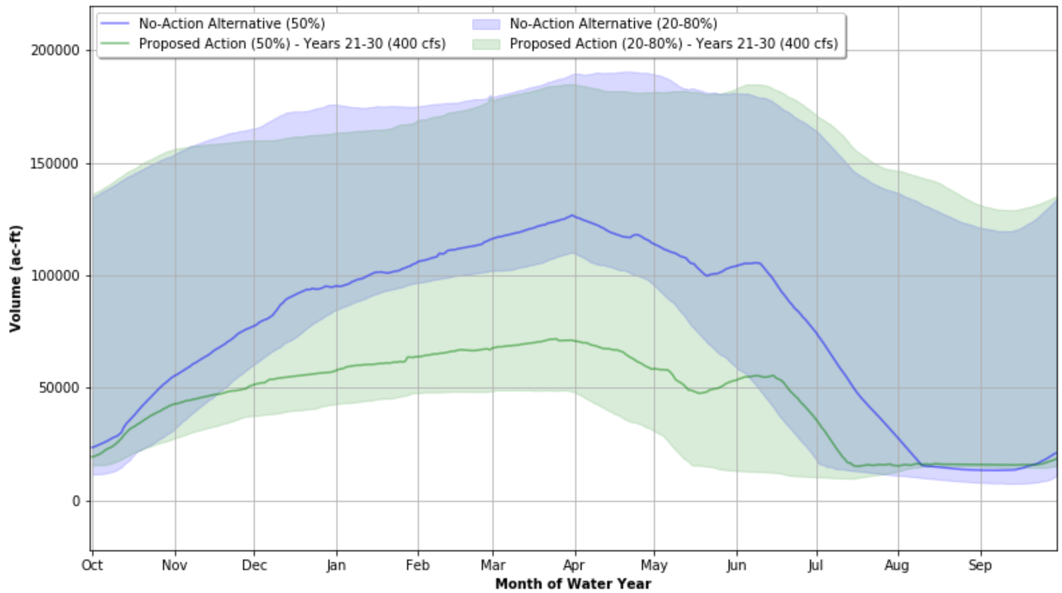
Table 8 summarizes the overall results of this comparison of each alternative to the no-action. The proposed action, Alternative 3, and Alternative 4 would outperform the no-action alternative during all key life history periods except breeding. None of the alternatives provides high quality stable flows that would maintain Oregon spotted frog habitat.

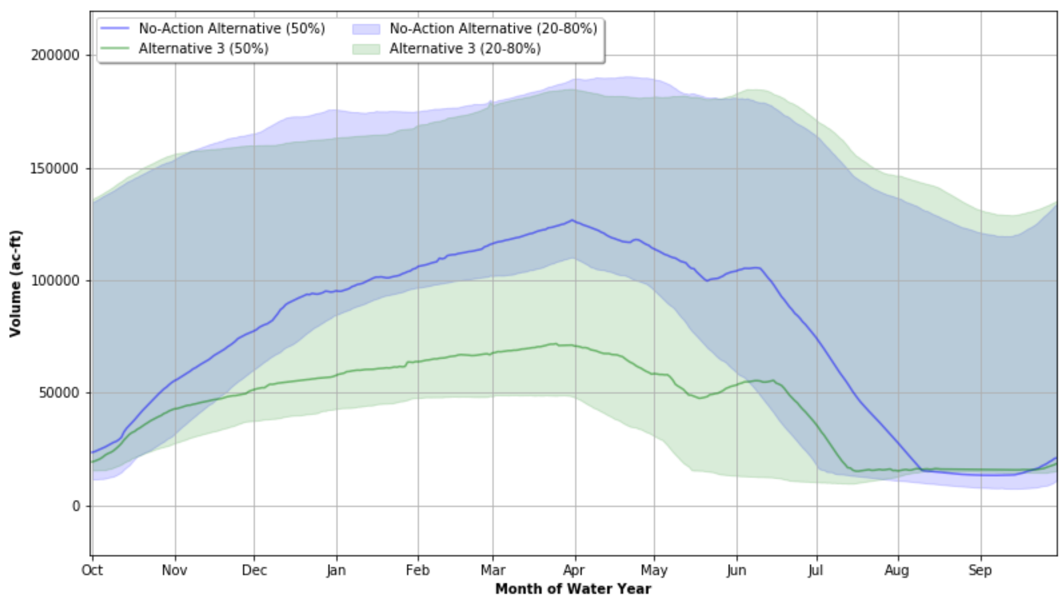
Reach Des-13 Wickiup Reservoir

Oregon spotted frogs are known to occupy and breed in Wickiup Reservoir, although their distribution and use of the reservoir appears to be limited compared to that of Crane Prairie Reservoir (U.S. Fish and Wildlife Service 2017, 2019).

Figure 4 depicts daily water volume hydrographs generated for Wickiup Reservoir (WIC) using RiverWare for the no-action alternative, the proposed action, Alternative 3, and Alternative 4. The hydrographs in Figure 4 represent a visual comparison of the storage volumes expected under the different alternatives at their full implementation scenarios.

Figure 4. Water Volume (acre-feet) in Wickiup Reservoir Modeled using RiverWare for the No-Action Alternative Compared to the Proposed Action (top), Alternative 3 (middle), and Alternative 4 400 (bottom) at their Full Implementation





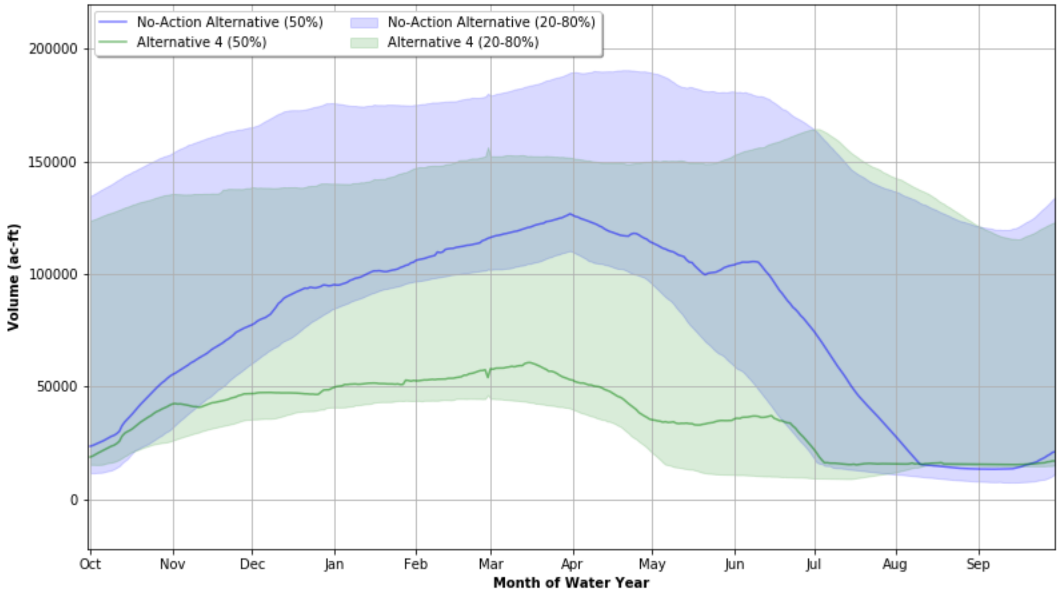


Table 6 and Table 7 provide comparisons among the alternatives (at full implementation) of storage volume (af) and water elevation (feet) available in Wickiup Reservoir during each of the key Oregon spotted frog life history periods. Data were calculated from the 20% (low flow years), 50% (median flow years), and 80% (high flow years) daily values for the 29-year model period, averaged over the key life history period days of the water year.

Table 6. Wickiup Reservoir Water Storage Volumes under Each Alternative during Key Oregon Spotted Frog Seasons

	Dry Years			Median Years			Wet Years		
Wickiup Reservoir	No-Action (ac-ft)	Proposed Action/ Alternative 3 % of No-Action	Alternative 4 % of No-Action	No-Action (ac-ft)	Proposed Action/ Alternative 3 % of No-Action	Alternative 4 % of No-Action	No-Action (ac-ft)	Proposed Action/ Alternative 3 % of No-Action	Alternative 4 % of No-Action
Breeding	10,4662	41%	34%	121,115	56%	41%	188,522	97%	80%
Rearing	48,363	39%	33%	77,036	53%	38%	164,716	102%	90%
Pre-winter	9854	157%	155%	19,487	97%	94%	128,703	104%	94%
Overwintering	73,812	54%	51%	88,856	63%	55%	169,516	97%	84%

Table 7. Wickiup Reservoir Water Elevations under Each Alternative during Key Oregon Spotted Frog Seasons (feet)

	Dry Years			Median Years			Wet Years		
Wickiup Reservoir	No-Action	Proposed Action/ Alternative 3 difference from No-Action	Alternative 4 difference from No-Action	No-Action	Proposed Action/ Alternative 3 difference from No-Action	Alternative 4 difference from No-Action	No-Action	Proposed Action/ Alternative 3 difference from No-Action	Alternative 4 difference from No-Action
Breeding	4,326.47	19.34	22.72	4,329.04	11.82	18.65	4,336.60	0.54	3.88
Rearing	4,305.16	12.42	14.44	4,316.23	11.50	16.87	4,334.10	-0.44	1.59
Pre-winter	4,285.81	-5.19	-5.10	4,293.71	0.29	0.68	4,330.04	-0.72	1.04
Overwintering	4,314.91	9.09	10.31	4,320.11	7.40	10.34	4,334.43	0.23	2.75

Breeding Sites

Under all alternatives, Wickiup Reservoir would essentially be used as a flow regulator to support Oregon spotted frog habitat in the Upper Deschutes downstream from the dam to varying degrees. This operational objective would be detrimental to Oregon spotted frogs using Wickiup during breeding or other life history periods.

Effects

- During a normal (median) year, the no-action alternative would maintain a higher volume of water than the proposed action, Alternative 3, and Alternative 4 during all key life history periods.
- During a dry year, the no-action alternative provides more water during breeding, rearing, and overwintering, but less during pre-winter than the proposed action, Alternative 3, or Alternative 4 (which are roughly equivalent to each other).
- During a wet year, the no-action alternative provides approximately the same volume of water as the proposed action and Alternative 3, but more than Alternative 4 during all seasons.
- During a normal (median) year, the no-action alternative provides a higher water elevation during all seasons compared to the proposed action, but especially breeding, rearing, and to a lesser degree overwintering.
- During a dry year, these differences are amplified such that the no-action alternative provides a higher water elevation in breeding, rearing, and overwintering, but less during pre-winter.
- During a wet year, the no-action alternative provides slightly less water during rearing and pre-winter, and slightly more during breeding and overwintering than the proposed action.
- Differences are amplified for Alternative 4 compared to no-action alternative for normal (median) and dry years; no-action alternative provides more water for all periods during a wet year.
- From the hydrographs (Figure 4), there is much greater variability of volume and water elevation when Wickiup is operated under any of the alternatives compared to the no-action. This means that wetland vegetation will experience larger year-to-year fluctuations in water availability. Less stability for the wetland plants will result in lower habitat suitability for the Oregon spotted frogs.

Summary Conclusion

Table 8 summarizes the overall results of this comparison of each alternative to the no-action. These conditions mean the Oregon spotted frog habitats associated with Wickiup Reservoir would experience adverse habitat conditions under the proposed action and Alternative 3 compared to the no-action alternative, and these conditions would be further exacerbated under Alternative 4.

Reaches Des-12a, Des-12, and Des-11

Reaches Des-12a, Des-12, and Des-11 are the uppermost reaches of the Deschutes River downstream from Wickiup Dam to Benham Falls. The flow in these reaches of the river is most closely associated with measurements collected at the WICO gauge, located just downstream from the Wickiup Reservoir. In the Deschutes Project Biological Opinion (U.S. Fish and Wildlife Service 2017), these three reaches are called Reach 1, Reach 2, and Reach 3; they are the same but referred to by reach name in the HCP.

Reach-Level Analysis

Based on observations made by the FWS and presented in the Deschutes Project Biological Opinion (U.S. Fish and Wildlife Service 2017, 2019), flows measured at the WICO gauge that generally improve conditions for Oregon spotted frog use of the available habitat within these three reaches include:

- At 900 cfs, water inundates emergent vegetation at the associated sites which improves suitability of sites for breeding and rearing.
    - During breeding, stability of flow is important as egg masses develop which are vulnerable to displacement during high flows, or desiccation if stranded by low flows.
    - During rearing, tadpoles and metamorphs are mobile, but need cover offered by vegetation, so flows that maintain vegetation inundation (e.g., at least 900 cfs) remain important, although individuals can tolerate higher water levels and more water level fluctuation.
    - Sunriver: at this breeding site, water flows into site through weirs once the WICO gauge flow reaches 1,580 cfs.

Additional flow thresholds and concepts based on the observations described in the Deschutes Project Biological Opinion (U.S. Fish and Wildlife Service 2017, 2019) analyzed here include:

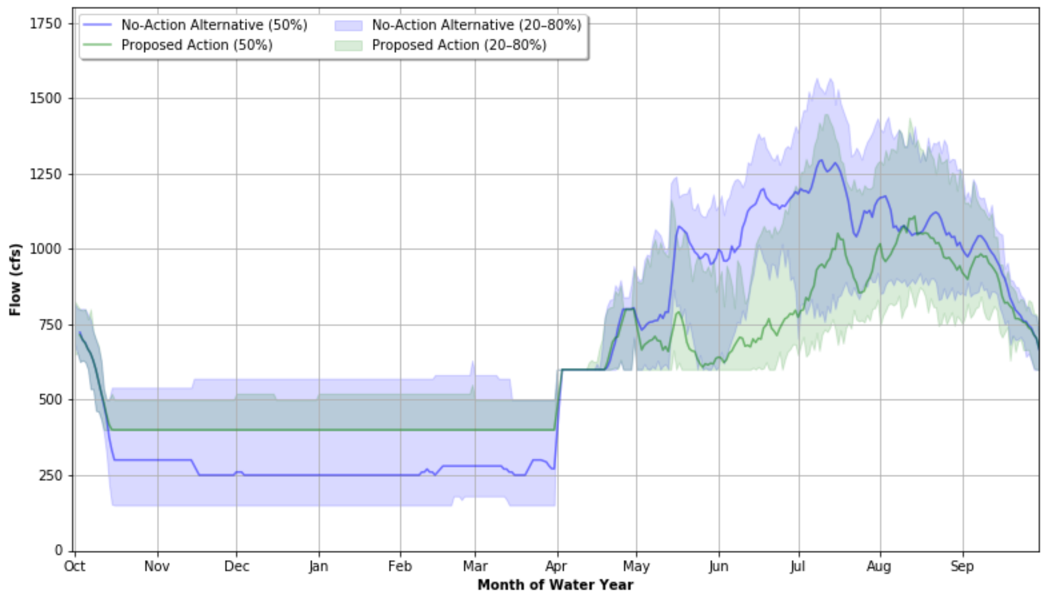
- Below 700 cfs, water flows towards the river channel and away from the wetlands. This threshold indicates the flow that would improve emergent vegetation conditions if it colonizes downslope in response to changes in inundation patterns.
- During the pre-winter as juveniles and adults move to overwintering locations with flowing water and refugia (e.g., mud banks, vegetation mats), flows in the river decrease as the irrigation season ends and storage begins. Inundation of emergent vegetation at or above 900 cfs remains important, but the magnitude of the decrease in flow and corresponding drop of water level in the river is also important during this period.
- Although frogs do move periodically during overwintering, flow stability protects individuals from exposure and freezing. Flows of at least 300 cfs increase the quality of overwintering habitat within the river channel. Higher flows (e.g., 500 cfs) inundate portions of some sites (e.g., Dead Slough), and provide a shorter distance from overwintering sites along the river's edge and the breeding locations within wetlands.

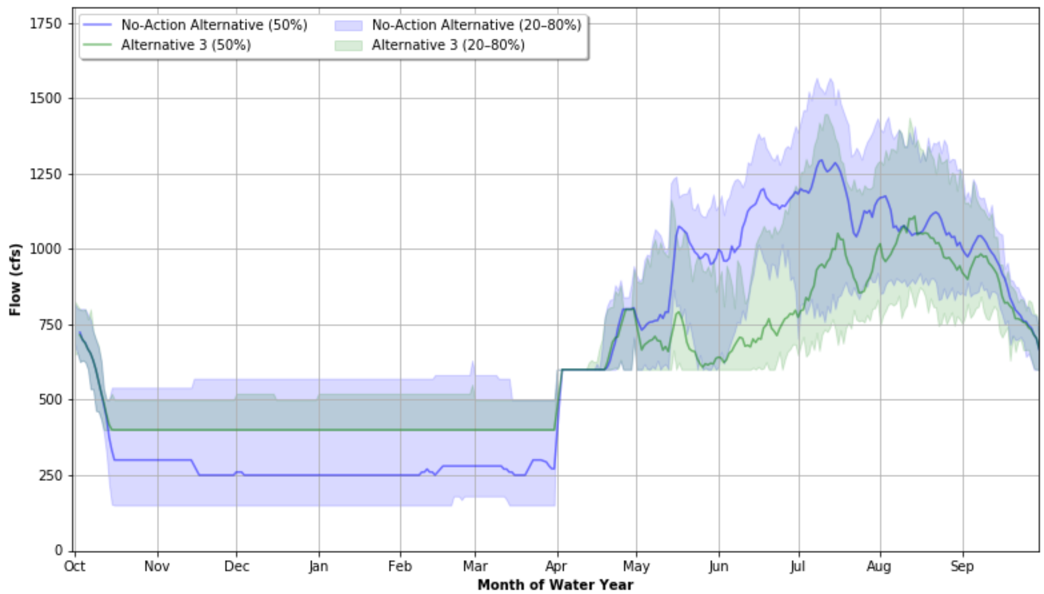
RiverWare Results

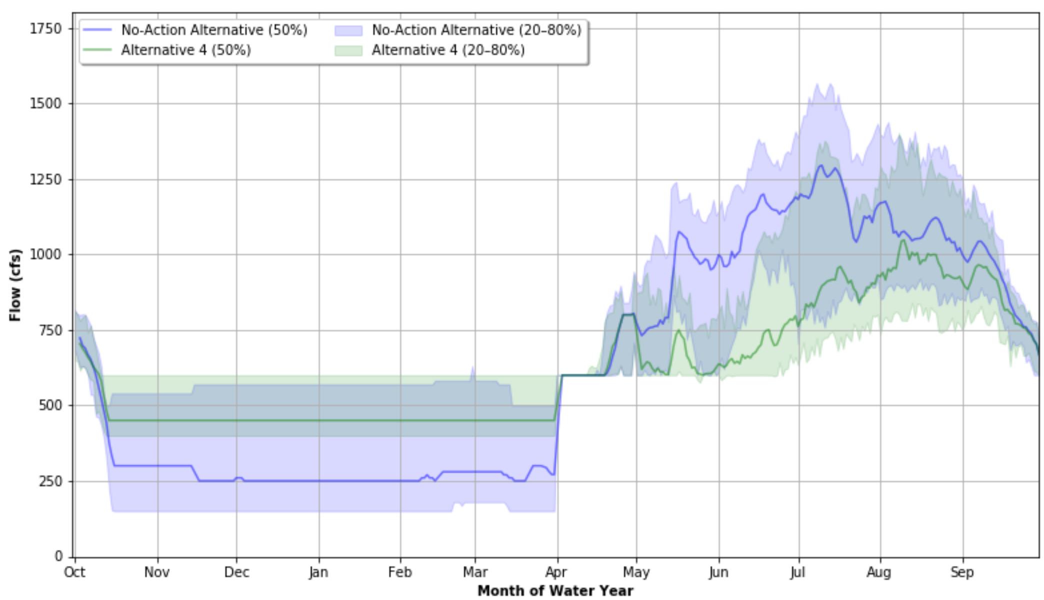
Hydrographs

Figure 5 depicts daily Deschutes River flow hydrographs generated for the WICO gauge location using RiverWare for the no-action alternative, the proposed action, Alternative 3, and Alternative 4. The hydrographs in Figure 5 represent a visual comparison of the river flows expected under the different alternatives at their full implementation stage, meaning where minimum flow in the Deschutes River during winter, the storage season, is at its highest level for each alternative.

Figure 5. Deschutes River Flow Modeled Using RiverWare at the WICO Gauge for the No-Action Alternative Compared to the Proposed Action (top), Alternative 3 (middle), and Alternative 4 (bottom) at their Full Implementation







For each alternative, the graphs present the median modeled flow (50%; solid line) and a band capturing the 20% through 80% modeled flows, meaning the flows expected to occur 20% to 80% of the time.

Day-Count Data

To further relate the modeled river flow data for each alternative to the key life history periods for Oregon spotted frogs, the boxplots below (Figure 6 through Figure 12) depict the number of days during each key life history period where the flow at the WICO gauge would be expected to exceed the flow thresholds described earlier in this appendix. In each boxplot, “x” indicates the mean number of days exceeding the threshold counted for that alternative. The box encloses the upper (top of box) and lower (bottom of box) quartiles and the median is indicated by a horizontal line within the box. Whiskers represent the lowest data point within 1.5 interquartile range (IQR) of the lower quartile, and the highest data point within 1.5 IQR of the upper range. Outliers are depicted as dots.

Breeding (March 15–April 30; 47 days)

The reach-level flow thresholds for the WICO gauge are 900 cfs and 700 cfs.

Figure 6. Boxplot of WICO Day Count for 900 cfs during Breeding

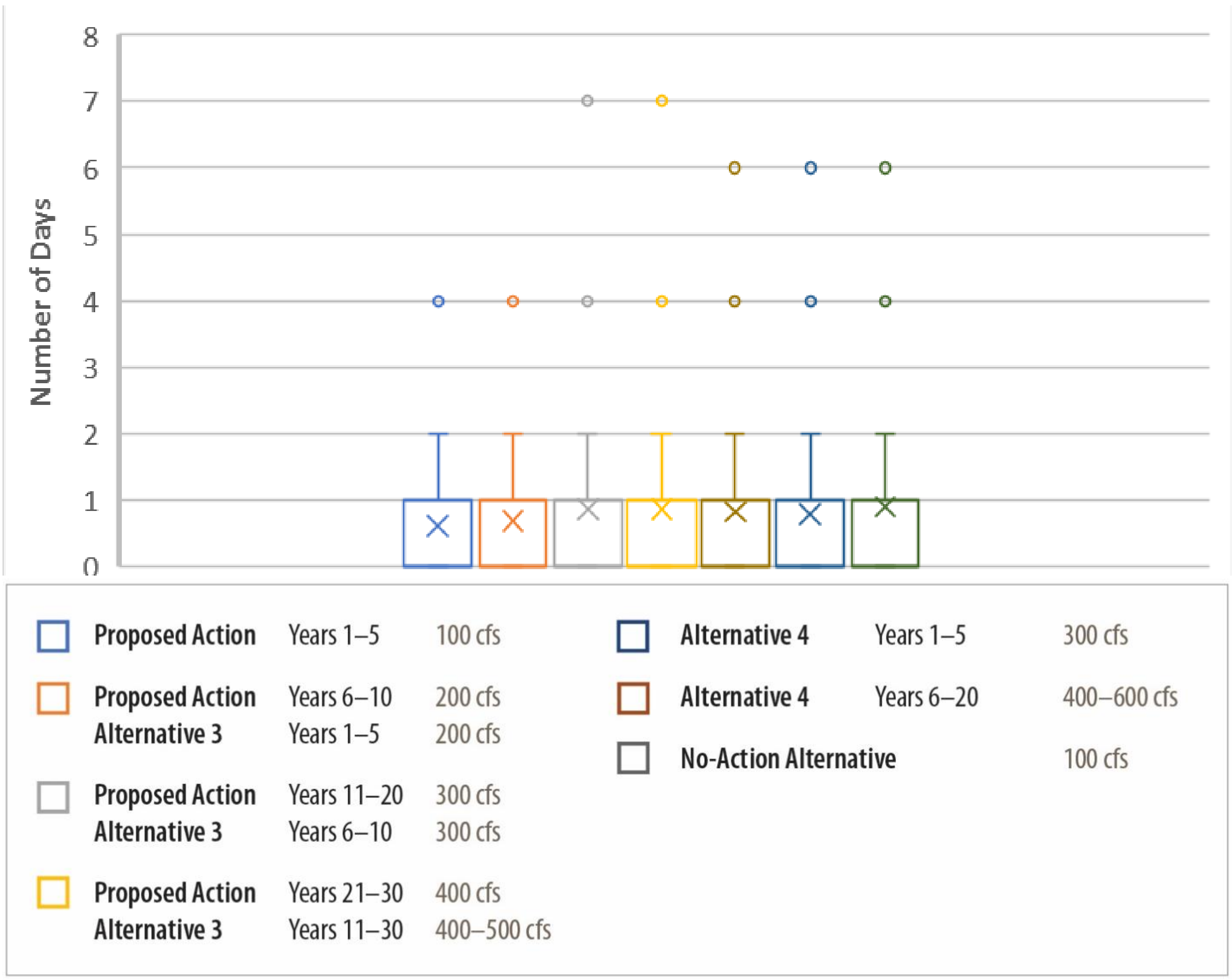
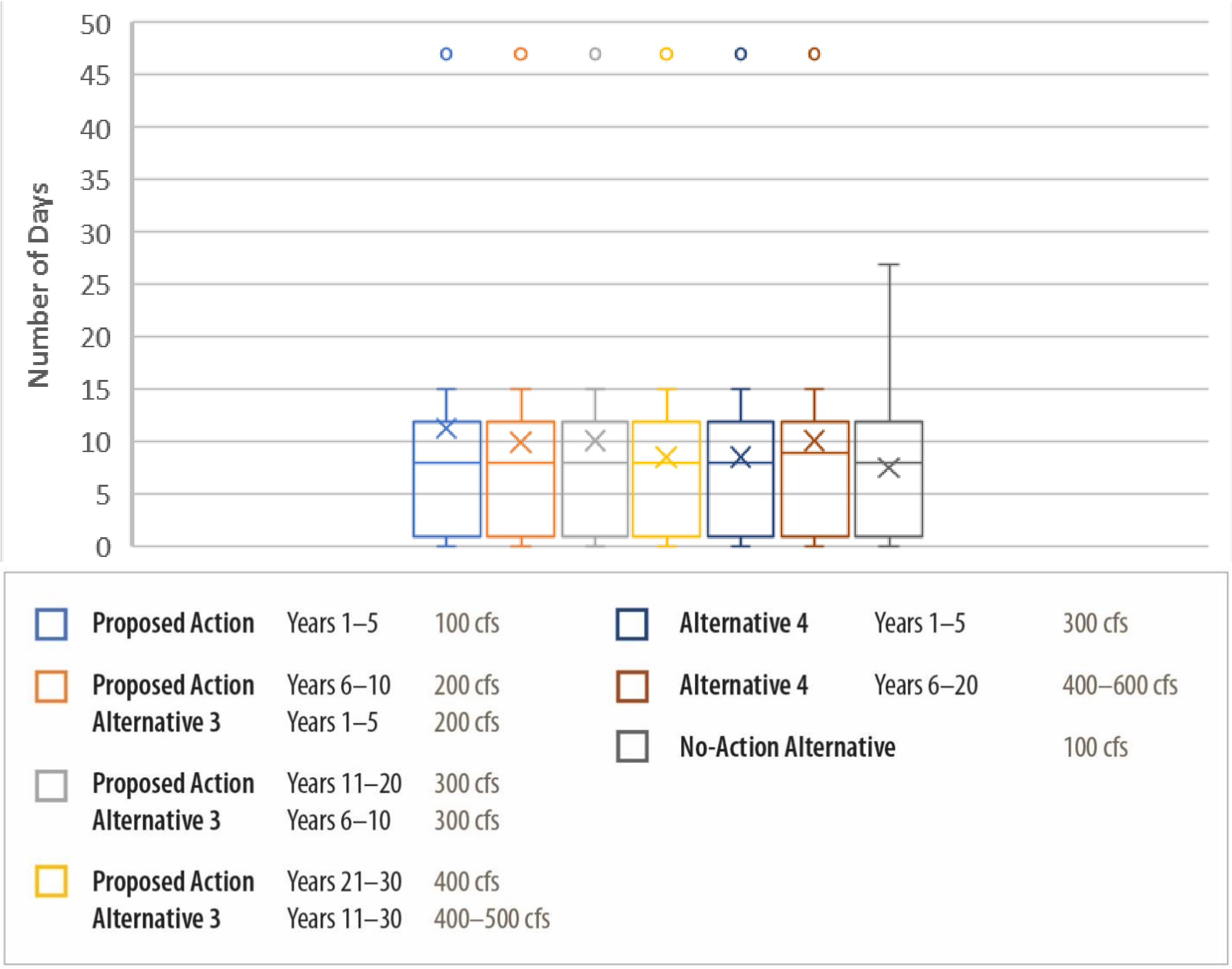


Figure 7. Boxplot of WICO Day Count for 700 cfs during Breeding



Rearing (April 1 – August 31; 153 days)

The reach-level flow thresholds for the WICO gauge are 900 cfs and 700 cfs.

Figure 8. Boxplot of WICO Day Count for 900 cfs during Rearing

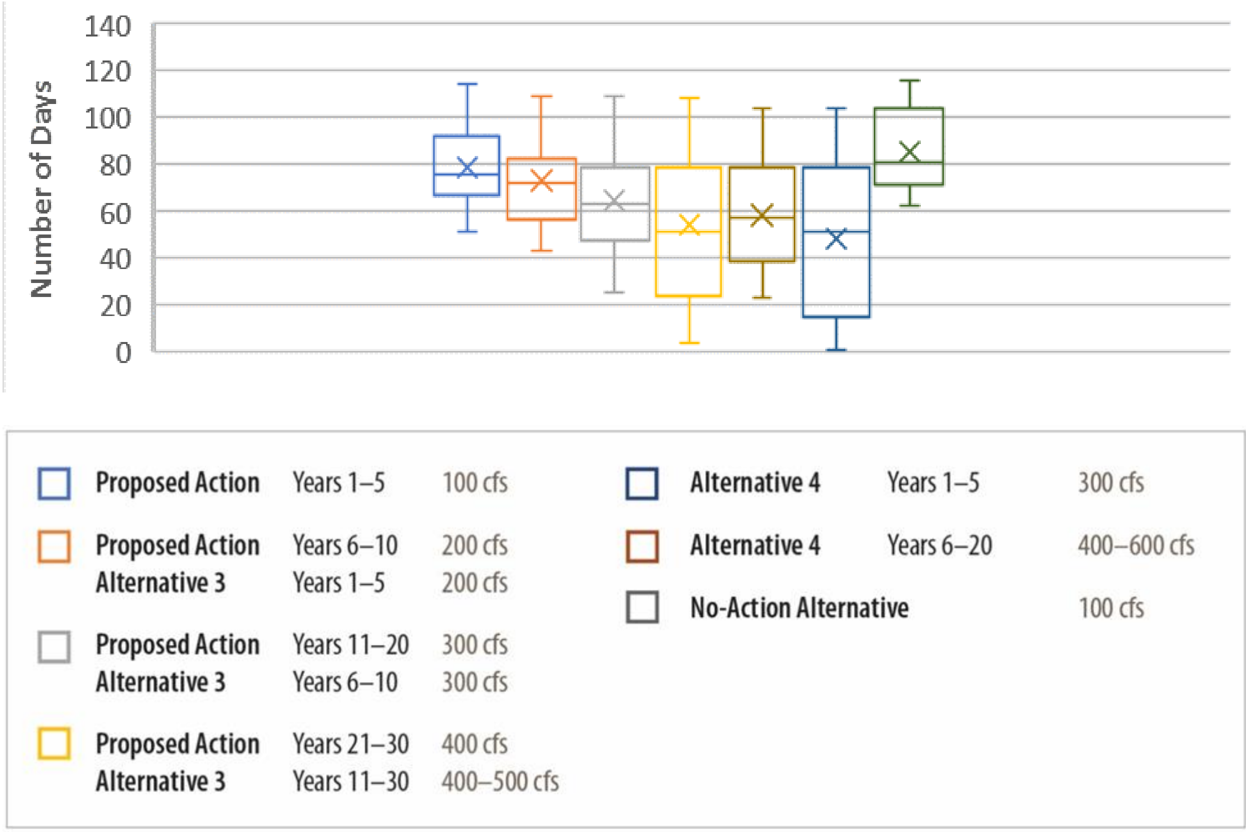
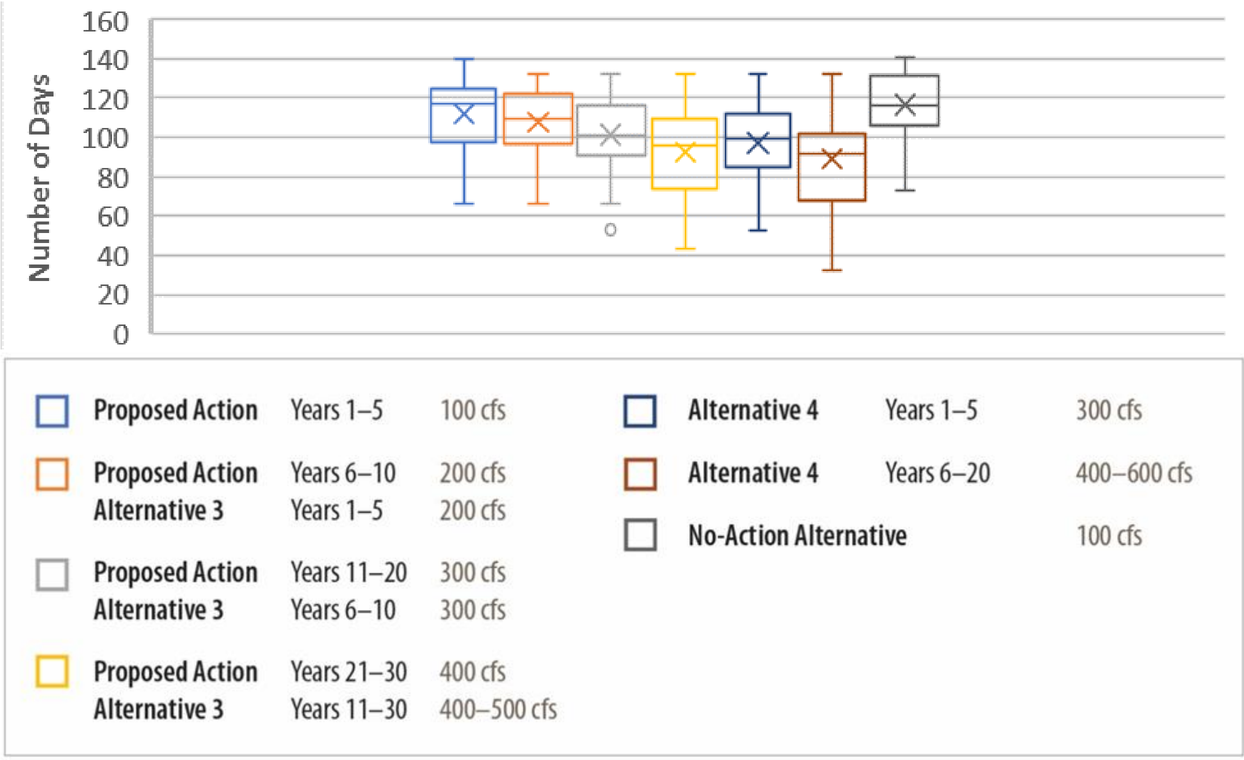


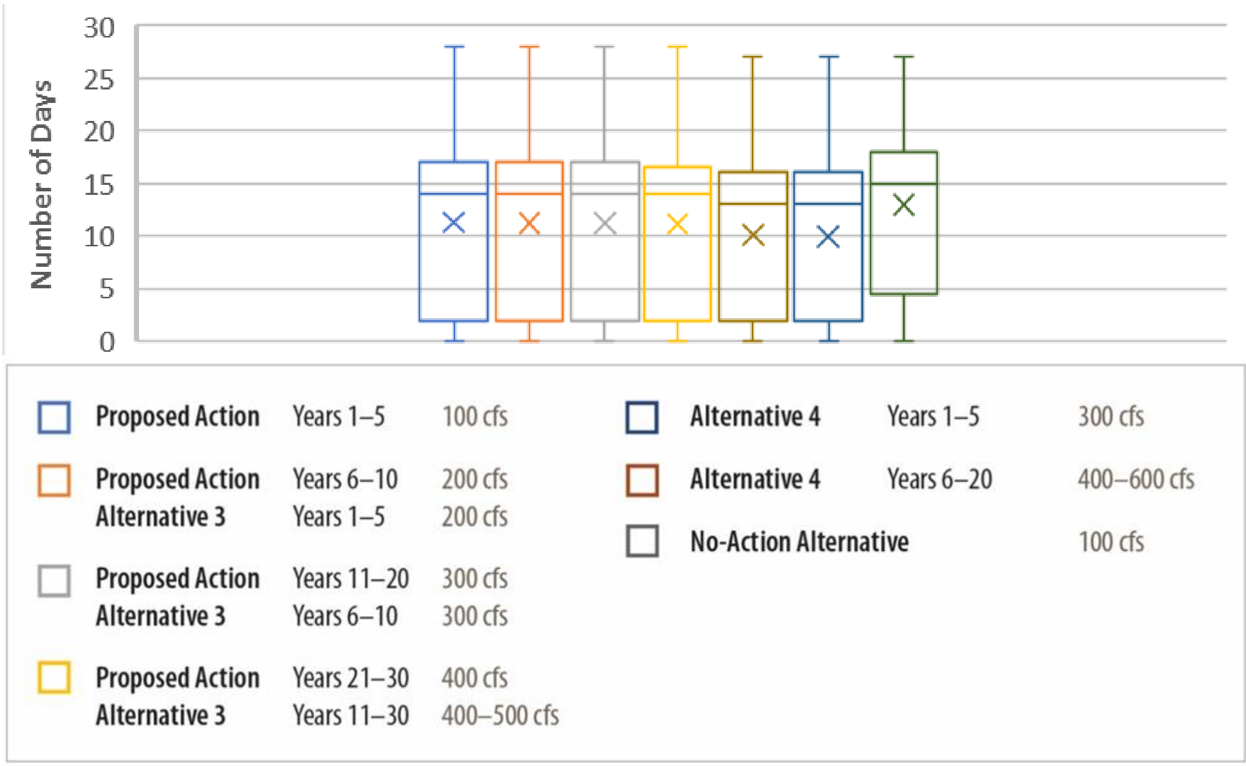
Figure 9. Boxplot of WICO Day Count for 700 cfs during Rearing



Pre-Winter (September 1–October 15; 45 days)

The reach-level flow threshold for the WICO gauge is 900 cfs.

Figure 10. Boxplot of WICO Day Count for 900 cfs during Pre-Winter



Overwintering (October 16–March 14; ~150 days)

The reach-level flow thresholds for the WICO gauge are 300 cfs and 500 cfs.

Figure 11. Boxplot of WICO Day Count for 300 cfs during Overwintering

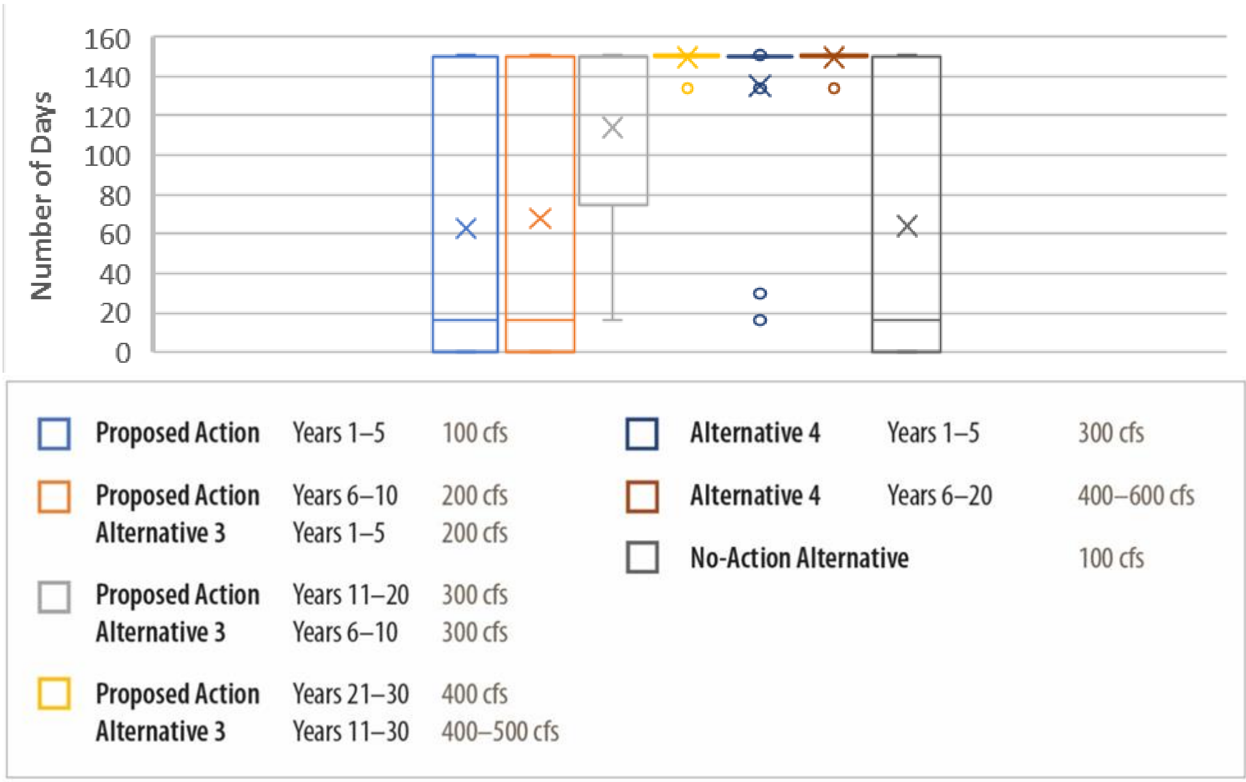
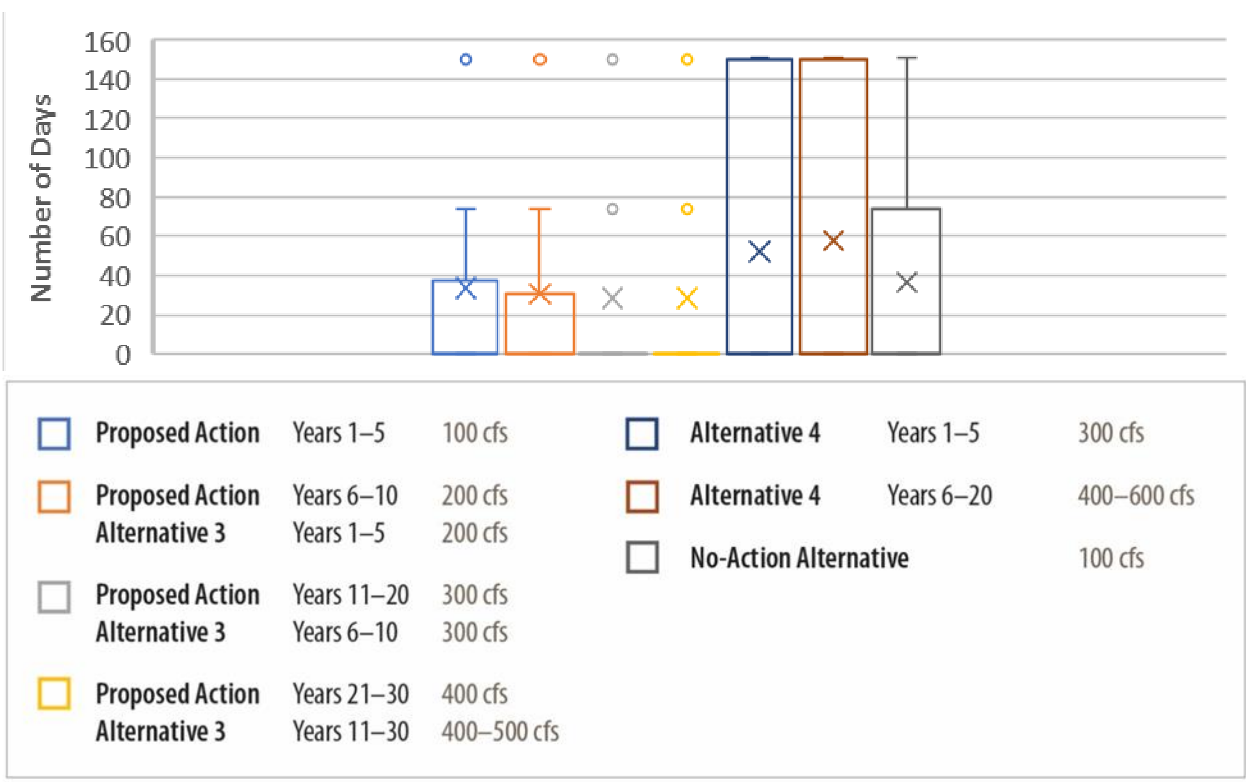


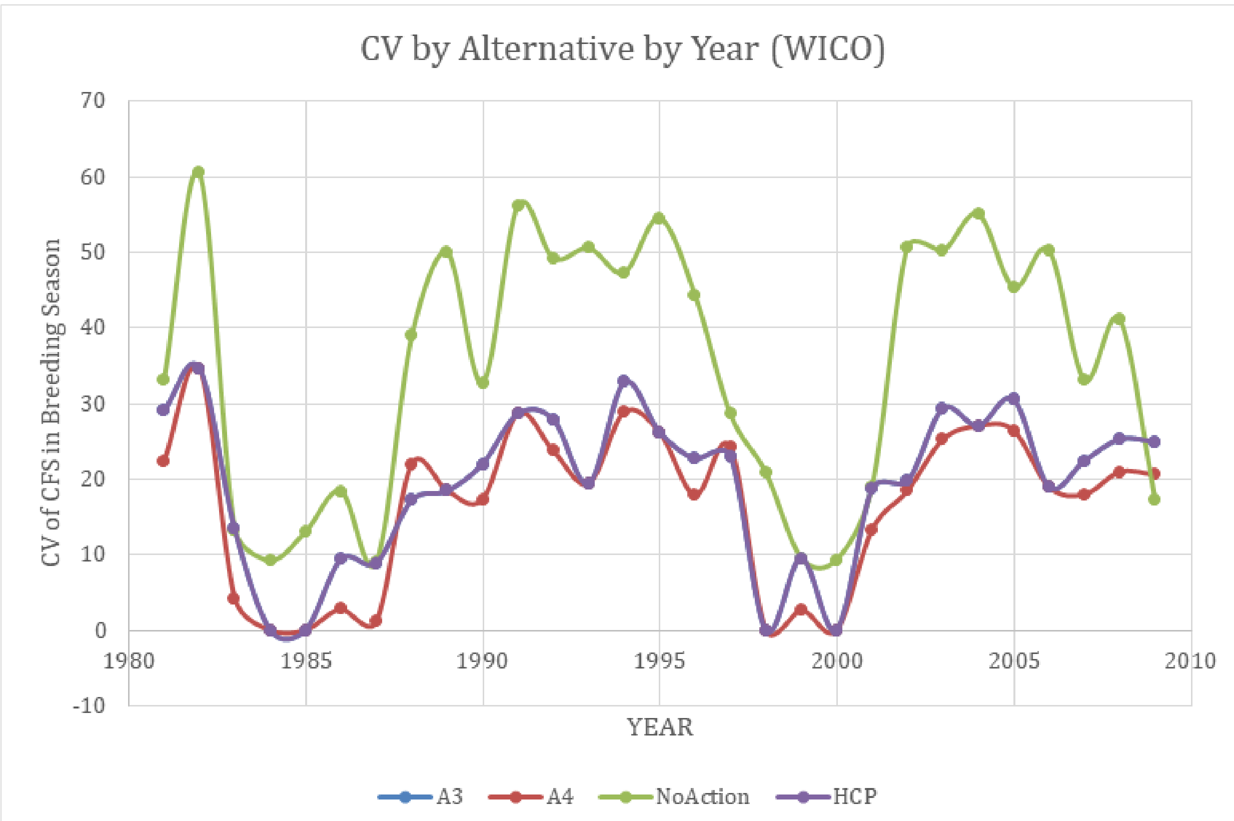
Figure 12. Boxplot of WICO Day Count for 500 cfs during Overwintering



Within-Year Flow Variation

To better understand within-year variation in flow for each alternative, Figure 13 reports the coefficient of variation (CV) during the breeding season. The CV is the standard deviation divided by the average flow and allows us to compare within-year variability among the alternatives. Within-year flow variation is particularly important during the breeding season because the immobile egg masses are the most vulnerable life stage to either desiccation from receding water or displacement and subsequent exposure to deeper water predators.

Figure 13. The CV of within-Year Deschutes River Flow Modeled using RiverWare at the WICO Gauge for Each Alternative during the Breeding Season (Proposed Action [HCP] and Alternative 3 [A3] overlap).



Effects

Emergent Vegetation

Emergent vegetation would be expected to respond to changes in flow regime by tracking the seasonal inundation patterns and colonizing areas that were historically unavailable during the growing season due to the high summer flows along the Upper Deschutes.

All alternatives differ from the historical flow regime in the Upper Deschutes by prescribing greater minimum flows during the winter and resulting in lower maximum flows during the summer than were observed on average prior to operations prescribed under the Deschutes Project Biological Opinion (U.S. Fish and Wildlife Service 2017, 2019). Historical flow data for WICO (OWRD 2019) collected from 1972 through 2002 (pre-implementation of the no-action alternative) indicate a median flow of 1,455 cfs on June 20, the beginning of the growing season.

The RiverWare model outputs indicate:

- Among the alternatives, inundation patterns during the growing season would be based on the highest flows under the no-action alternative, lower flows under the proposed action and Alternative 3, and lowest under Alternative 4 (Figure 5 [hydrographs]). This means that emergent vegetation would be inundated up to the highest topographical or elevation level under the no-action alternative, lower elevation under the proposed action and Alternative 3, and lowest elevation under Alternative 4.

Invasive Species

Reed canarygrass is already well established in the study area. Although its site-specific distribution would be expected to change by tracking water inundation elevation patterns during the growing season, it would be expected to persist throughout the study area under all alternatives. Alternative 3 and Alternative 4 include a conservation measure (Conservation Measure DR-2) that could support control of this invasive species.

The more stable hydrograph under the proposed action, Alternative 3, and Alternative 4, compared to the no-action alternative, would be more likely to improve conditions for bullfrogs by providing year-round inundation of wetlands.[2]. The more stable hydrograph would also be more likely to improve conditions for non-native fish species such as brown bullhead catfish, brown trout and three-spined sticklebacks known to prey on Oregon spotted frogs. The Conservation Measure DR-2 under Alternative 3 and Alternative 4 could be used to fund control measures for bullfrogs which are already widely used successfully in the Deschutes Basin, and they could be used to address non-native fish species.

Oregon Spotted Frog

In off-channel wetlands, emergent vegetation would track the flow inundation patterns to colonize areas that would become available during the growing season at the lower elevations. The total area covered by emergent vegetation would not necessarily change, but the topographical elevation where wetland vegetation is supported by water would be lower as flows are reduced during the growing season. This effect would be strongest under full implementation of the Alternative 4, somewhat reduced under the proposed action and Alternative 3, and least under the no-action alternative. Along the river channel, vegetation would be expected to colonize areas lower in the channel profile, with the same rank differences between alternatives. Individual Oregon spotted frog sites would respond differently depending on individual site topography, substrate characteristics, and dependence on the river as a water source.

Breeding

- During the breeding season, inundation levels would rarely reach the vegetation inundation threshold observed by the FWS (>900 cfs) under any of the alternatives (Figure 6).

[2] Bullfrogs require permanent wetland habitat to reproduce as tadpoles typically overwinter and metamorphose during their second year.

- Days with flows exceeding the 700 cfs threshold result in water flowing towards off-channel sites rather than towards the river. Such days are most common under Alternative 4, slightly less common under the proposed action and Alternative 3, and least common under the no-action alternative (Figure 7).
- Alternative 4 would marginally provide the best habitat conditions; more days of inundated emergent vegetation during the breeding season, compared to the other alternatives. Alternative 3 and the proposed action would equally provide marginally better habitat conditions for Oregon spotted frogs when compared to the no-action alternative during the breeding season. This conclusion would only hold true for sites where the topographic profile would allow inundation of emergent vegetation at less than the 900 cfs threshold, where there is area available to be colonized by emergent vegetation during the growing season at lower flows. Refer to the site-specific section for a discussion of inundation flows at specific sites.
- The modeled hydrograph for flow at the WICO gauge (Figure 5) indicates that at full implementation Alternative 4 would result in the smallest increase in flow around April 1 as flows switch from the storage to irrigation season. Smaller changes in flow and associated water levels improve conditions for Oregon spotted frogs because there is less chance of displacing egg masses. The proposed action and Alternative 3 would experience a slightly larger increase in flow around April 1 while the no-action alternative would experience the largest change in flow and associated risk of egg mass displacement and mortality.
- Within-year variation is much larger under the no-action alternative compared to all other alternatives (Figure 13). This means eggs would be more exposed to variable flows, and the potential for egg mass mortality under the no-action alternative compared to the proposed action, Alternative 3, and Alternative 4.
- Alternatives 3 and 4 include Conservation Measure DR-2 that is lacking from the proposed action and the no-action alternative. This measure could be used to restore breeding habitat connectivity or hydrology at some sites which could improve breeding habitat conditions.

Rearing

During rearing, the no-action alternative would experience approximately 80 days above 900 cfs flow at the WICO gauge, compared with approximately 50 days under the fully implemented proposed action, Alternative 3 and Alternative 4 (Figure 8). Flows above this level inundate wetland vegetation providing cover for developing tadpoles and frogs. This pattern remains the same among the alternatives for 700 cfs (Figure 9).

- The no-action alternative demonstrates less year-to-year variability, and thus more stability, in day count than the other alternatives.
- The modeled hydrograph (Figure 5) corroborates the day count data. It indicates a higher level of flow and subsequent vegetation inundation is maintained throughout most of the rearing season under the no-action alternative, although all alternatives converge during August.

Pre-Winter

- The no-action alternative provides slightly more days of wetland vegetation inundation above 900 cfs (median of 15) compared to the fully implemented proposed action and Alternative 3 (median of 14), and still more than Alternative 4 (median of 13) (Figure 10).

- The hydrograph (Figure 5) demonstrates an important difference among the alternatives during this period. The pre-winter season is concurrent with the operational shift from irrigation (high flows) to storage (lower flows) so flows decrease precipitously until they reach the winter minimum. Under the no-action alternative, frogs would experience a greater amount of change in flow during the pre-winter season than they would under other alternatives; approximately 1,000 cfs to approximately 300 cfs. Fully implemented Alternative 4 has the least amount of change as flows shift from approximately 1,000 cfs to just below 500 cfs. The less drastic change in water inundation elevation means that overwintering frogs in the river would be closer to breeding locations (adjacent wetlands). Oregon spotted frogs are known to generally move short distances during the pre-winter season (Pearl et al. 2018) so the less drastic change in water inundation elevation may mean fewer frogs would select poor overwintering sites that end up disconnected or above the waterline. Alternative 4 would have the most positive impact on Oregon spotted frogs during this period.

Overwintering

- Sustained higher winter flows under the proposed action, Alternative 3, and Alternative 4 improve conditions for overwintering Oregon spotted frogs by inundating larger areas of wetland habitat and maintaining a shorter travel distance between overwintering locations in the river and breeding sites in the adjacent wetlands.
- The fully implemented proposed action, Alternative 3, and Alternative 4 equally outperform the no-action alternative by maintaining more than 300 cfs in the river and associated overwintering sites for the duration of the season. The delayed timeframe of the proposed action compared to Alternative 3 means that Alternative 3 would more quickly have a positive effect on Oregon spotted frogs (Figure 11). Under Alternative 4, more sites would experience at least 500 cfs than under any of the other alternatives which could result in more consistently wetted overwintering sites and shorter distances for frogs to travel between breeding and overwintering locations (Figure 12).
- From the hydrograph (Figure 5), the fully implemented Alternative 4 would maintain more water in the system over winter than any of the other alternatives, but its overwinter flow would vary more from year to year than either the fully implemented proposed action or Alternative 3. This type of variation should not have as much effect on individual frogs, but it could affect the overall suitability and availability of overwintering sites.

Site-Specific Analysis

Within the three reaches associated with WICO, occupied site connectivity with the river and its associated flows are varied. Some sites are closely connected to the river (e.g., Bull Bend) whereas others function relatively independently from the fluctuations in the river flows (e.g., Sunriver). In addition, groundwater inputs, and site-specific characteristics such as site topography, elevation, and substrate are known to affect the extent and timing of site-specific responses to changes in river flow (U.S. Fish and Wildlife Service 2017, 2019). In general, varied connectivity and sensitivity to changes in river flow mean that the more stable hydrograph expected under the proposed action, Alternative 3, and Alternative 4 compared to the no-action alternative would impact individual sites to varying degrees, but the reach-level conclusions would apply to these sites.

Bull Bend

Bull Bend is located in reach Des-12a. Pre-metamorphic Oregon spotted frogs have been detected at this site, but it is not a key breeding location. This site is directly connected to the Deschutes River and it is highly influenced by the operational flow management of Wickiup and Crane Prairie.

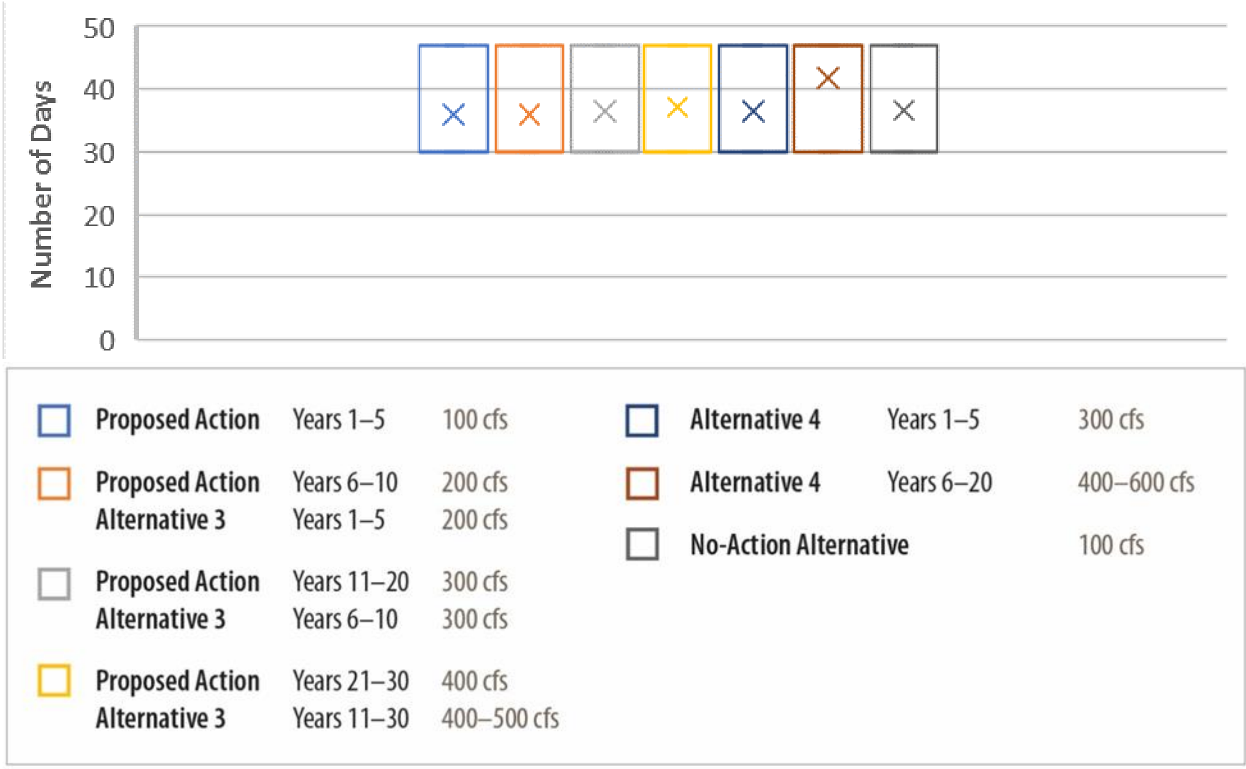
From the draw down photo series included in the Deschutes Project Biological Opinion (U.S. Fish and Wildlife Service 2017:Appendix, 2019), at approximately 300 cfs at the WICO gauge, water at the Bull Bend site only remains in the river channel. This means the minimum threshold for inundation of emergent vegetation at this site would be above 300 cfs if the vegetation were to migrate its coverage down-elevation from its current interface towards the river. One study (RDG 2017) indicated that Bull Bend requires at least 800 cfs of flow measured at the WICO gauge to experience inundation of its existing wetland vegetation. At lower flows, at least until wetland vegetation migrates downslope, frogs would have to migrate across exposed barren substrate to reach wetland vegetation, and there would be a high risk of dewatering at any overwintering refugia in the wetland areas.

Breeding

During most of the breeding season inundation levels would be similar under all alternatives, except the fully implemented proposed action, Alternative 3, and Alternative 4 would result in more days of wetland vegetation inundation early in the period.

From the draw down photo series (U.S. Fish and Wildlife Service 2017: Appendix, 2019), at least a portion of the site appears to be inundated when the river flow exceeds 300 cfs. The inundation day count results indicate this site would experience inundation above 400 cfs similarly under all alternatives. The fully implemented Alternative 4 would slightly outperform the other alternatives as its median number of days exceeding 400 cfs would be 47 versus 30 for the other alternatives (Figure 14).

Figure 14. Boxplot of WICO Day Count for 400 cfs during Breeding



Rearing and Pre-Winter

Because of its close relationship with the Deschutes River, this site is expected to perform consistently with the results reported in the reach-level analysis (*Reaches Des-12a, Des-12, and Des-11* section).

Overwintering

Bull Bend requires more than 300 cfs for any portion of the site to be inundated outside of the river channel and 400 cfs flow at WICO appears to provide a small amount of off-channel habitat at Bull Bend (from drawdown photos U.S. Fish and Wildlife Service 2017 Appendix, 2019). This could be important because wintering outside of the river channel reduces the risk of predation (U.S. Fish and Wildlife Service 2017, 2019). As at the reach level, the proposed action, Alternative 3, and Alternative 4 would be expected to outperform the no-action alternative, with the fully implemented Alternative 4 consistently providing the highest overwinter flows.

La Pine State Park (Dead Slough)

Dead Slough is a consistently productive breeding site that supports a large number of breeding adult frogs each year. This site is significant because it is the only consistently used breeding site in Reach Des-12a; the reach extends approximately 22 miles in length. Dead Slough experiences a significant spring-water input which buffers the impacts of low river flows particularly in the winter, but the site remains very responsive to changes in flow in the river.

From the ramp down photo series included in the Deschutes Project Biological Opinion (U.S. Fish and Wildlife Service 2017: Appendix, 2019), and other photographs of the site collected by FWS (O'Reilly pers. comm. [b]) (Figure 15 and Figure 16 below) inundation of this site greatly increases as flows rise from 500 cfs to 900 cfs at the WICO gauge.

Figure 15. Photo from 9/21/2016 of Dead Slough Inlet (left) and Outlet (right) taken by the U.S. Fish and Wildlife Service when WICO Gauge Read 933 cfs (OWRD) (Note full connectivity with river)

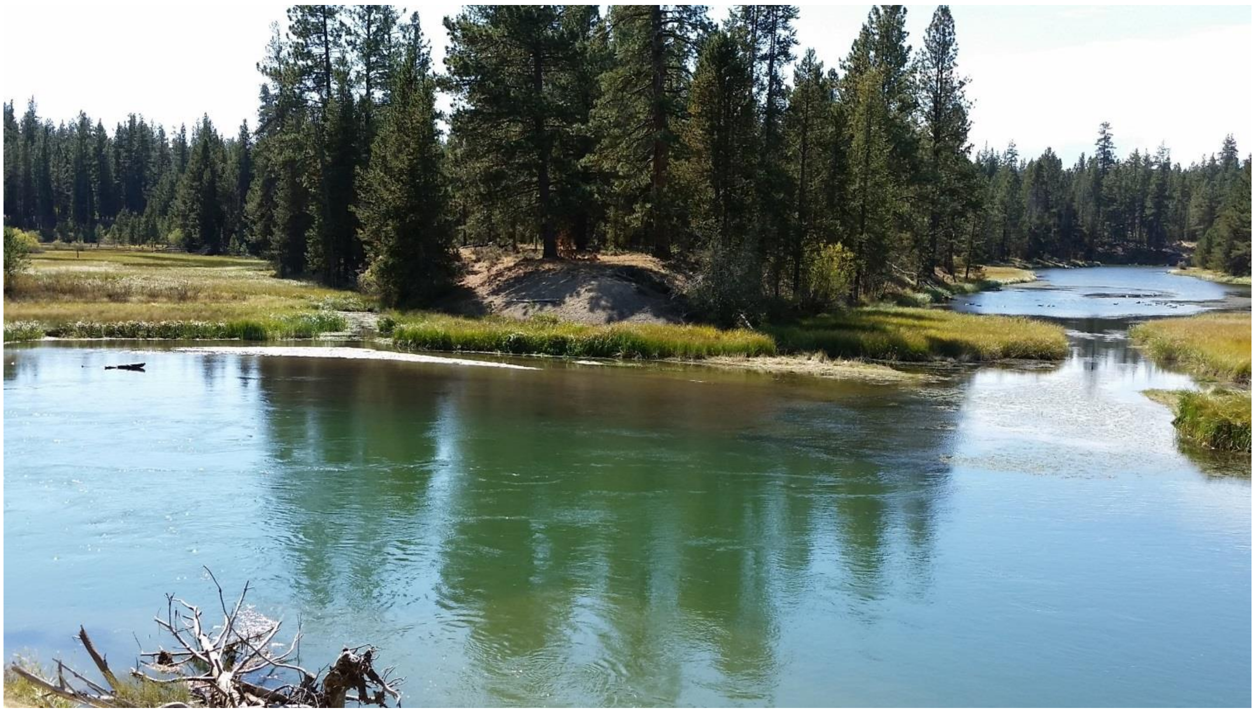


Figure 16. Photo of Dead Slough Looking from within Site towards Outlet on 4/10/2015 (U.S. Fish and Wildlife Service) (River flow at the WICO gauge was 513 cfs [OWRD])

The current extent of vegetation is likely to be contacted by the water at higher flows of greater than approximately 800 cfs at the WICO gauge (U.S. Fish and Wildlife Service 2017:Appendix photos, 2019).

Breeding

During most of the breeding season inundation levels would be similar under all alternatives, and water would rarely inundate vegetation at this site using the 900 cfs threshold (Figure 6).

If emergent vegetation responds to lower flows during the breeding season and migrates downslope at this site, and assuming water flows towards the site when river flows are above 700 cfs, the day count results indicate that the fully implemented Alternative 4 would only slightly outperform the other alternatives as its median number of days exceeding 700 cfs would be 9 versus 8 for the other alternatives (Figure 7).

Rearing and Pre-Winter

Because of its close relationship with the Deschutes River, this site is expected to perform consistently with the results reported in the reach-level analysis (*Reaches Des-12a, Des-12, and Des-11* section).

Overwintering

Dead Slough requires more than 500 cfs flow measured at WICO for the site to be inundated outside of the slough channel (Figure 16). As at the reach level, the fully implemented Alternative 4 would be expected to outperform the no-action alternative (Figure 12). Both the no-action alternative and Alternative 4 would outperform the fully implemented proposed action and Alternative 3 by providing more days of inundation by flows at or above 500 cfs. The higher flows could potentially better protect overwintering frogs.

La Pine State Park (SW Slough)

Southwest (SW) Slough is a confirmed breeding site for Oregon spotted frogs; however, breeding is intermittent, and few eggs masses are typically detected (U.S. Fish and Wildlife Service 2017, 2019). Groundwater discharge is low in this reach (Des-12a) which means this site experiences greater impacts from reservoir flow management than reaches located farther downstream in the system. This site is an oxbow and has direct connectivity with the Deschutes River. It quickly responds to changes in river flow, but it also typically maintains some water in the unvegetated slough channel throughout the winter when flows in the river are at their lowest levels (U.S. Fish and Wildlife Service 2017, 2019).

The draw down photos included in the Deschutes Project Biological Opinion (U.S. Fish and Wildlife Service 2017: Appendix, 2019) indicate water drops below the emergent wetland vegetation below 700 cfs at the WICO gauge, and water is confined to the unvegetated slough channel around 500 cfs. This site would be expected to respond to river flow management similarly to Dead Slough.

Breeding

During most of the breeding season inundation levels would be similar under all alternatives, except the fully implemented proposed action, Alternative 3, and Alternative 4 would result in more days of wetland vegetation inundation early in the period (Figure 7).

The day count results indicate this site would experience flows moving towards the site above 700 cfs similarly under all alternatives (Figure 7). The fully implemented Alternative 4 would slightly outperform the other alternatives as its median number of days exceeding 700 cfs would be 9 versus 8 for the other alternatives.

Rearing and Pre-Winter

Because of its close relationship with the Deschutes River, SW Slough is expected to perform consistently with the results reported in the reach-level analysis (*Reaches Des-12a, Des-12, and Des-11* section).

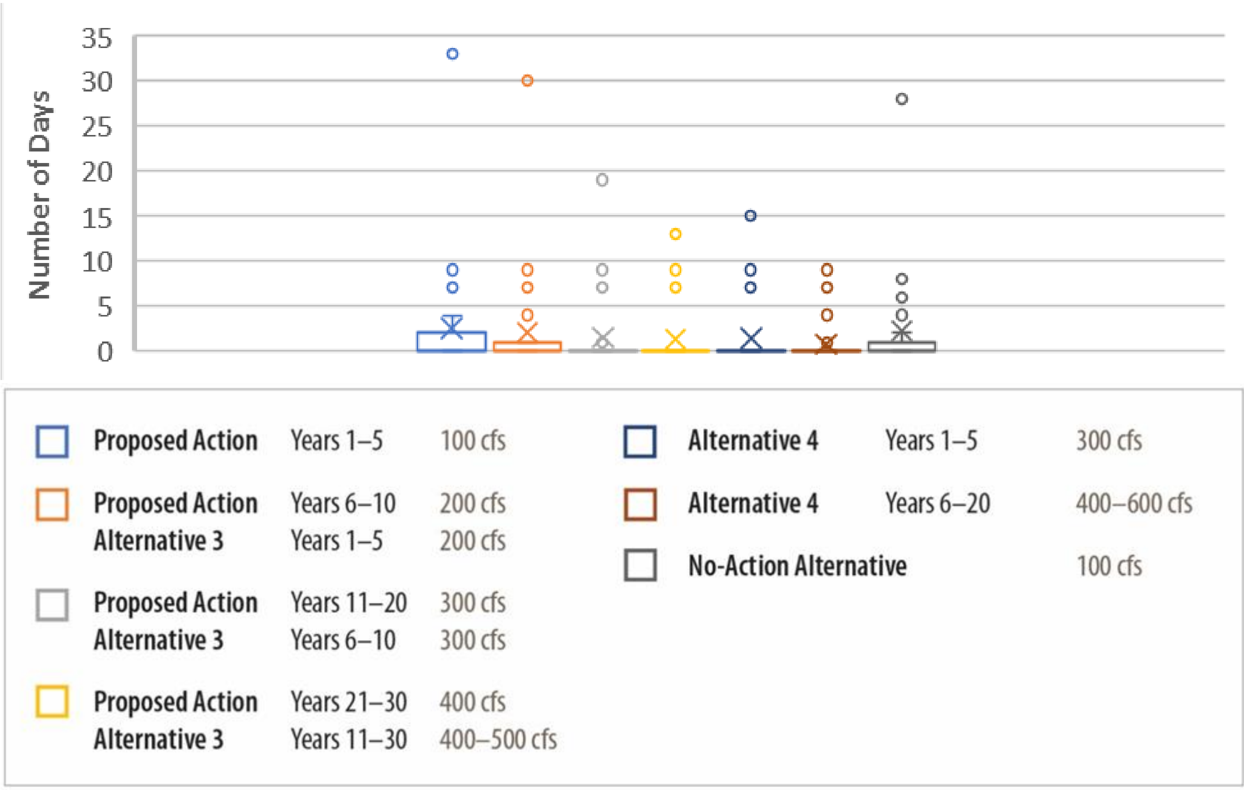
Overwintering

SW Slough requires more than 500 cfs flow measured at WICO for the site to be inundated beyond the slough channel itself, potentially providing more overwintering habitat. As at the reach level, the fully implemented Alternative 4 would be expected to outperform the no-action alternative (Figure 12). Both the no-action alternative and Alternative 4 would outperform the fully implemented proposed action and Alternative 3.

Sunriver

Sunriver is a large breeding complex. The site is connected to the Deschutes River by a weir at the confluence of the Sun River and the Deschutes. Through weir operations, the site functions relatively independently from the Deschutes surface water flow, and water only flows from the Deschutes River into the Sun River when WICO flows exceed 1,580 cfs (O’Reilly pers. comm. [c]). From the hydrographs (Figure 5), and day count data during the rearing period which is the period of highest flows (Figure 17) WICO would only be expected to rarely exceed 1,600 cfs during the breeding or rearing season under the proposed action, Alternative 3, and Alternative 4. Therefore, it is expected that the proposed action and alternatives would have little impact on the Sunriver Oregon spotted frog site complex.

Figure 17. Boxplot of WICO Day Count for 1,600 cfs during Rearing



Summary Conclusion

Table 8 summarizes the overall results of this comparison of each alternative to the no-action. Alternative 4 outperforms the other alternatives for all reaches and sites associated with the WICO gauge during all life history periods except rearing.

Reaches Des-10a and Des-10

Reaches Des-10a and Des-10 are located along the Deschutes River downstream from Benham Falls to Lava Island Falls. The flow in these reaches of the river is most closely associated with measurements collected at the BENO gauge, located at Benham Falls. In the Deschutes Project Biological Opinion (U.S. Fish and Wildlife Service 2017, 2019), these two reaches are called Reach 4 and Reach 5; they are the same but referred to by reach name in the HCP.

There are two known occupied sites within Reach Des-10a: Southwest Slough Camp and the East Slough Camp complex. Both locations consistently support breeding Oregon spotted frogs, and because of this both sites are important to maintaining the species (U.S. Fish and Wildlife Service

2017, 2019). There are no known occupied sites within Reach Des-10 (U.S. Fish and Wildlife Service 2017, 2019).

Reach-Level Analysis

Habitat flow thresholds and other important criteria for Oregon spotted frog sites associated with flows at the BENO gauge include:

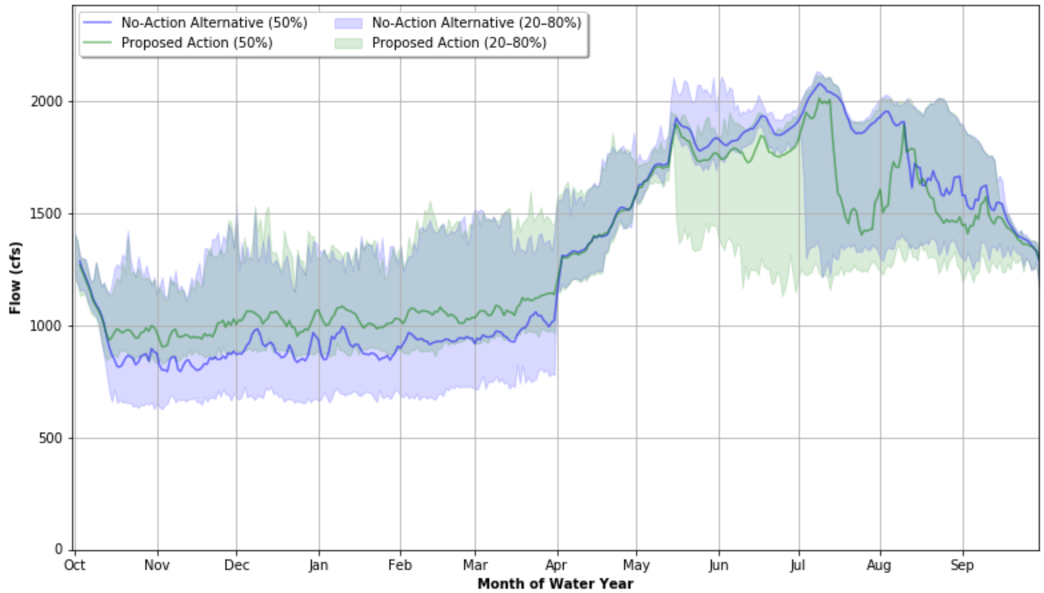
- When BENO measures 1,200 to 1,600 cfs, water inundates emergent vegetation at the associated sites. The site-specific inundating flow varies but the range of 1,200 to 1,600 cfs covers both sites within these reaches (U.S. Fish and Wildlife Service 2017, 2019). When emergent vegetation is inundated it provides suitable habitat for breeding and egg deposition and cover from predation throughout the rearing and pre-winter periods.
    - During breeding, stability of flow is important, as egg masses are vulnerable to displacement during high flows, or desiccation if stranded by low flows.
    - During rearing, tadpoles and metamorphs are mobile, but need vegetation cover, and thus need flows that inundate vegetation (e.g., at least 1,200 to 1,600 cfs depending on site). Adults can tolerate more water level fluctuation.
- During the pre-winter as juveniles and adults move to overwintering locations with flowing water and refugia (e.g., mud banks, vegetation mats), flows in the river decrease as the irrigation season ends and storage begins. Inundation of emergent vegetation at or above 1200 to 1,600 cfs remains important, but the amount of flow reduction and corresponding drop of water level in the river is also important during this period because a larger drop in water level can result in a greater travel distance for frogs to reach overwintering sites.
- Although frogs do move periodically during overwintering, flow stability protects individuals from exposure and freezing. Stable flows of 1,200 to 1,600 cfs inundate portions of some sites, and provide a shorter distance from overwintering sites along the river's edge and the breeding locations within wetlands.

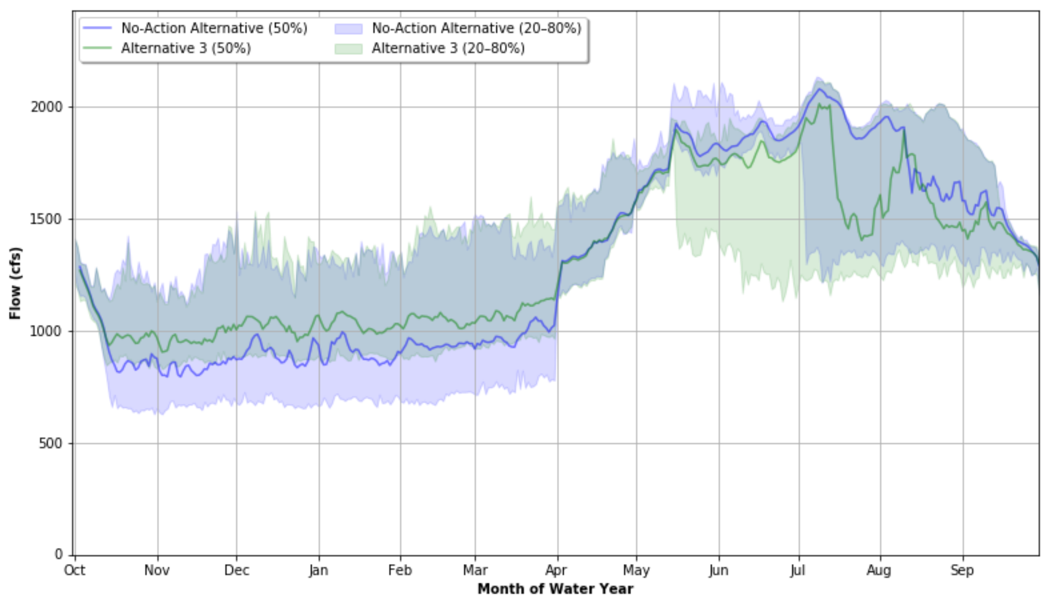
RiverWare Results

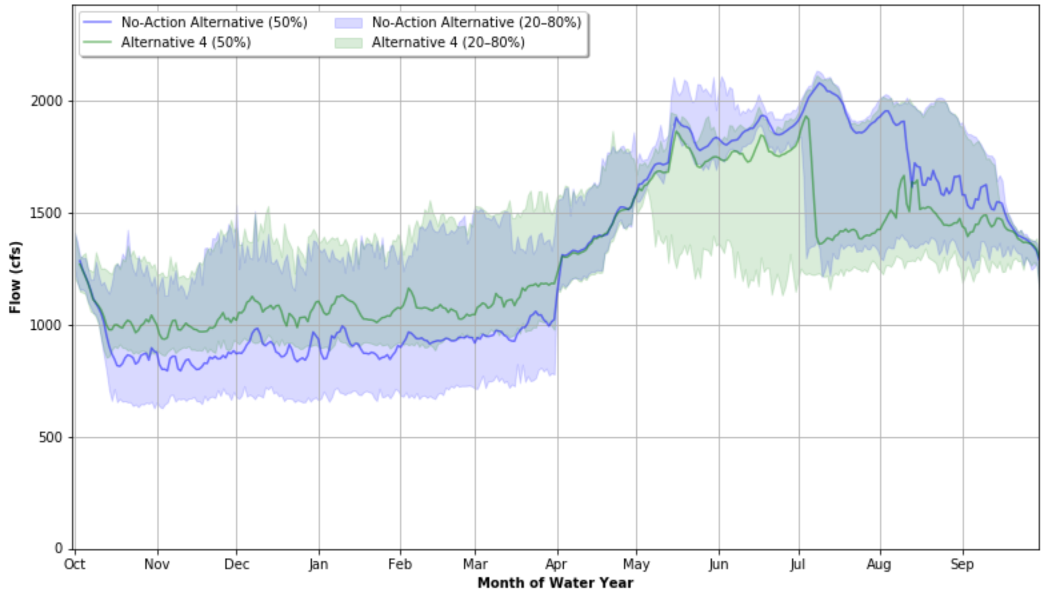
Hydrographs

Figure 18 depicts daily Deschutes River flow hydrographs generated for the BENO gauge location using RiverWare for the no-action alternative, the proposed action, Alternative 3, and Alternative 4. The hydrographs in Figure 18 represent a visual comparison of the river flows expected under the different alternatives at their full implementation stage, meaning where minimum flow in the Deschutes River during winter, the storage season, is at its highest level for each alternative.

Figure 18. Deschutes River Flow Modeled using RiverWare at the BENO Gauge for the No-Action Alternative Compared to the Proposed Action (top), Alternative 3 (middle), and Alternative 4 (bottom) at their Full Implementation







For each alternative, the graphs present the median modeled flow (50%; solid line) and a band capturing the 20% through 80% modeled flows, meaning the flows expected to occur 20% to 80% of the time.

Day-Count Data

To further relate the modeled river flow data for each alternative to the key life history periods for Oregon spotted frogs, the boxplots below (Figure 19 through Figure 25) depict the number of days during each key life history period where the flow at the BENO gauge would be expected to exceed the flow thresholds described at the beginning of the reach analysis. In each boxplot, "x" indicates the mean number of days exceeding the threshold counted for that alternative. The box encloses the upper (top of box) and lower (bottom of box) quartiles and the median is indicated by a horizontal line within the box. Whiskers represent the lowest data point within 1.5 interquartile range (IQR) of the lower quartile, and the highest data point within 1.5 IQR of the upper range. Outliers are depicted as dots.

Breeding (March 15 – April 30)

Figure 19. Boxplot of BENO Day Count for 1,200 cfs

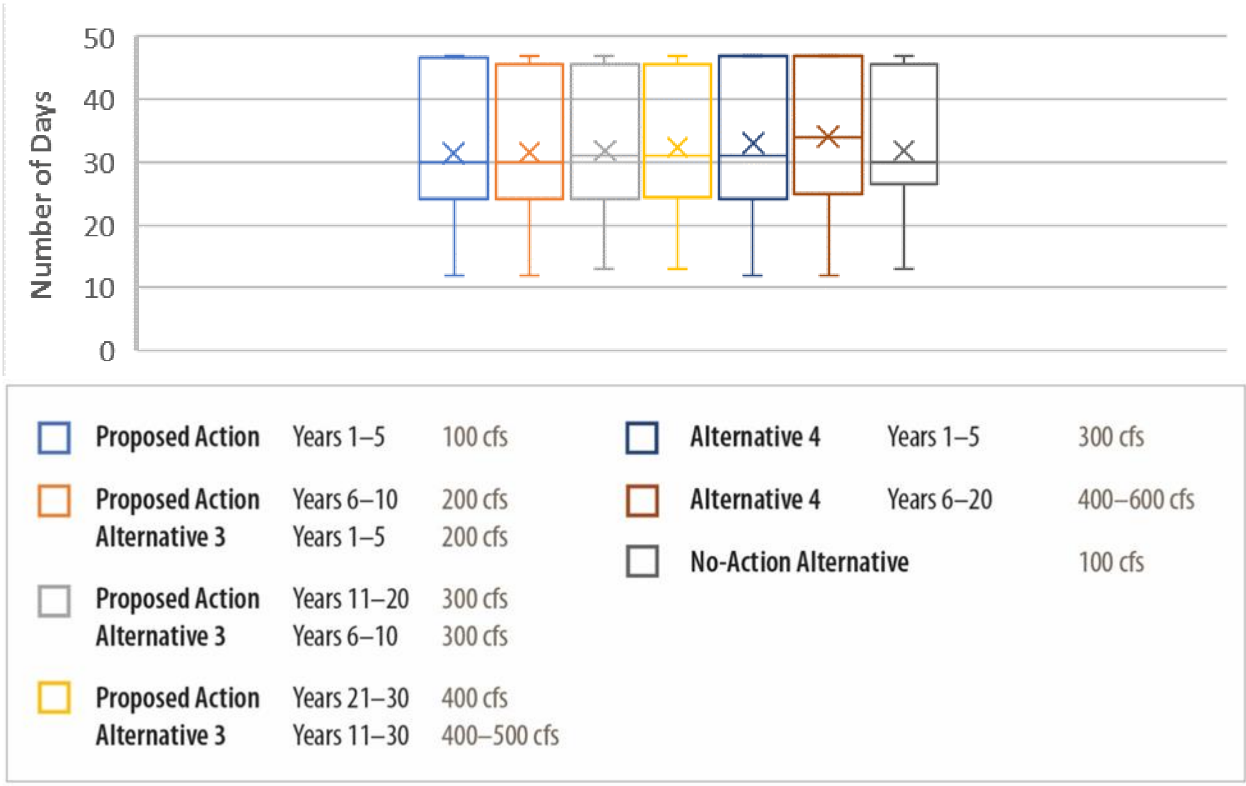
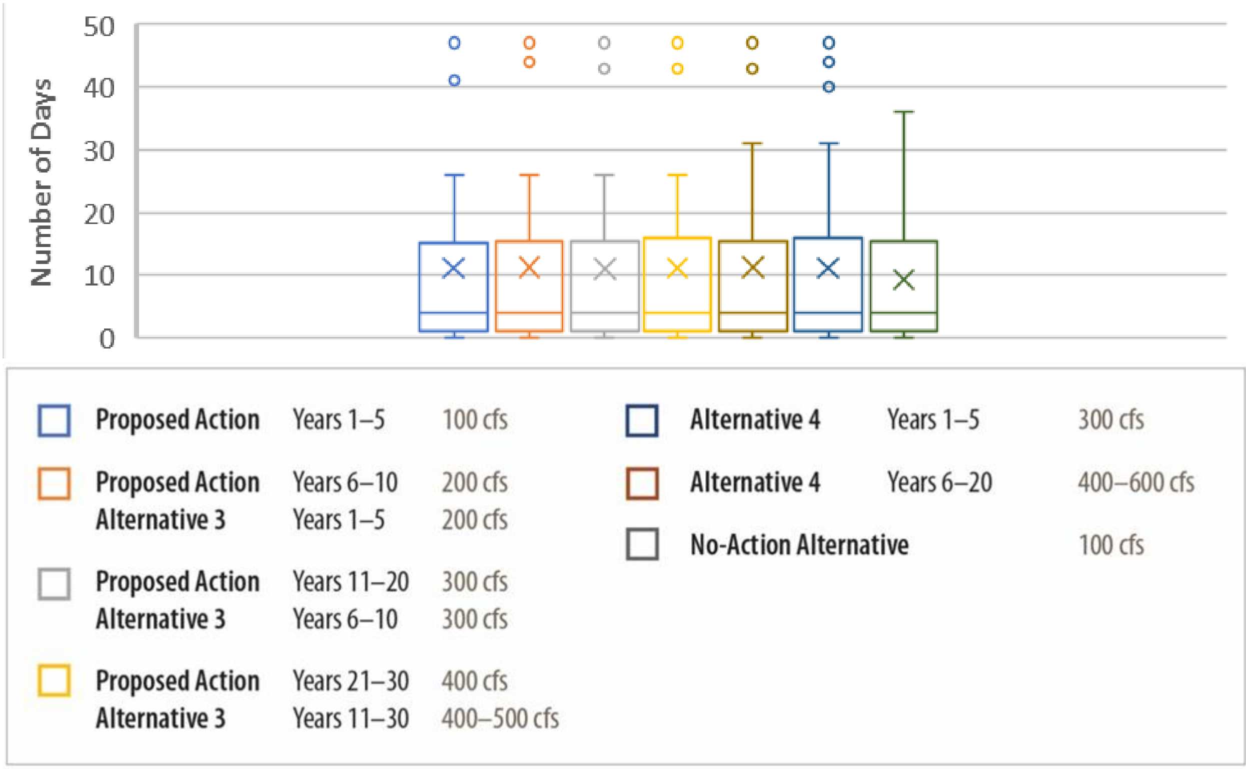
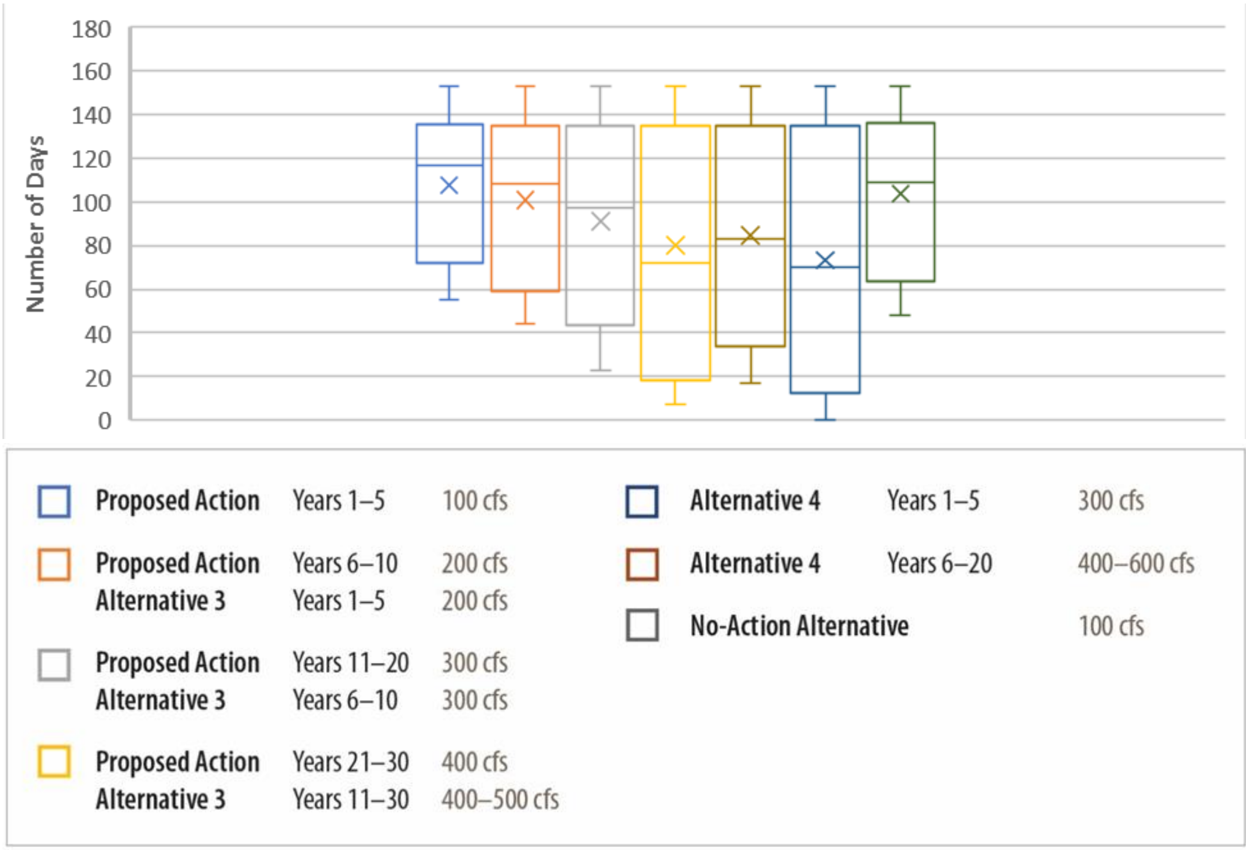


Figure 20. Boxplot of BENO Day Count for 1,600 cfs



Rearing (April 1 – August 31)

Figure 21. Boxplot of BENO Day Count for 1,600 cfs



Pre-Winter (September 1 – October 15)

Figure 22. Boxplot of BENO Day Count for 1,200 cfs

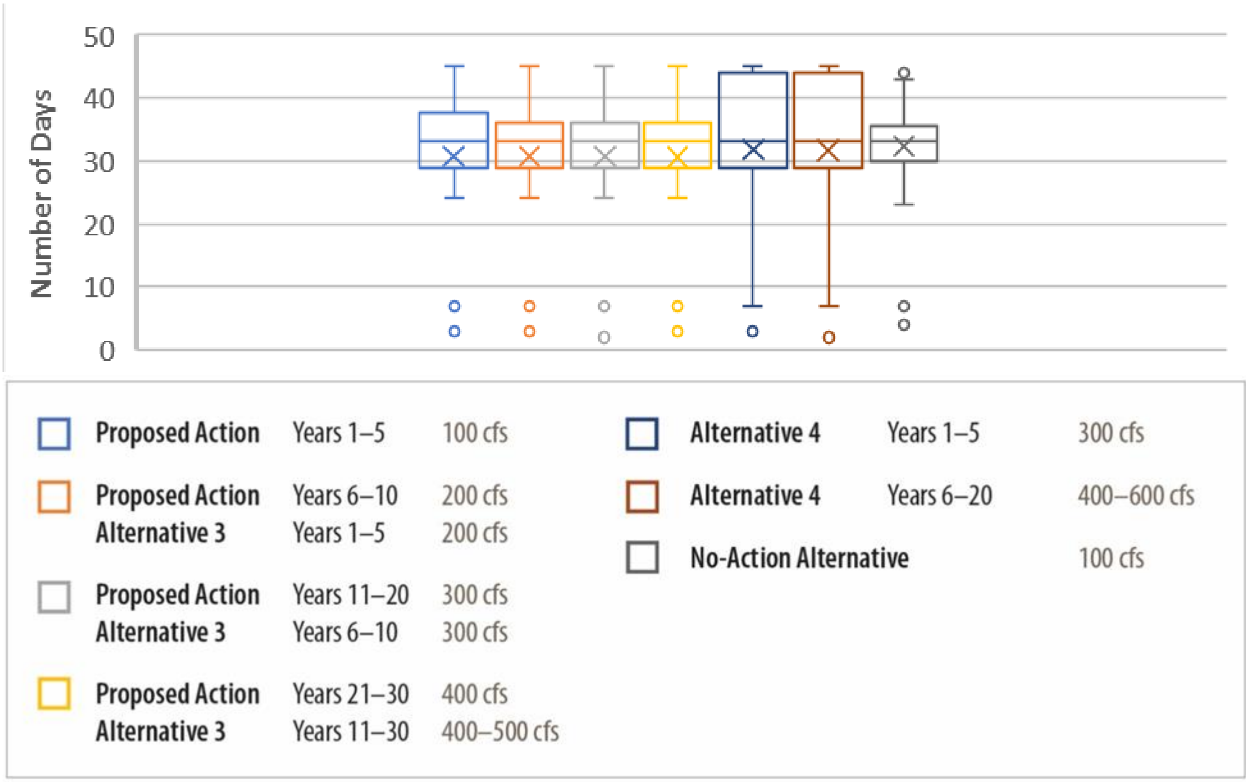
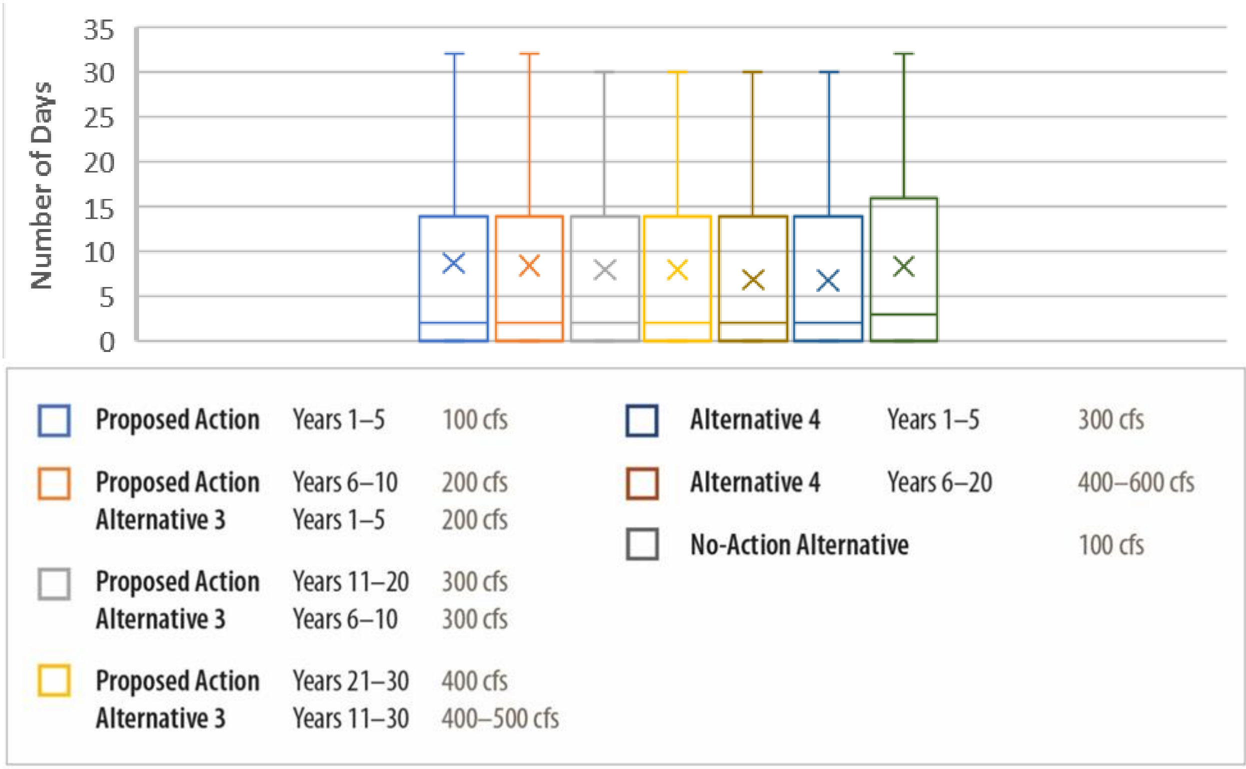


Figure 23. Boxplot of BENO Day Count for 1,600 cfs



Overwintering (October 16 – March 14)

Figure 24. Boxplot of BENO Day Count for 1,200 cfs

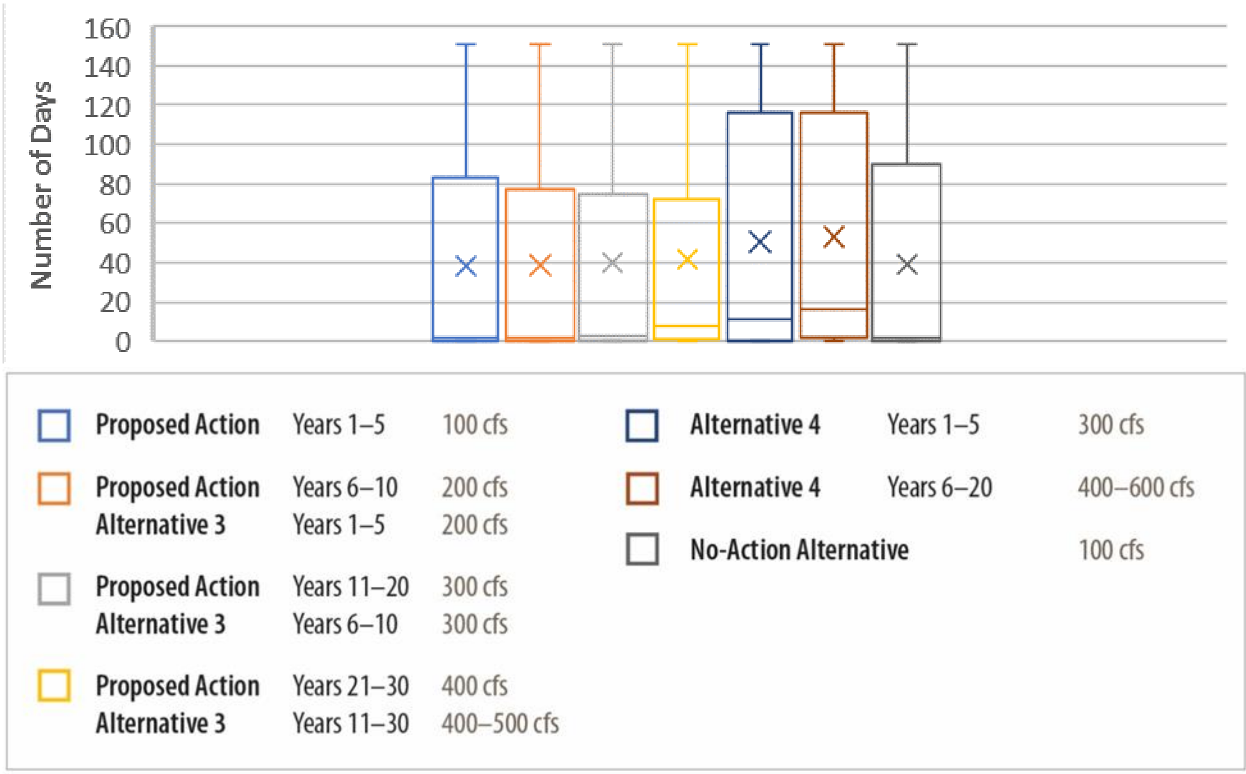
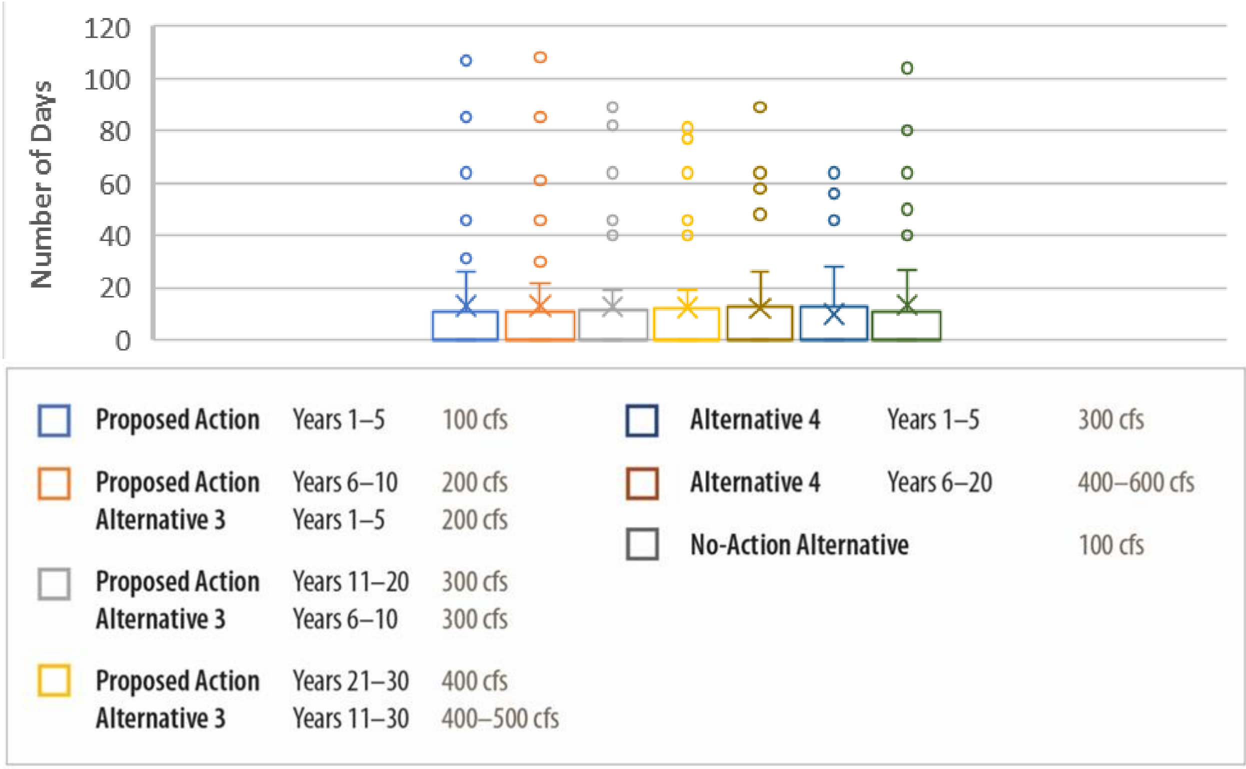


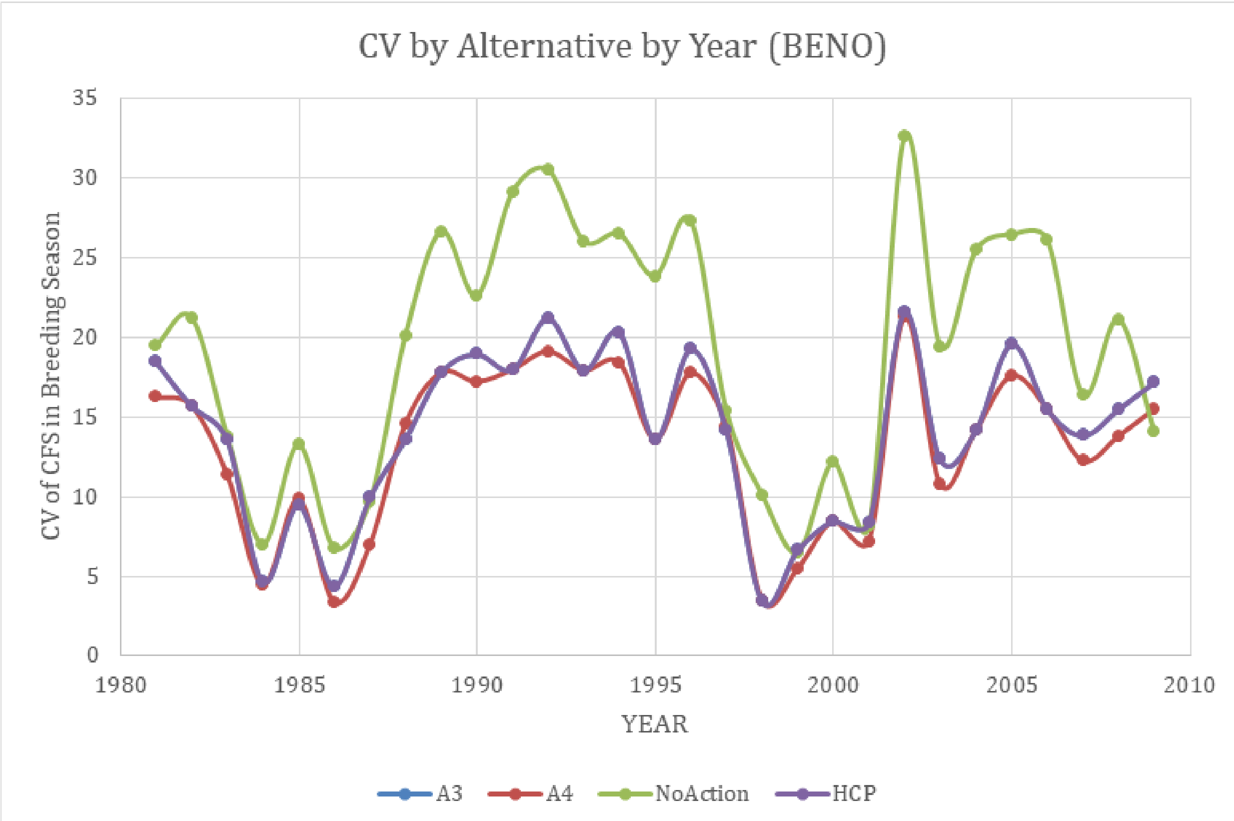
Figure 25. Boxplot of BENO Day Count for 1,600 cfs



Within-Year Flow Variation

To better understand within-year variation in flow for each alternative, Figure 26 reports the Coefficient of Variation (CV) during the breeding season. The CV is the standard deviation divided by the average flow and allows us to compare within-year variability among the alternatives. Within-year flow variation is particularly important during the breeding season because the immobile egg masses are the most vulnerable life stage to either desiccation from receding water or displacement and subsequent exposure to deeper water predators.

Figure 26. The CV of within-Year Deschutes River Flow Modeled using RiverWare at the BENO Gauge for Each Alternative during the Breeding Season (Proposed Action [HCP] and Alternative 3 [A3] overlap).



Effects

Emergent Vegetation

Emergent vegetation would be expected to respond to changes in flow regime by tracking the seasonal inundation patterns and colonizing areas that were historically unavailable during the growing season due to the high summer inundation patterns along the Upper Deschutes.

All alternatives differ from the historical flow regime in the Upper Deschutes by prescribing greater minimum flows during the winter and resulting in lower maximum flows during the summer than were observed on average prior to operations described under the Deschutes Project Biological Opinion (U.S. Fish and Wildlife Service 2017, 2019).

The RiverWare model outputs indicate:

- Among the alternatives, inundation patterns during the growing season would be based on the highest flows under the no-action alternative, lower flows under the proposed action and Alternative 3, and lowest under Alternative 4 (Fig 19 [hydrographs]). This means that emergent vegetation would be inundated up to the highest topographical or elevation level under the no-action alternative, lower elevation under the proposed action and Alternative 3, and lowest elevation under Alternative 4.

Invasive Species

Reed canarygrass is already well established in the study area. Although its site-specific distribution would be expected to change by tracking water inundation elevation patterns during the growing season, it would be expected to persist throughout the study area under all alternatives. Alternative 3 and Alternative 4 include a conservation measure (Conservation Measure DR-2) that could support control of this invasive species.

The more stable hydrograph under the proposed action, Alternative 3, and Alternative 4, compared to the no-action alternative, would be more likely to improve conditions for bullfrogs by providing year-round inundation of wetlands.[3] More stability in the hydrograph would also be more likely to improve conditions for non-native fish species such as brown bullhead catfish, brown trout, and three-spined sticklebacks known to prey on Oregon spotted frogs. However, Conservation Measure DR-2 provided under Alternative 3 and Alternative 4 could be used to fund bullfrog control measures, or to address non-native fish species.

Oregon Spotted Frog

Emergent vegetation would track the flow inundation patterns to colonize areas that would become available during the growing season at the lower elevations. The total area covered by emergent vegetation would not necessarily change, but the topographical elevation where wetland vegetation is supported by water would be at the lowest elevations as flows are reduced during the growing season under full implementation of the Alternative 4, followed by higher elevations under the proposed action and Alternative 3, and the highest elevations under the no-action alternative. Along the river channel, vegetation would be expected to colonize areas lower in the channel profile. Individual Oregon spotted frog sites would respond variably depending on individual site topography, substrate characteristics, and dependence on the river as a water source.

Breeding

- During the breeding season, sites experience the most days of wetland vegetation inundation above the flow thresholds of 1,200 to 1,600 cfs under the fully implemented Alternative 4, but there is more year-to-year variability in days of inundation compared to the no-action alternative (Figure 19 and Figure 20). Wetland vegetation inundation provides substrate and cover for egg masses.

- The fully implemented proposed action and Alternative 3 experience slightly more days of inundation above the 1,200 cfs threshold, and slightly more year-to-year variation compared to the no-action alternative (Figure 19 and Figure 20).

- From the hydrographs (Figure 18), sites within the reach would experience the smallest change (increase) in flow compared to the no-action alternative at the onset of the irrigation season around April 1st under the fully implemented Alternative 4. The fully implemented Alternative 3 and proposed action would both result in smaller changes in flow at the onset of the irrigation season compared to the no-action alternative, but not as small as that modeled for the fully implemented Alternative 4 (Figure 18). Smaller changes in flow and associated water levels

[3] Bullfrogs require permanent wetland habitat to reproduce as tadpoles typically overwinter and metamorphose during their second year

improve conditions for Oregon spotted frogs because there is less chance of displacing egg masses.

- Within-year variation is much larger under the no-action alternative compared to all other alternatives (Figure 26). Within-year variation can increase the risk of egg mass mortality from stranding or displacement.

The fully implemented Alternative 4 would outperform the fully implemented proposed action, Alternative 3, and the no-action alternative in number of days sites would be inundated above 1,200 cfs, and sites would experience the smallest amount of change in water inundation levels at the beginning of the breeding season under Alternative 4.

Rearing

- Sites associated with the BENO gauge would experience flows exceeding the 1,600 cfs threshold and experience inundated vegetation during the rearing period most often under the no-action alternative (Figure 21). Inundated vegetation provides cover for developing tadpoles and juvenile or adult frogs.
- The fully implemented proposed action and Alternative 3 would both outperform the Alternative 4 in number of days expected to exceed the inundation threshold of 1,600 cfs (Figure 21).
- The fully implemented proposed action, Alternative 3, and Alternative 4 would experience more year-to-year variation, and thus less stability, in number of days reaching the inundation threshold of 1,600 cfs (Figure 21).
- From the hydrographs (Figure 18), beginning in early- or mid-July through August 1, the fully implemented proposed action and Alternative 3 experience a decrease in flow and more year-to-year variability compared to the no-action alternative. This observation is amplified for Alternative 4.

The no-action alternative would outperform the fully implemented proposed action, Alternative 3 and Alternative 4 in number of days reaching the 1,600 cfs inundation threshold and in year-to-year stability.

Pre-Winter

- The count of days when inundation levels exceed 1,200 cfs, maintaining contact with wetland vegetation at some sites, are the same among the no-action alternative and fully implemented proposed action, Alternative 3, and Alternative 4 (median = 33 [73% of period] days for all four) (Figure 22). Wetland vegetation provides cover for juvenile and adult frogs inhabiting the site.
    - Alternative 4 results in more year-to-year variability than the other alternatives (Figure 22).
- The count of days when inundation levels exceed 1,600 cfs are low among all alternatives (median = 3 days for the no-action alternative and 2 days for fully implemented all other alternatives) (Figure 23).
    - The no-action alternative shows slightly more year-to-year variation than the other alternatives (Figure 23).

- From the hydrographs (Figure 18), flows modeled for the fully implemented proposed action, Alternative 3 and Alternative 4 experience a similar decrease in flow through the pre-winter season. The no-action alternative experiences a larger decrease as flows are greater at the end of the rearing season and less during the overwintering period for this alternative compared to the others. The smaller change in water inundation elevation under the proposed action, Alternative 3, and Alternative 4 could mean fewer frogs would select poor overwintering sites that end up disconnected or above the waterline.
- Alternatives 3 and 4 include Conservation Measure DR-2 that is lacking from the proposed action and the no-action alternative.

The proposed action, Alternative 3, and Alternative 4 would perform similarly to the no-action alternative regarding days of inundation, but the change in inundation level would be less drastic under the proposed action, Alternative 3 and Alternative 4 compared to the no-action alternative. The less drastic change in water inundation elevation may mean fewer frogs would select poor overwintering sites that end up disconnected or above the waterline. The proposed action lacks Conservation Measure DR-2 which would fund activities to restore and maintain habitat to benefit the covered species within the Deschutes River, including Oregon spotted frog. For these reasons, the fully implemented Alternative 3 and Alternative 4 would outperform the proposed action and no-action alternative.

Overwintering

- Flows reach the 1,200 cfs threshold rarely under any alternative, but slightly more often under the fully implemented Alternative 4 (median = 16 days or 9% of period) than the proposed action or Alternative 3 (median = 8 days or 0.05% of the period), and the no-action alternative (median = 2 days or 0.01% of the period) (Figure 24).
  - Alternative 4 also demonstrates a higher year-to-year variation than any other alternative in number of days the flow exceeds 1,200 cfs (Figure 24).
- From the hydrographs (Figure 18), flows under the proposed action, Alternative 3 and Alternative 4 steadily exceed the amount of flow under the no-action alternative throughout the overwintering season. Higher flows could result in more consistently wetted overwintering sites and shorter distances for frogs to travel between breeding and overwintering locations.

At full implementation, the proposed action and Alternative 3 provide higher sustained water levels throughout the overwintering period than the no-action alternative. Fully implemented Alternative 4 provides the highest sustained water elevation, and during wet years provides more opportunity for higher levels of inundation which could protect overwintering Oregon spotted frogs. Full implementation of Alternative 4 would outperform the other alternatives.

Site-Specific Analysis

Sites within this reach include the East Slough Camp complex and Southwest Slough Camp. Both sites demonstrate variable dependence on river flow with sub-sites at East Slough Camp closely tracking the river flow during the year while other sub-sites are partially independent of flows in the Deschutes River. SW Slough Camp appears to operate largely independently from flows in the river because it is perched well above the river surface elevation (Vaughn 2018).

East Slough Camp

East Slough Camp is a large complex of sites located in Reach Des-10a. Breeding has been confirmed throughout the complex. Sub-sites have varying levels of connectivity with the Deschutes River ranging from surface connections, to isolated areas that remain disconnected from the river for most of the year and are fed by groundwater.

The sub-sites of the East Slough Camp complex vary in minimum threshold flows at the BENO gauge required to support functional breeding habitat from approximately 1,200 to 1,600 cfs (U.S. Fish and Wildlife Service 2017, 2019). Vaughn (2018) collected pressure transducer data from several East Slough Camp sub-sites between September of 2015 and October 2017 to better understand the relationship between river water flow and level (*i.e.* stage) and wetland inundation. Vaughn (2018) confirmed that BENO gauge data can be used to determine level and flow in the river adjacent to the East Slough Camp complex. Flows measured at BENO can be adjusted to account for groundwater loss between BENO and the East Slough Camp complex.

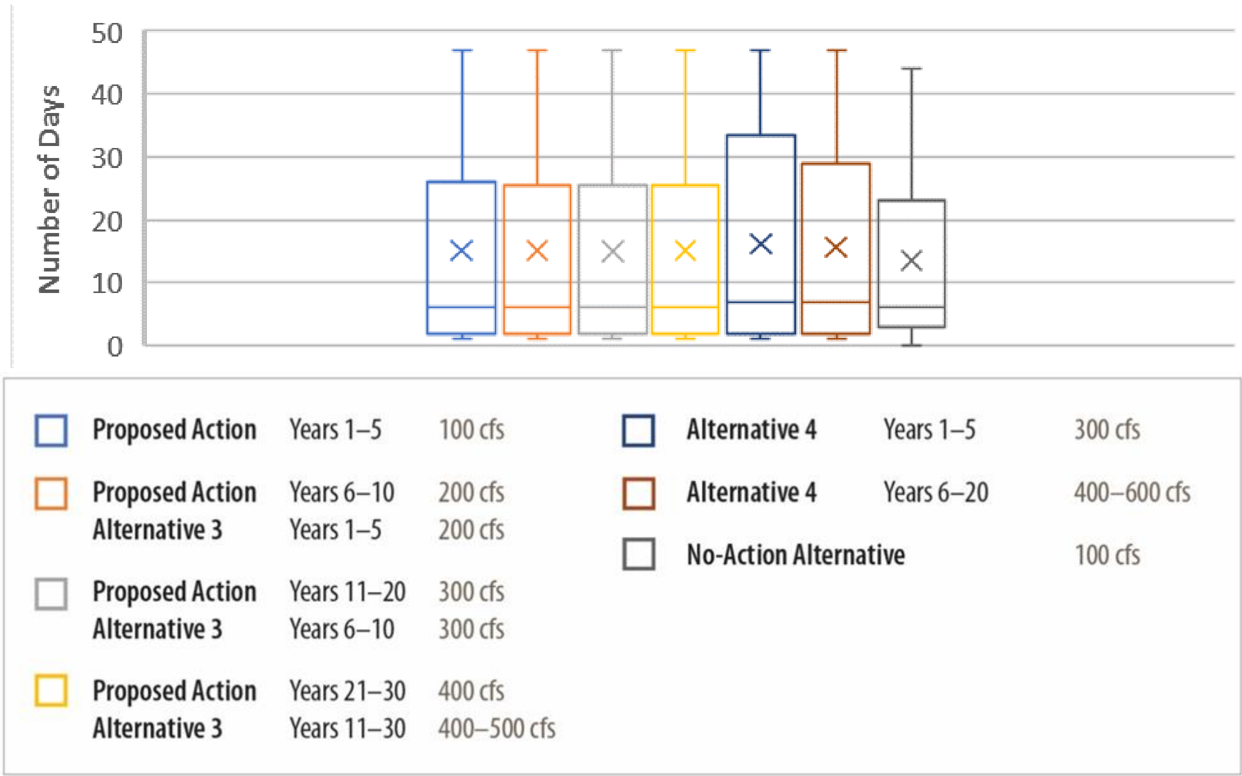
Sub-sites demonstrated seasonal and site-specific variation in how closely they tracked the flow and elevation levels recorded in the river adjacent to the complex. Wetland B (Levelogger 1065047), one of the known breeding locations within the complex, is affected by flows in the Deschutes River. During most of the year (spring, summer, and early fall), water depth in this wetland closely tracks the flow in the river although the wetland experiences a lag of several days before it responds to water flow changes in the river. This wetland typically dries during the winter. Water level at the sub-site is less predictable during winter and early spring due to other factors such as winter precipitation. During dry years the wetland depends on the river for inundation during breeding, but in wet years the wetland can become inundated before river flows are increased for irrigation. Photographs of this site collected by FWS and USFS indicate it is sufficiently inundated to support Oregon spotted frog breeding within a few days of flows reaching 1,500 cfs at the BENO gauge (U.S. Fish and Wildlife Service 2017, 2019).

Other sub-sites behave similarly to Wetland B by closely tracking the flow in the river during spring, summer, and fall; however, some sites retain water throughout the winter even during dry years and lag times of response to changes in flow in the river vary by sub-site from a few days to several weeks (Vaughn 2018).

The boxplot below (Figure 27) depicts the number of days during the breeding life history time period where the flow at the BENO gauge would be expected to exceed 1,500 cfs, the threshold specific to wetland inundation for the example sub-site, Wetland B.

Breeding (March 15 – April 30)

Figure 27. Boxplot of BENO Day Count for 1,500 cfs



From the RiverWare data presented in Figure 19 through Figure 27, the modeled BENO gauge flows and associated day counts where flows reach specific thresholds support the same conclusions for the East Slough Camp complex as noted for the broader reach. Specifically, during breeding Wetland B would experience the most days of inundation (when flows reach 1,500 cfs at BENO) under the fully implemented Alternative 4 (Figure 27).

Summary Conclusion

Table 8 summarizes the overall results of this comparison of each alternative to the no-action. The proposed action, Alternatives 3 and 4 would outperform the no-action alternative during all key life history periods except rearing.

Reach Des-9

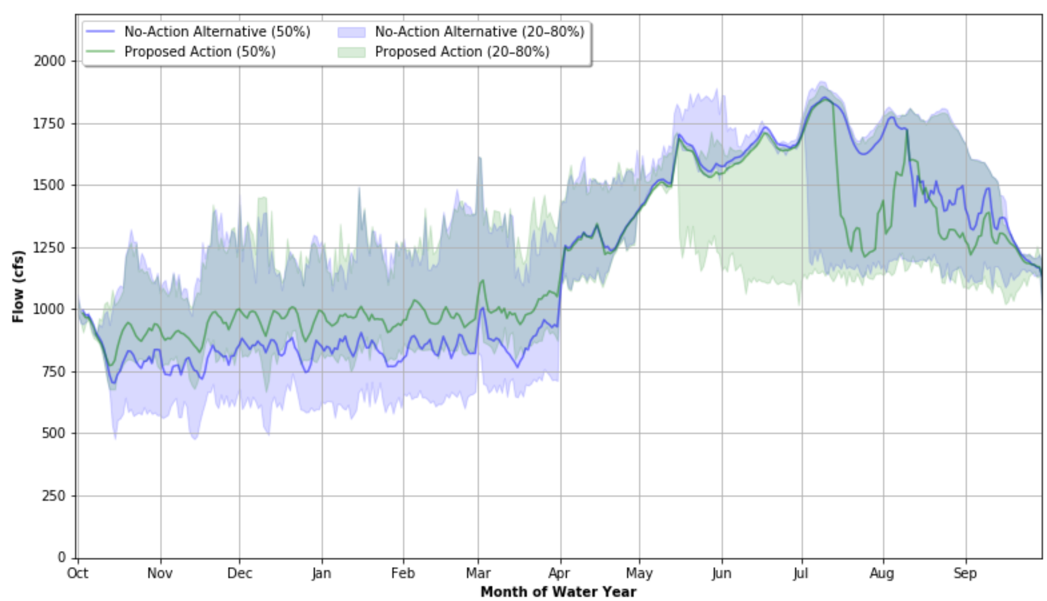
Reach Des-9 does not support any known Oregon spotted frog breeding sites, although there is one site where juveniles have been detected. This reach is located along the river between known breeding sites so Oregon spotted frogs likely disperse through this reach, and there is a possibility Oregon spotted frogs use some of the wetlands associated with the river for breeding.

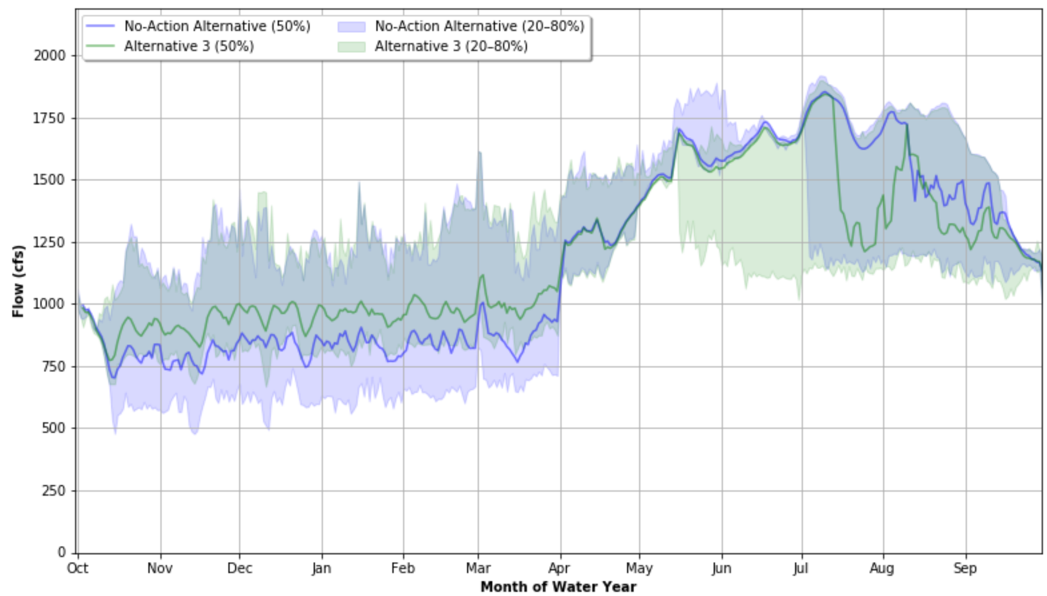
The flow in this reach does not directly correspond to the nearest gauge, BENO at Benham Falls and no flow threshold has been identified for this reach because there are little data available for wetlands located within the reach. This assessment relied on a hydrograph produced from internodal data from the RiverWare model (Siphon2COID.Inflow). The hydrograph at this internode can be related back to the flows at the BENO gauge by subtracting from BENO the Arnold Canal diversion flows and approximately 50% of the loss to ground water estimated for the stretch of river extending from BENO to Bend by Gannett et al. (2001). Assuming loss to ground water is consistent from BENO to Bend, reach Des-9 only covers approximately half the distance. These data are caveated because they involve reporting results for a location (internode) that was not designed as a reporting node in the model. They include a degree of uncertainty because the gains and losses in the model have been artificially tied to internodal location rather than spread out along the entire reach. The analysis assumes the Siphon2COID.Inflow data accurately model the flow in the Deschutes River in this reach.

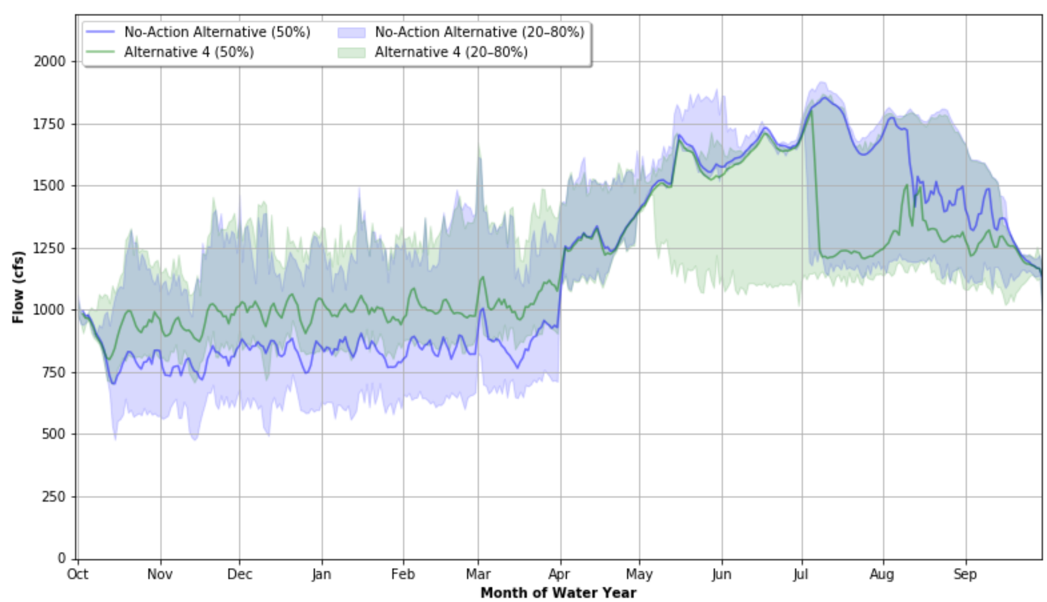
RiverWare Results

Figure 28 depicts daily Deschutes River flow hydrographs generated for the Siphon2COID.Inflow internode location using RiverWare for the no-action alternative, the proposed action, Alternative 3, and Alternative 4. The hydrographs in Figure 28 represent a visual comparison of the river flows expected under the different alternatives at their full implementation stage, meaning where minimum flow in the Deschutes River during winter, the storage season, is at its highest level for each alternative.

Figure 28. Deschutes River Flow Modeled using RiverWare at the Siphon2COID.Inflow Internode for the No-Action Alternative Compared to the Proposed Action (top), Alternative 3 (middle), and Alternative 4 (bottom) at their Full Implementation







For each alternative, the graphs present the median modeled flow (50%; solid line) and a band capturing the 20% through 80% modeled flows, meaning the flows expected to occur 20% to 80% of the time.

Effects

Emergent Vegetation

Emergent vegetation would be expected to respond to changes in flow regime by tracking the seasonal inundation patterns and colonizing areas that were historically unavailable during the growing season due to the high summer inundation patterns along the Upper Deschutes.

All alternatives differ from the historical flow regime in the Upper Deschutes by prescribing greater minimum flows during the winter and resulting in lower maximum flows during the summer than were observed on average prior to operations prescribed under the Deschutes Project Biological Opinion (U.S. Fish and Wildlife Service 2017, 2019).

The RiverWare model outputs indicate:

- Among the alternative, inundation patterns during the growing season would be based on the highest flows under the no-action alternative, lower flows under the proposed action and Alternative 3, and lowest under Alternative 4 (Fig 30 [hydrographs]). This means that emergent vegetation would be inundated up to the highest topographical or elevation level under the no-action alternative, lower elevation under the proposed action and Alternative 3, and lowest elevation under Alternative 4.

Invasive Species

Reed canarygrass is already well established in the study area. Although its site-specific distribution would be expected to change by tracking water inundation elevation patterns during the growing season, it would be expected to persist throughout the study area under all alternatives. Alternative 3 and Alternative 4 include a conservation measure (Conservation Measure DR-2) that could support control of this invasive species. The more stable hydrograph under the proposed action, Alternative 3, and Alternative 4, compared to the no-action alternative, would be more likely to improve conditions for bullfrogs by providing year-round inundation of wetlands.[4] More stability in the hydrograph would also be more likely to improve conditions for non-native fish species such as brown bullhead catfish, brown trout, and three-spined sticklebacks known to prey on Oregon spotted frogs. However, Conservation Measure DR-2 provided under Alternative 3 and Alternative 4 could be used to fund bullfrog control measures, or address non-native fish species.

Oregon Spotted Frog

Emergent vegetation would track the flow inundation patterns to colonize areas that would become available during the growing season at the lower elevations. The total area covered by emergent vegetation would not necessarily change, but the topographical elevation where wetland vegetation is supported by water would be at the lowest elevations as flows are reduced during the growing season under full implementation of the Alternative 4, followed by higher elevations under the proposed action and Alternative 3, and the highest elevations under the no-action alternative. Along the river channel, vegetation would be expected to colonize areas lower in the channel profile. Individual Oregon spotted frog sites would respond variably depending on individual site topography, substrate characteristics, and dependence on the river as a water source.

Breeding

- From the hydrographs, sites within the reach would experience the largest change (increase) in flow under the no-action alternative as flows ramp up from the winter minimum at the onset of the irrigation season around April 1st. Flows are consistent among all alternatives during the month of April.

[4] Bullfrogs require permanent wetland habitat to reproduce as tadpoles typically overwinter and metamorphose during their second year.

The fully implemented Alternative 4 provides the smallest amount of change in water inundation levels at the beginning of the breeding season and would be least likely to dislodge egg masses. The proposed action and Alternative 3 are similar to Alternative 4 but have slightly greater changes in flow.

Rearing

- From the hydrographs, beginning in early- or mid-July through early August, the fully implemented proposed action and Alternative 3 experience a decrease in flow compared to the no-action alternative. This observation is amplified for Alternative 4. Decreased flows could result in drying of wetlands and exposure of juvenile frogs to higher risk of predation if forced to migrate to the river channel.

The no-action alternative would outperform the fully implemented proposed action, Alternative 3, and Alternative 4 in amount and stability of flow during rearing.

Pre-Winter

- From the hydrographs, flows modeled for the fully implemented proposed action, Alternative 3 and Alternative 4 experience a similar decrease in flow through the pre-winter season, although the decrease is least under Alternative 4. The no-action alternative experiences a larger decrease as flows are greater at the end of the rearing season and less during the overwintering period for this alternative compared to the others.
- Alternatives 3 and 4 include Conservation Measure DR-2 that is lacking from the proposed action and the no-action alternative.

The change in inundation level would be less under the proposed action and Alternative 3 and least under Alternative 4 compared to the no-action alternative. The less drastic change in water inundation elevation may mean fewer frogs would select poor overwintering sites that end up disconnected or above the waterline. The no-action alternative and the proposed action both lack Conservation Measure DR-2 which would fund activities to restore and maintain habitat to benefit the covered species within the Deschutes River, including Oregon spotted frog. For these reasons, the fully implemented Alternative 3 and Alternative 4 would outperform the proposed action and no-action alternative.

Overwintering

- From the hydrographs, flows under the proposed action, Alternative 3 and Alternative 4 steadily exceed the amount of flow under the no-action alternative throughout the overwintering season. Higher flows could result in more consistently wetted overwintering sites and shorter distances for frogs to travel between breeding and overwintering locations.

At full implementation, the proposed action and Alternative 3 provide higher sustained water levels throughout the overwintering period than the no-action alternative. Fully implemented Alternative 4 provides the highest sustained water elevation which could protect overwintering Oregon spotted frogs. Full implementation of Alternative 4 would outperform the other alternatives.

Summary Conclusion

Table 8 summarizes the overall results of this comparison of each alternative to the no-action. Alternative 4 provides the best conditions for Oregon spotted frogs except during rearing when the no-action alternative provides the most days of inundation.

Reach Des-8a

Reach Des-8a is located along the Deschutes River extending from the Central Oregon Irrigation Diversion (COID) downstream to Colorado Street in downtown Bend, Oregon. In the Deschutes Project Biological Opinion (U.S. Fish and Wildlife Service 2017, 2019), this reach is called Reach 7; it is the same but referred to by reach name in the HCP.

There are two known occupied locations in Reach Des-8a: the Old Mill/Casting Pond and the Les Schwab Amphitheater (LSA) Marsh. These two locations are close to each other and individual frogs have been documented moving between the two locations (U.S. Fish and Wildlife Service 2017, 2019). The Old Mill/Casting Pond is not connected to the river while LSA Marsh is a wetland adjacent to and directly connected with the main river channel on the upstream (south) side of the Colorado Bridge and waterpark. Breeding has been sporadically detected at both locations since 2013, although successful use of each site for oviposition appears to be declining (U.S. Fish and Wildlife Service 2017, 2019). LSA Marsh and Old Mill/Casting Pond represent the farthest downstream breeding sites for Oregon spotted frog.

Reach-Level Analysis

The flow in this reach of the river does not directly reflect the flows measured at the BENO gauge, the closest upstream gauge, because water is diverted for irrigation and lost through groundwater seepage between the BENO gauge location at Benham Falls and this reach. This assessment relied on a hydrograph produced from internodal data from the RiverWare model (Siphon2COID.Outflow). The hydrograph at this internode can be related back to the flows at the BENO gauge by subtracting from BENO the Arnold Irrigation District and Central Oregon Irrigation District diversion flows as well as the approximately 7% loss to groundwater estimated for the reach extending from BENO to Bend by Gannett et al. (2001). These data are caveated because they involve reporting results for a location (internode) that was not designed as a reporting node in the model. They include a degree of uncertainty because the gains and losses in the model have been artificially tied to internodal location rather than spread out along the entire reach.

The analysis assumes the Siphon2COID.Outflow data accurately model the flow in the Deschutes River at the Colorado Street Bridge, adjacent to the LSA Marsh. A draft report (Vaughn 2019) reported a similar flow pattern for the Colorado Street Bridge location although the median flows estimated by Vaughn (2019) during winter, which were calculated from measured flows at the BENO gauge adjusted for diversions and losses, appear to be approximately 500 cfs compared to the RiverWare-modeled median around 750 cfs.

Habitat flow thresholds and other important criteria for Oregon spotted frog sites associated with flows in Des-8a at the Colorado Street Bridge (Siphon2COID.Outflow internode) include:

- From Vaughn (2019), the LSA Marsh appears to remain wetted throughout the year, so there is not a vegetation inundation threshold that would capture days of inundation, and associated increased habitat value, during the life history periods. Instead, based on the hydrographs, 1,200 cfs at the Siphon2COID.Outflow internode was selected to compare days of inundation during breeding and rearing seasons among the alternatives because these values were in the range of those reported by Vaughn (2019) for those timeframes, and breeding and rearing occurred at the site during the same time frame (O'Reilly pers. comm. [d]).

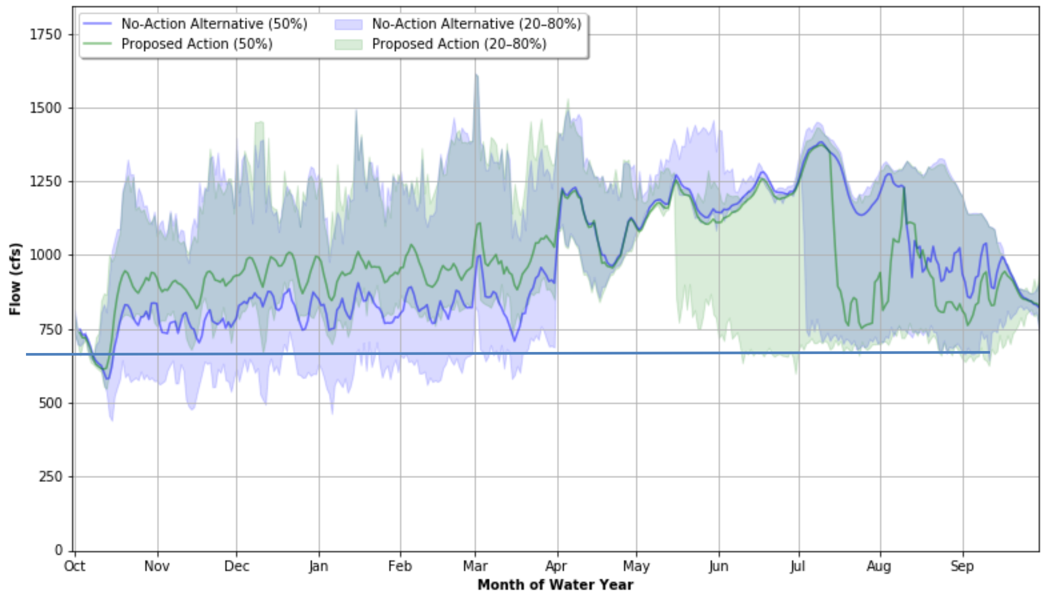
- For the overwintering period, the analysis used 900 cfs (at the Siphon2COID.Outflow internode) as a comparative flow threshold. Based on the modeled hydrographs, this flow appeared to discriminate among the alternatives and allow us to differentiate among alternatives that consistently provide a higher amount of winter flow and associated water elevation. This increases habitat quality by reducing the travel distance for Oregon spotted frogs moving from overwintering sites to breeding locations within the reach. The analysis also compared alternatives using the 500 cfs flow threshold at the Siphon2COID.Outflow internode because that flow approximates the typical winter flow experienced by one of the sites in the reach, LSA Marsh.
- As in other reaches, the analysis also compared the pattern of flow change during pre-winter and other life history periods to discern patterns or trends that could differentially affect Oregon spotted frog use of the habitat.

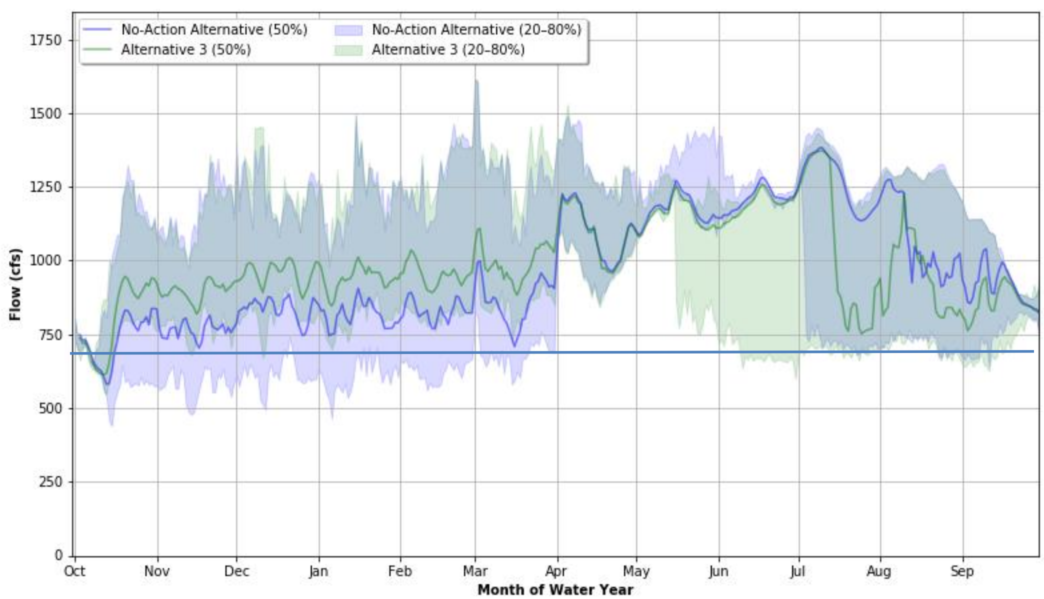
RiverWare Results

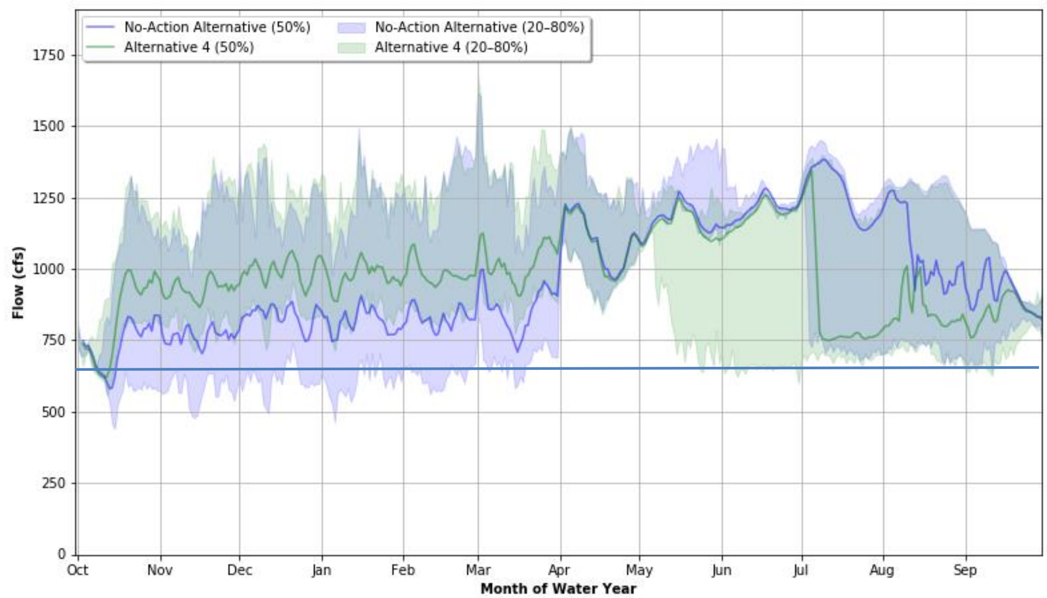
Hydrographs

Figure 29 depicts daily Deschutes River flow hydrographs generated for the Siphon2COID.Outflow internode (Colorado Street Bridge) location using RiverWare for the no-action alternative, the proposed action, Alternative 3, and Alternative 4. The hydrographs in Figure 29 represent a visual comparison of the river flows expected under the different alternatives at their full implementation stage, meaning where minimum flow in the Deschutes River during winter, the storage season, is at its highest level for each alternative.

Figure 29. Deschutes River Flow Modeled using RiverWare at the Siphon2COID.Outflow Internode for the No-Action Alternative Compared to the Proposed Action (top), Alternative 3 (middle), and Alternative 4 (bottom) at their Full Implementation (Line indicates approx. 900 cfs)







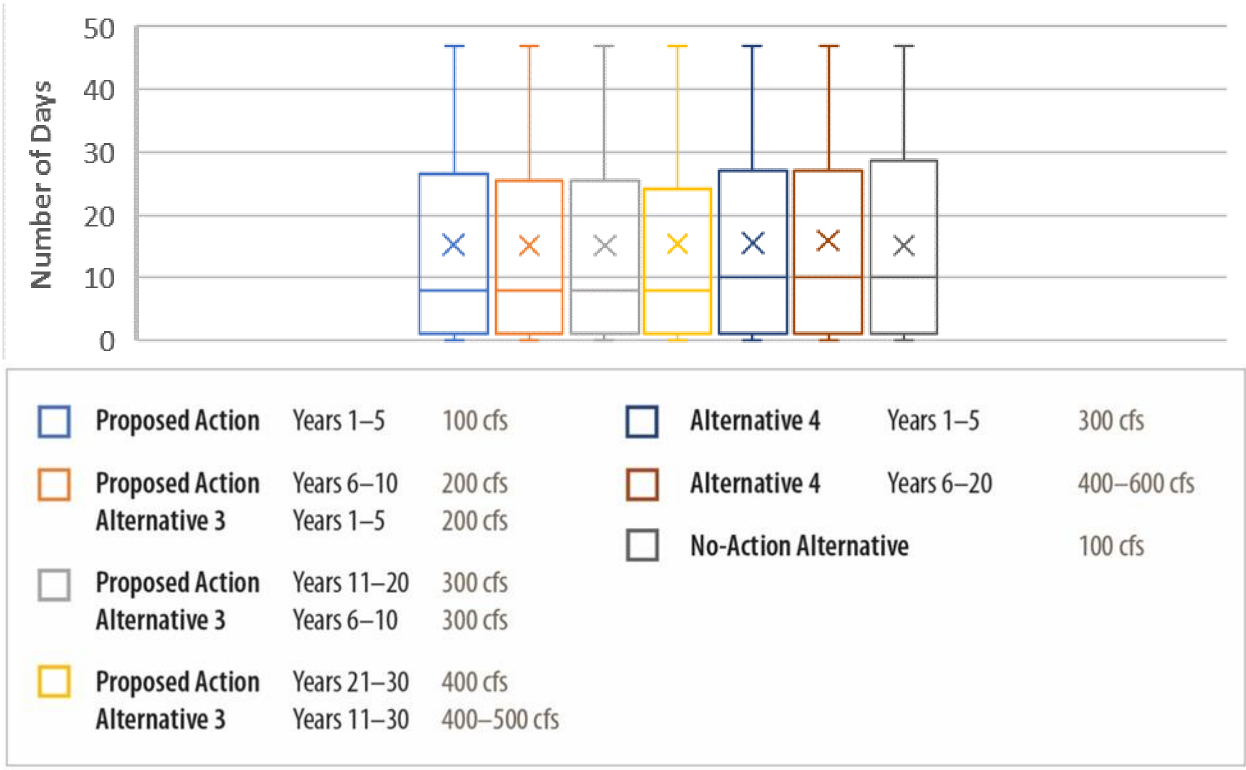
For each alternative, the graphs present the median modeled flow (50%; solid line) and a band capturing the 20% through 80% modeled flows, meaning the flows expected to occur 20% to 80% of the time.

Day-Count Data

To further relate the modeled river flow data for each alternative to the key life history periods for Oregon spotted frogs, the boxplots below (Figure 30 through Figure 34) depict the number of days during each key life history time period where the flow at the Siphon2COID.Outflow RiverWare internode (e.g., Colorado Street Bridge) would be expected to exceed the flow thresholds described earlier in this appendix. In each boxplot, "x" indicates the mean number of days exceeding the threshold counted for that alternative. The box encloses the upper (top of box) and lower (bottom of box) quartiles and the median is indicated by a horizontal line within the box. Whiskers represent the lowest data point within 1.5 interquartile range (IQR) of the lower quartile, and the highest data point within 1.5 IQR of the upper range. Outliers are depicted as dots.

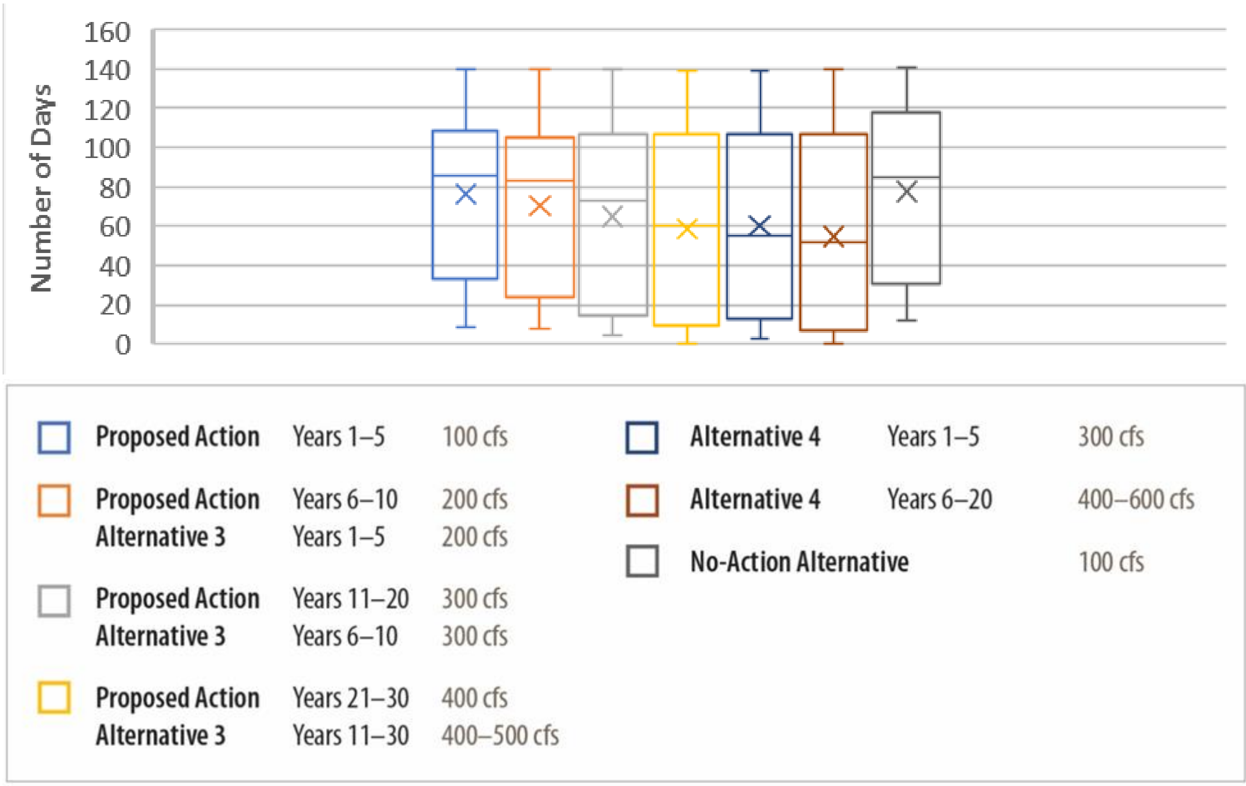
Breeding (March 15 – April 30)

Figure 30. Boxplot of Siphon2COID.Outflow Day Count for 1,200 cfs



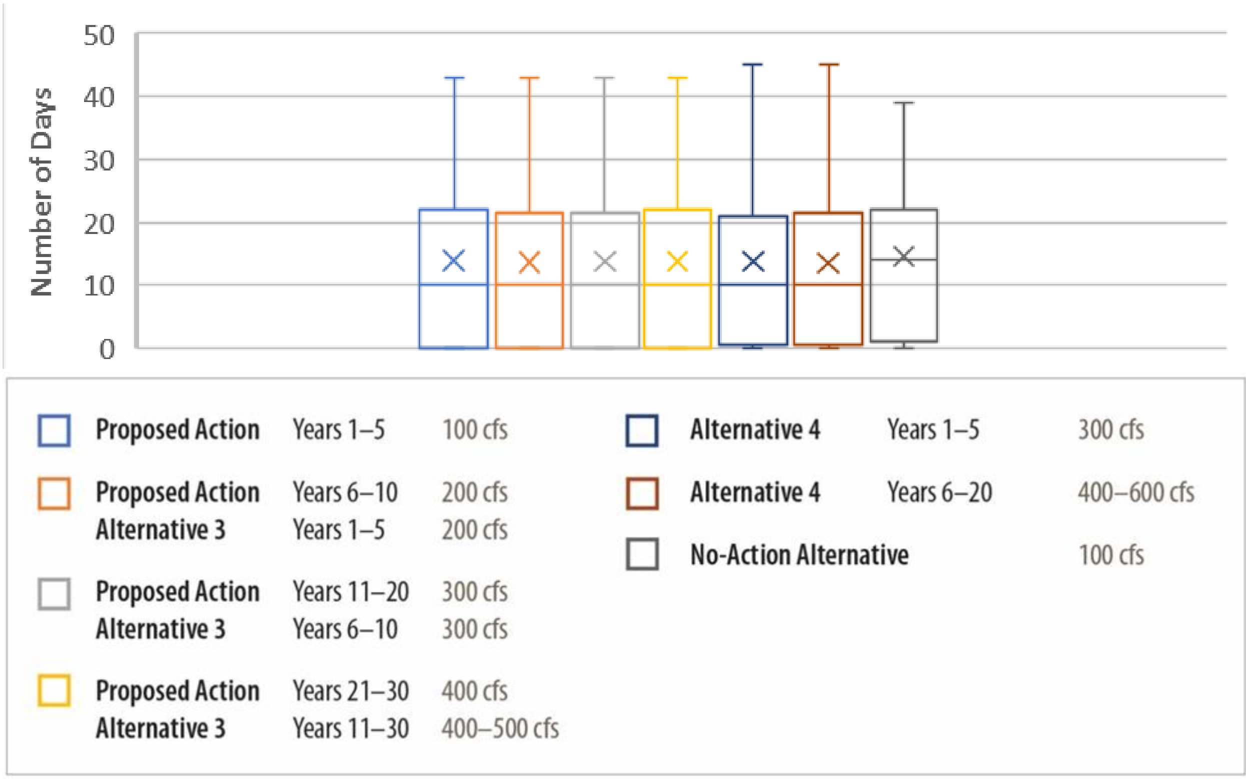
Rearing (April 1 – August 31)

Figure 31. Boxplot of Siphon2COID.Outflow Day Count for 1,200 cfs during Rearing



Pre-Winter (September 1 – October 15)

Figure 32. Boxplot of Siphon2COID.Outflow Day Count for 900 cfs during Pre-Winter



Overwintering (October 16 – March 14)

Figure 33. Boxplot of Siphon2COID.Outflow Day Count for 900 cfs during Overwintering

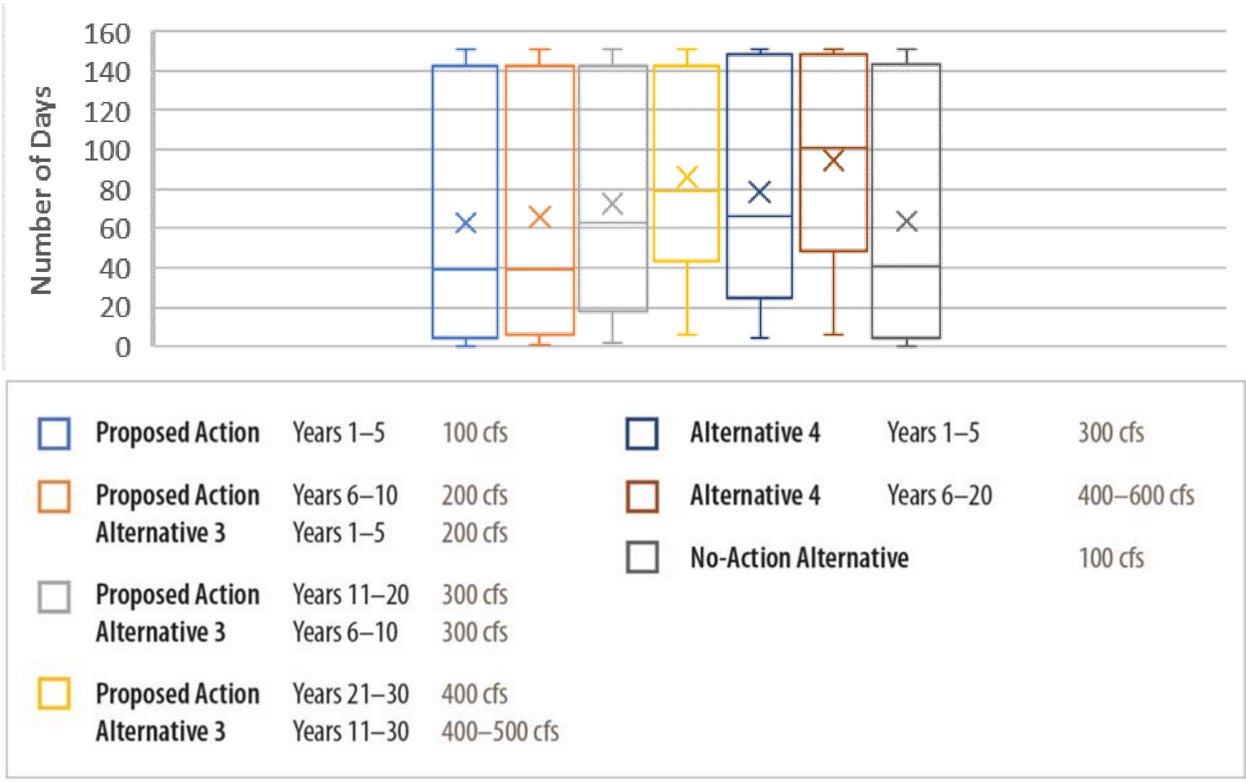
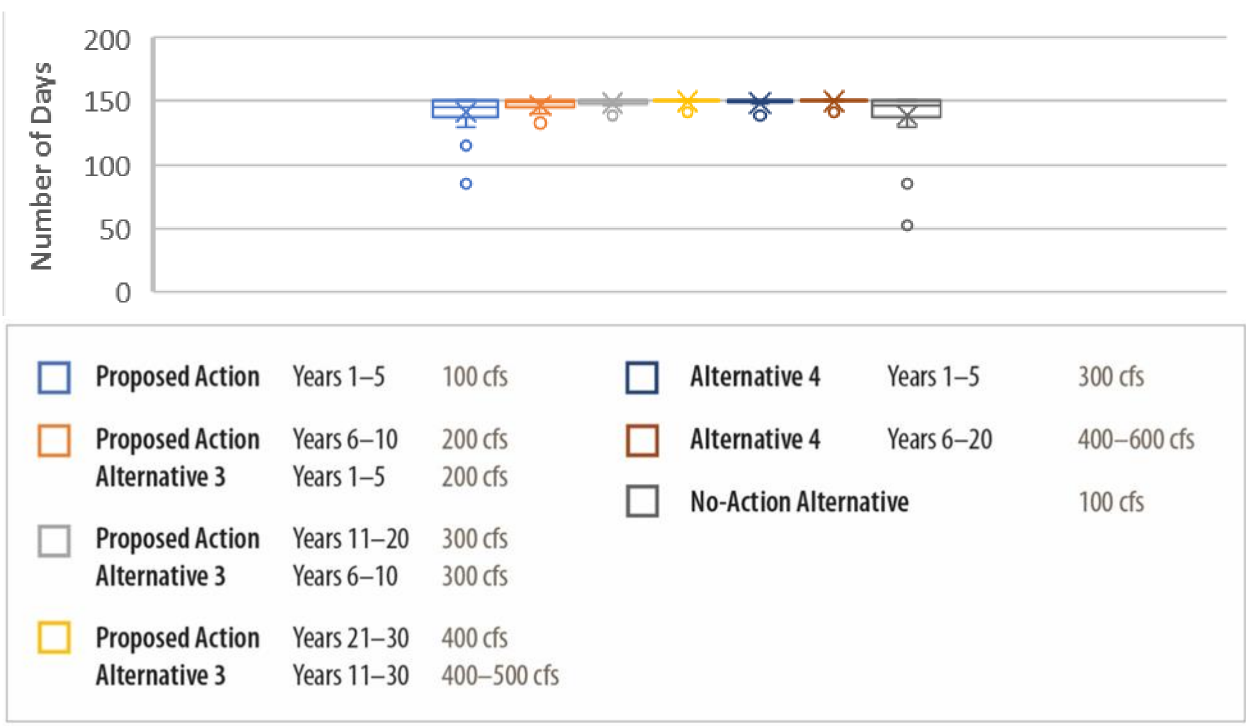


Figure 34. Boxplot of Siphon2COID.Outflow Day Count for 500 cfs during Overwintering



Effects

Emergent Vegetation

Emergent vegetation would be expected to respond to changes in flow regime by tracking the seasonal inundation patterns and colonizing areas that were historically unavailable during the growing season due to the high summer inundation patterns along the Upper Deschutes.

All alternatives differ from the historical flow regime in the Upper Deschutes by prescribing greater minimum flows during the winter and resulting in lower maximum flows during the summer than were observed on average prior to operations prescribed under the Deschutes Project Biological Opinion (U.S. Fish and Wildlife Service 2017, 2019).

The RiverWare model outputs indicate:

- Among the alternative, inundation patterns during the growing season would be based on the highest flows under the no-action alternative, lower flows under the proposed and Alternative 3, and lowest under Alternative 4 (Figure 29). This means that emergent vegetation would be supported up to the highest topographical or elevation level under the no-action alternative, lower elevation under the proposed action and Alternative 3, and lowest elevation under Alternative 4.

Invasive Species

Reed canarygrass is already well established in the study area. Although its site-specific distribution would be expected to change by tracking water inundation elevation patterns during the growing season, it would be expected to persist throughout the study area under all alternatives. Alternative 3 and Alternative 4 include a conservation measure (Conservation Measure DR-2) that could support control of this invasive species.

The more stable hydrograph under the proposed action, Alternative 3, and Alternative 4, compared to the no-action alternative, would be more likely to improve conditions for bullfrogs by providing year-round inundation of wetlands.[5] More stability in the hydrograph would also be more likely to improve conditions for non-native fish species such as brown bullhead catfish, brown trout, and three-spined sticklebacks known to prey on Oregon spotted frogs. However, Conservation Measure DR-2 provided under Alternative 3 and Alternative 4 could be used to fund bullfrog control measures, or address non-native fish species.

Oregon Spotted Frog

Emergent vegetation would track the flow inundation patterns to colonize areas that would become available during the growing season at the lower elevations. The total area covered by emergent vegetation would not necessarily change, but the topographical elevation where wetland vegetation is supported by water would be at the lowest elevations as flows are reduced during the growing season under full implementation of the Alternative 4, followed by higher elevations under the proposed action and Alternative 3, and the highest elevations under the no-action alternative. Along the river channel, vegetation would be expected to colonize areas lower in the channel profile.

[5] Bullfrogs require permanent wetland habitat to reproduce as tadpoles typically overwinter and metamorphose during their second year.

Individual Oregon spotted frog sites would respond variably depending on individual site topography, substrate characteristics, and dependence on the river as a water source.

Breeding

- During the breeding season, sites experience slightly more days of higher flows, above the flow threshold of 1,200 cfs, under the no-action alternative than the fully implemented Alternative 4, and somewhat fewer under the proposed action and fully implemented Alternative 3 (Figure 30). Wetland vegetation inundation provides substrate and cover for egg masses.
- There is slightly more year-to-year variability in days of flows greater than 1,200 cfs under the no-action alternative, compared to Alternative 4, and then the proposed action and Alternative 3 (Figure 30).
- From the hydrographs (Figure 29), sites within the reach would experience the largest change (increase) in flow under the no-action alternative as flows ramp up from the winter minimum at the onset of the irrigation season around April 1. Smaller changes in flow and associated water levels improve conditions for Oregon spotted frogs because there is less chance of displacing egg masses. Flows are consistent among all alternatives during the month of April.

The fully implemented Alternative 4 provides the most favorable combination of days of flows above 1,200 cfs and the smallest amount of change in water inundation levels at the beginning of the breeding season.

Rearing

- The no-action alternative consistently provides more days at higher flows (exceeding 1,200 cfs) that inundate vegetation during the rearing period than all other alternatives (Figure 31). Inundated vegetation provides cover for developing tadpoles and juvenile or adult frogs.
- Year-to-year variability, and associated stability, is similar among all alternatives (Figure 31).
- From the hydrographs (Figure 29), beginning in early- or mid-July through early August, the fully implemented proposed action, and Alternative 3 experience a decrease in flow and more year-to-year variability compared to the no-action alternative. This observation is amplified for Alternative 4.

The no-action alternative would outperform the fully implemented proposed action, Alternative 3 and Alternative 4 in number of days reaching the 1,200 cfs inundation threshold and in year-to-year stability.

Pre-Winter

- The count of days when flows exceed 900 cfs are slightly greater under the no-action alternative (median = 14 [31% of period]) compared to the fully implemented proposed action, Alternative 3, and Alternative 4 (median = 10 [22% of period] days for all three) (Figure 32).
- Year-to-year variability in count of days exceeding 900 cfs is similar among all alternatives (Figure 32).
- From the hydrographs (Figure 29), flows modeled for the fully implemented proposed action, Alternative 3 and Alternative 4 experience a similar decrease in flow through the pre-winter season, although the decrease is least under Alternative 4. The no-action alternative experiences

a larger decrease as flows are greater at the end of the rearing season and less during the overwintering period for this alternative compared to the others. The smaller change in water inundation elevation under the proposed action, Alternative 3, and Alternative 4 could mean fewer frogs would select poor overwintering sites that end up disconnected or above the waterline.

- Lower flow conditions late in the rearing season are more common under Alternative 4 than the proposed action or Alternative 3, and less common under the no-action alternative.

- Alternatives 3 and 4 include a Conservation Measure DR-2 that is lacking from the proposed action and the no-action alternative.

The proposed action, Alternative 3 and Alternative 4 would perform slightly worse than the no-action alternative regarding days of higher flows (exceeding 900 cfs), but the change in inundation level would be less drastic under the proposed action and Alternative 3 and even less so under Alternative 4 compared to the no-action alternative. The less drastic change in water inundation elevation may mean fewer frogs would select poor overwintering sites that end up disconnected or above the waterline. The no-action alternative and the proposed action both lack Conservation Measure DR-2 which would fund activities to restore and maintain habitat to benefit the covered species within the Deschutes River, including Oregon spotted frog. For these reasons, the fully implemented Alternative 3 and Alternative 4 would outperform the proposed action and no-action alternative.

Overwintering

- Flows reach the 900 cfs threshold most often under the fully implemented Alternative 4 (median = 101 days or 67% of period), followed by the proposed action or Alternative 3 (median = 79 days or 53% of the period), and finally the no-action alternative (median = 41 days or 27% of the period) (Figure 34).
    - Alternative 4 also demonstrates the lowest year-to-year variation in count of days flow exceeds 900 cfs compared to any other alternative (Figure 34).
- Flows regularly exceed the 500 cfs threshold under all alternatives, but the no-action alternative demonstrates a slightly higher failure to reach this flow than the other alternatives (Figure 34).
- From the hydrographs (Figure 29), flows under the proposed action, Alternative 3 and Alternative 4 steadily exceed the amount of flow under the no-action alternative throughout the overwintering season. Higher flows could result in more consistently wetted overwintering sites and shorter distances for frogs to travel between breeding and overwintering locations.

At full implementation, the proposed action and Alternative 3 provide higher sustained water levels throughout the overwintering period than the no-action alternative. Fully implemented Alternative 4 provides the highest sustained water elevation, and during wet years provides more opportunity for higher levels of inundation which could protect overwintering Oregon spotted frogs. Full implementation of Alternative 4 would outperform the other alternatives.

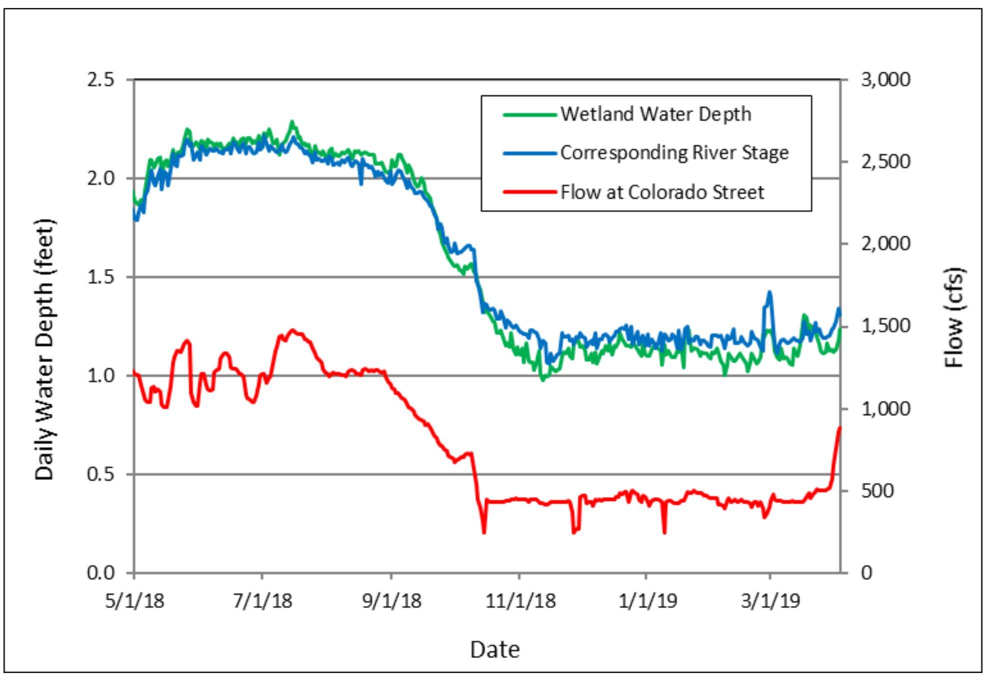
Site-Specific Analysis

LSA Marsh

LSA Marsh represents the most downstream extent of the Oregon spotted frog distribution in the Deschutes River system. It is also one of only two confirmed breeding locations in the reach, the other being Old Mill/Casting Pond, which is proximal to the LSA Marsh and not independent. LSA Marsh is therefore an important site for the species.

There is a strong correlation between the LSA Marsh and river flow volume in the Deschutes River (Figure 35). LSA Marsh wetland water elevations closely tracked changes in flow in the river from late April 2018 through April of 2019, indicating a direct hydrological connection between the river channel and the LSA Marsh (Vaughn 2019). Vaughn (2019) used the flow volume in the Deschutes River measured at the BENO gauge adjusted to reflect groundwater inputs and losses to reasonably predict the behavior of inundation in the adjacent LSA Marsh. Flows measured at BENO were adjusted to estimate flows within Reach 7 (Des-8a) adjacent to the LSA Marsh by subtracting measured flows diverted at the COID and Arnold canals and subtracting an additional 89 cfs to account for channel losses due to groundwater and evaporation, per Gannett et al. 2001.

Figure 35. Trends in Flow, River Stage and Wetland Water Depth in Deschutes River Reach Des-8a on a Daily Basis from April 27, 2018, to April 3, 2019



Source: Vaughn 2019.

The RiverWare Siphon2COID.Outflow internode data provide the closest modeled approximation of flows in Reach Des-8a under the alternatives. The hydrograph generated for Siphon2COID.Outflow (Figure 35) is consistent with the 2017 hydrograph presented in the Deschutes Project Biological Opinion from the period of October through late spring (U.S. Fish and Wildlife Service 2017, 2019). The Deschutes Project Biological Opinion noted a large amount of variability in flows at Reach 7 (Des-8a) and the data presented by the model reflect this. During the winter period of 2017, flows hovered around 600 cfs which is also consistent with the RiverWare output for the no-action alternative.

The strong correlation between river flow and wetland elevation demonstrated by Vaughn (2019) allows us to determine in-river flow thresholds that also improve conditions for Oregon spotted frog habitat in the adjacent LSA Marsh by reviewing historical flow data. The historical river flow records from the LSA Marsh site collected from 2010 through 2016 indicate flows stayed above at least 500 cfs during the winter. Oregon spotted frogs persisted at the LSA Marsh site under these conditions (U.S. Fish and Wildlife Service 2017, 2019). Throughout the rearing period which corresponds with the irrigation season and the highest annual flows, habitat conditions persisted while flows remained within a range of approximately 1,000 to 2,000 cfs. From these patterns and the known persistence of Oregon spotted frogs at the LSA Marsh, it can be inferred that Oregon spotted frog habitat conditions at LSA Marsh would be maintained with a minimum flow threshold of 500 cfs during the winter and flows of at least 1,000 cfs in summer.

The alternatives assessment and conclusions described for the Des-8a reach would also apply to the LSA Marsh because of the strong relationship between flows in the Deschutes River and water levels in the LSA Marsh.

Summary Conclusion

Table 8 summarizes the overall results of this comparison of each alternative to the no-action. Alternative 4 provides the best conditions for Oregon spotted frogs except during rearing when the no-action alternative provides the most days of inundation.

Reaches CLD-3 through CLD-6: Crescent Creek

Crescent Creek contains five known breeding sites for Oregon spotted frogs. All of these locations are at least 5 miles downstream from Crescent Lake. As explained in the Deschutes Project Biological Opinion (2017), it remains unclear the extent of influence Crescent Lake operations have on Oregon spotted frog habitat in Crescent Creek and along the Little Deschutes downstream of the Crescent Creek confluence, although there is a notable influence in the fall at the onset of the storage season. This uncertainty is due to large flow inputs from other unregulated sources such as Big Marsh Creek which flows into Crescent Creek, and the Little Deschutes River upstream from its confluence with Crescent Creek. Oregon spotted frog habitat is located along Crescent Creek downstream from Big Marsh Creek and along the Little Deschutes.

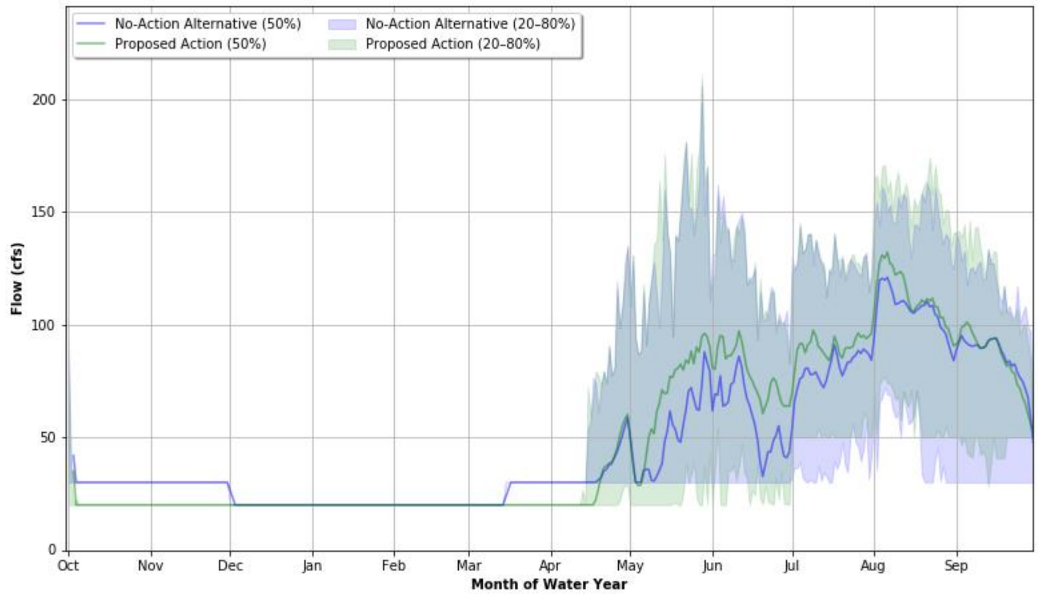
Reach-Level Analysis

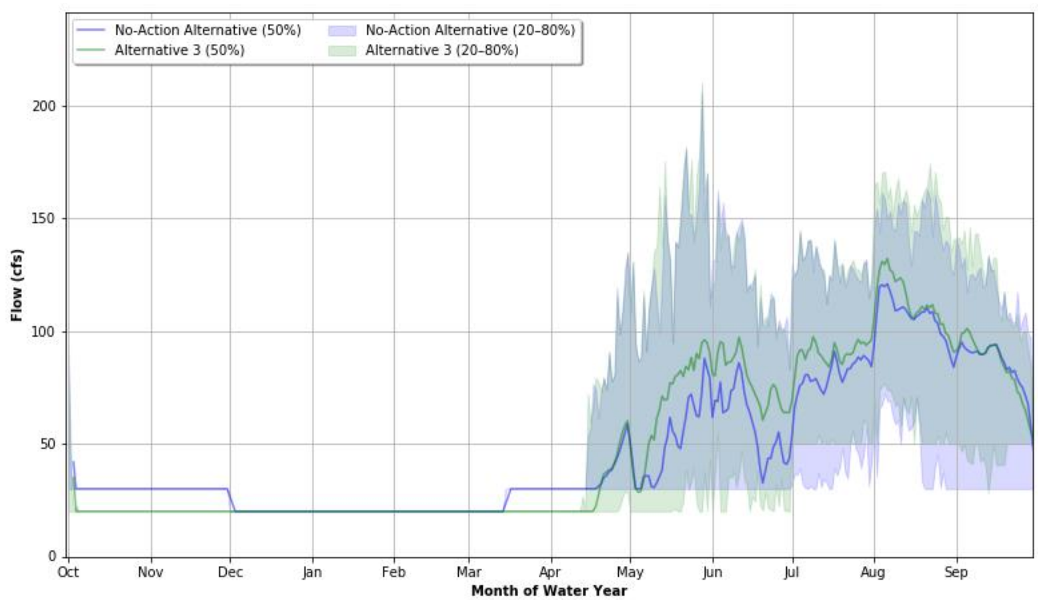
From the Deschutes Project Biological Opinion (2017), there are not clearly determined flow thresholds known to support high quality Oregon spotted frog habitat conditions. The analysis relied on the modeled hydrographs for the comparative assessment of the alternatives. The CREO gauge is located on Crescent Creek just downstream from Crescent Lake.

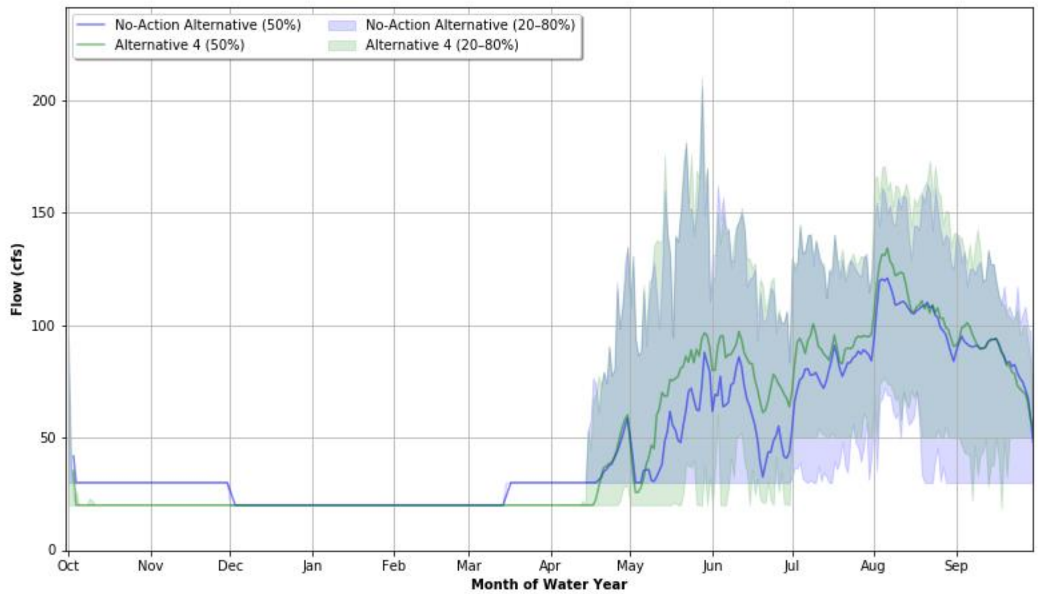
RiverWare Results

Figure 36 depicts daily flow hydrographs generated for the CREO gauge flows using RiverWare for the no-action alternative and the fully implemented proposed action, Alternative 3, and Alternative 4.

Figure 36. Crescent Creek Flow Modeled using RiverWare at the CREO Gauge for the No-Action Alternative Compared to the Proposed Action (top), Alternative 3 (middle), and Alternative 4 (bottom) at their Full Implementation







Pressure Transducer Data

Pressure transducer data collected in Crescent Creek and in the Little Deschutes River near La Pine, OR during 2015 were used to capture the relationship between flow and water surface elevations in this system under operational conditions similar to the no-action alternative (R2 Resource Consultants and Biota Pacific 2016). There was a minimum instream flow of 30 cfs in Crescent Creek from October through January, and irrigation water was released from late June through October.

Effects

Emergent Vegetation

Emergent vegetation would be expected to respond to changes in flow regime by tracking the seasonal inundation patterns as they overlap with the growing season.

The RiverWare model outputs indicate:

- Among the alternatives, inundation patterns during the growing season would be based on the highest flows under the proposed action, Alternative 3, and Alternative 4, which are roughly equivalent, and lowest under the no-action alternative (Fig 38 [hydrographs]). This means that emergent vegetation would be inundated up to the highest topographical or elevation level under the proposed action, Alternative 3, and Alternative 4.

Invasive Species

Reed canarygrass is already well established in the study area. Although its site-specific distribution would be expected to change by tracking water inundation elevation patterns during the growing season, it would be expected to persist throughout the study area under all alternatives. Alternative 3 and Alternative 4 include a conservation measure (Conservation Measure DR-2) that could support control of this invasive species. The less stable hydrograph under the proposed action, Alternative 3, and Alternative 4, compared to the no-action alternative, would be less likely to improve conditions for bullfrogs or for non-native fish species such as brown bullhead catfish, brown trout, and three-spined sticklebacks known to prey on Oregon spotted frogs.[6] In addition, Conservation Measure DR-2, under Alternative 3 and Alternative 4, could be used to fund bullfrog or non-native fish species control measures.

Oregon Spotted Frog

Emergent vegetation would track the flow inundation patterns to colonize areas that would become available during the growing season at the lower elevations. The total area covered by emergent vegetation would not necessarily change, but the topographical elevation where wetland vegetation is supported by water would be at the lowest elevations as flows are reduced during the growing season under the no-action alternative, followed by higher elevations under the proposed action, Alternative 3, and Alternative 4. Along the creek channel, vegetation would be expected to colonize areas lower in the channel profile under the no-action alternative compared to the proposed action, Alternative 3, and Alternative 4. Individual Oregon spotted frog sites would respond variably depending on individual site topography, substrate characteristics, and dependence on Crescent Creek as a water source.

Breeding Period

- During last half of March, the no-action alternative allows slightly more flow than the proposed action, Alternative 3, or Alternative 4 (Figure 36). The more gradual step up in flow under the no-action alternative may aid movement of frogs from overwintering sites to breeding locations compared to the proposed action, Alternative 3, and Alternative 4.

Rearing Period

- The proposed action, Alternative 3, and Alternative 4 consistently experience slightly more water in the system throughout the rearing period compared to the no-action alternative, therefore, sites closely associated with the creek hydrology would sustain more wetted area over the growing season, and possibly more habitat (Figure 36).

Pre-Winter

- Flows experience a greater decrease during the pre-winter for the proposed action, Alternative 3, and Alternative 4 compared to the no-action alternative (Figure 36). The less drastic change in flows may mean fewer frogs would select poor overwintering sites that end up disconnected or above the waterline.

Overwintering

- The hydrograph (Figure 36) indicates a reduced minimum outflow of 20 cfs under the proposed action, Alternative 3, and Alternative 4 compared to 30 cfs under the no-action alternative during the early and late portions the overwintering period. The 30 cfs flow volume is intended to benefit Oregon spotted frogs by maintaining more water in the system prior to the arrival of winter rains in the fall.

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[6] Bullfrogs require permanent wetland habitat to reproduce as tadpoles typically overwinter and metamorphose during their second year.

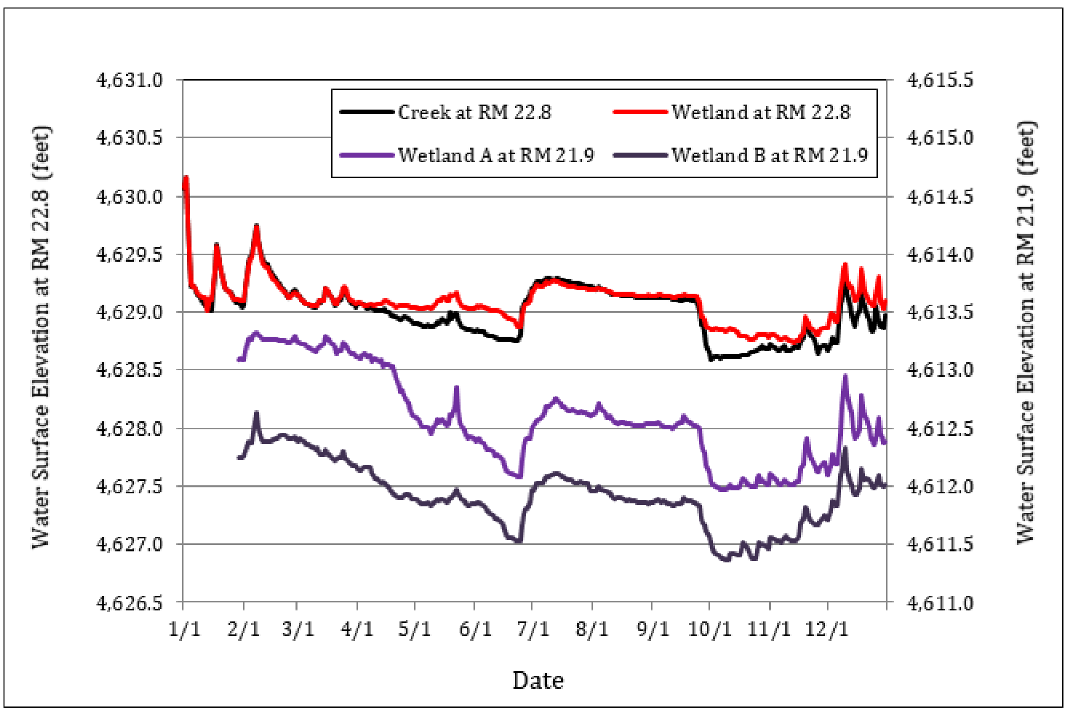
Site-Specific Analysis

Wetlands A and B below Hwy 58: RM 21.9

Wetlands A and B below Hwy 58 are occupied and support breeding Oregon spotted frogs. Frogs potentially overwinter in the wetlands. These two sites have surface connections with Crescent Creek although Wetland A is directly connected to surface flows year-round while Wetland B is only connected during high flow conditions (Chapter 8 of the Draft Deschutes Basin HCP). Both are influenced by rain and snow runoff as well as groundwater. Both are also located below the confluence of Big Marsh Creek with Crescent Creek. Big Marsh Creek contributes a significant amount of flow to Crescent Creek reducing the relative contribution of Crescent Lake to about 40 to 50% of the annual flow below this confluence (R2 and Biota Pacific Environmental Sciences 2016). This means that flows reported at the CREO gauge on Crescent Creek provide a general understanding of the seasonal flow patterns but they do not predict the site-specific inundation patterns at Wetland A and B and other sites farther downstream along Crescent Creek.

R2 and Biota Pacific Environmental Sciences collected pressure transducer data within Crescent Creek close to Wetlands A and B and within the wetlands during 2015 (R2 and Biota Pacific Environmental Sciences 2016). They reported a strong relationship between flow in the creek and associated elevation of water in the two wetlands (Figure 37).

Figure 37. Relationship between Daily Average Surface Water Elevation in Wetlands and Crescent Creek



Source: R2 and Biota Pacific Environmental Sciences 2016.

From the pressure transducer data, it can be concluded that the alternatives assessment described for the Crescent Creek reaches (CLD-3 through CLD-6) would also generally apply to Wetlands A and B along Crescent Creek because of the strong relationship between flows in Crescent Creek and water levels in the two wetlands, but the reach-level analysis would not detect site-specific responses to the flow changes that could occur under the different alternatives. The reach-level conclusions for each life history period allow a relative comparison of flow inputs to the system under the alternatives; however, there remains some risk that unanticipated site-specific responses to the alternatives in combination with other variable factors in the system could occur and could have negative impacts on the Oregon spotted frog and its habitat.

BLM Oxbows: RM 1.7

The BLM oxbows at river mile (RM) 1.7 on Crescent Creek are a known breeding site for Oregon spotted frogs. This site is directly connected to the creek and flows within the wetland directly track those in the creek (HCP). Similarly to RM 21.9 (Wetlands A and B below Hwy 58) the alternatives assessment and conclusions described for the Crescent Creek reaches (CLD-3 through CLD-6) would also apply to the BLM oxbows along Crescent Creek because of the strong relationship between flows in Crescent Creek and water levels in this wetland but the reach-level analysis would not detect site-specific responses to the flow changes that could occur under the different alternatives. The reach-level conclusions for each life history period allow a relative comparison of flow inputs to the system under the alternatives; however, there remains some risk that unanticipated site-specific responses to the alternatives in combination with other variable factors in the system could occur and could have negative impacts on the Oregon spotted frog and its habitat.

Summary Conclusion

Table 8 summarizes the overall results of this comparison of each alternative to the no-action. The no-action alternative outperforms the proposed action, Alternative 3, and Alternative 4 during all seasons except the rearing period. The proposed action, Alternative 3, and Alternative 4 perform similarly to each other with the exception of access to Conservation Measure DR-2 which is only included in Alternatives 3 and 4.

Reaches CLD-1 and CLD-2 Little Deschutes River

Oregon spotted frogs are distributed throughout the extent of the Little Deschutes River downstream of its confluence with Crescent Creek (U.S. Fish and Wildlife Service 2017, 2019). There are nine monitored breeding sites within the study area on the Little Deschutes below its confluence with Crescent Creek.

Reach-Level Analysis

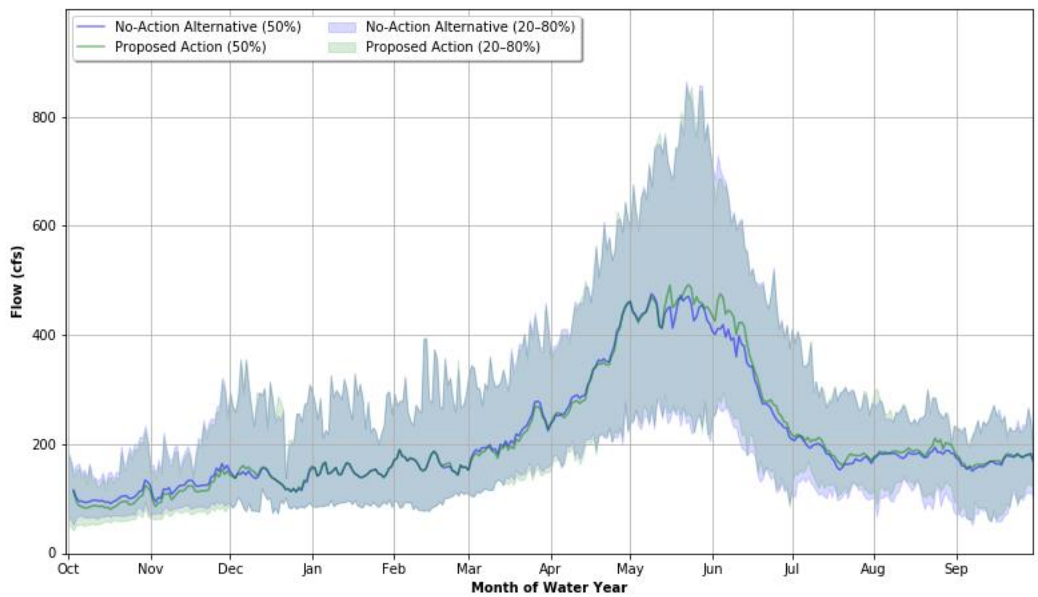
From the Deschutes Project Biological Opinion (2017), there are not clearly determined flow thresholds known to support high quality Oregon spotted frog habitat conditions in the Little Deschutes River. The analysis relied on the modeled hydrographs for the comparative assessment of the alternatives.

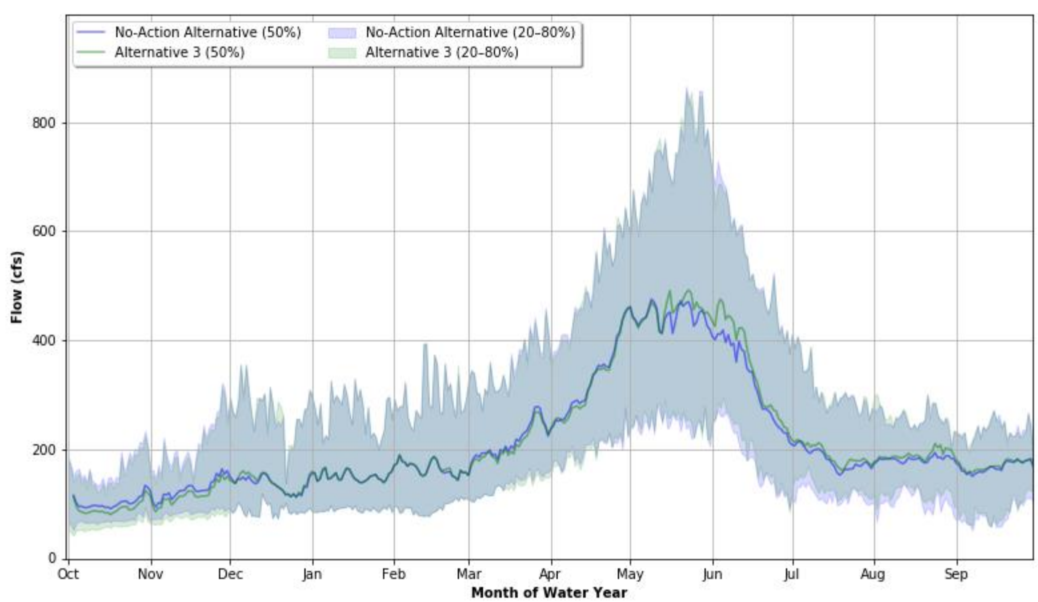
RiverWare Results

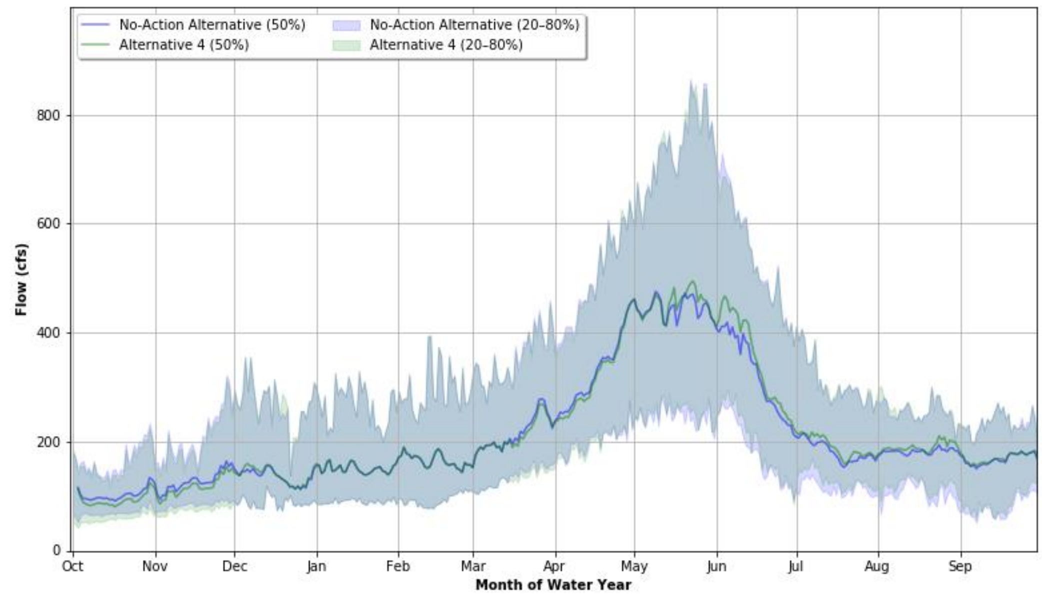
Hydrographs

Figure 38 depicts daily flow hydrographs generated for the LAPO gauge flows using RiverWare for the no-action alternative and the fully implemented proposed action, Alternative 3, and Alternative 4.

Figure 38. Little Deschutes River Flow Modeled using RiverWare at the LAPO Gauge for the No-Action Alternative Compared to the Proposed Action (top), Alternative 3 (middle), and Alternative 4 (bottom) at their Full Implementation



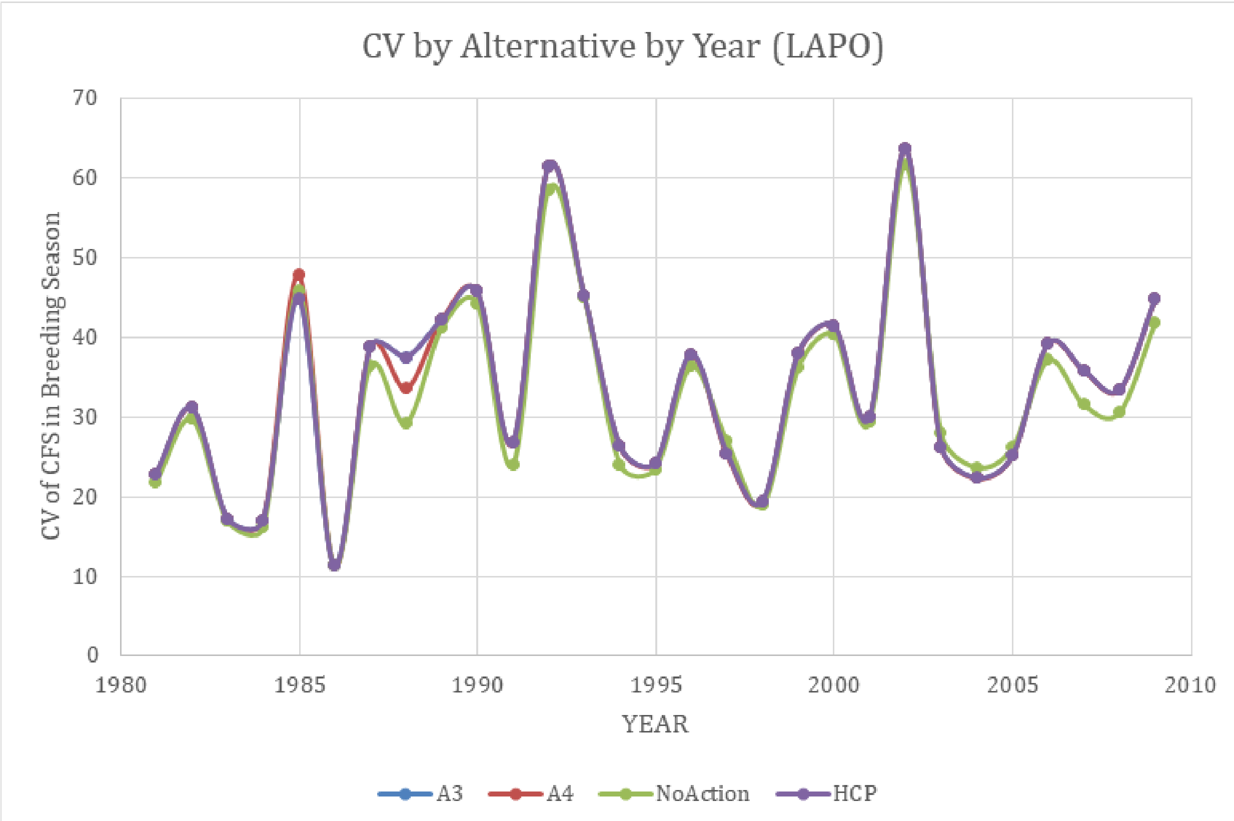




Within-Year Flow Variation

To better understand within-year variation in flow for each alternative, Figure 39 reports the Coefficient of Variation (CV) during the breeding season. The CV is the standard deviation divided by the average flow and allows us to compare within-year variability among the alternatives. Within-year flow variation is particularly important during the breeding season because the immobile egg masses are the most vulnerable life stage to either desiccation from receding water or displacement and subsequent exposure to deeper water predators.

Figure 39. The CV of within-Year Little Deschutes River Flow Modeled using RiverWare at the LAPO Gauge for Each Alternative during the Breeding Season (Proposed Action [HCP] and Alternative 3 [A3] overlap).



Effects

Emergent Vegetation

Emergent vegetation would be expected to respond to changes in flow regime by tracking the seasonal inundation patterns as they overlap with the growing season.

The RiverWare model outputs indicate:

- Among the alternative, inundation patterns during the growing season are similar among all of the alternatives (Figure 38 [hydrographs]). This means emergent vegetation would be inundated equally under all of the alternatives.

Invasive Species

Invasive species such as reed canarygrass, bullfrogs, and non-native predatory fish would be expected to respond similarly to all of the alternatives because flow regimes do not significantly vary among either any of the alternatives. Conservation Measure DR-2, under Alternative 3 and Alternative 4, could be used to fund control measures for bullfrogs, other non-native aquatic predators, and reed canarygrass.

Oregon Spotted Frog

Breeding Period

- There is little difference among all alternatives during the breeding season (Figure 38). Within-year variation is slightly less for the no-action alternative, providing slightly more stability in habitat inundation patterns and less risk of egg mass mortality, although the difference may be negligible (Figure 39).

Rearing Period

- There is little difference among the alternatives during the rearing period (Figure 38).

Pre-Winter

- There is little difference among the alternatives during the pre-winter period (Figure 38).

Overwintering

- There is little difference among the alternatives during the overwintering period (Figure 38).

Site-Specific Analysis

Casey Tract

The Casey Tract is located adjacent to the Lower Little Deschutes River downstream from the city of La Pine and it represents sites located below the confluence with Crescent Creek. Casey Tract is a productive breeding location for Oregon spotted frogs and breeding has been confirmed at the site since 2012. No pressure transducer data have been collected for the Casey Tract; however, this site is proximal to the LAPO gauge and flows measured for the Little Deschutes River at LAPO can be used to understand seasonal patterns of flow in the river.

The alternatives assessment and conclusions described for the Little Deschutes River reaches (CLD-1 and CLD-2) would also apply to the Casey Tract because of the strong relationship between flows in the Little Deschutes and water levels in the Casey Tract wetland.

Summary Conclusion

Table 8 summarizes the overall results of this comparison of each alternative to the no-action. All alternatives perform similarly to each other with the exception of access to Conservation Measure DR-2 which is only available to Alternatives 3 and 4.

Summary and Conclusions

This assessment compared the potential effects on Oregon spotted frogs and their habitat of the proposed action, Alternative 3, and Alternative 4 to the no-action alternative.

Table 8 summarizes the reach- and site-specific conclusions, indicating whether each alternative would have a net beneficial effect, and adverse effect, or a mix of beneficial and adverse effects compared to the no-action alternative. Effects are summarized by reach and key life history period.

Based on the assessment, Alternative 3 appears to offer the most improved conditions for Oregon spotted frogs and their habitat among the alternatives. Although Alternative 4 resulted in superior conditions during breeding, pre-winter, and overwintering at most reaches, it also performed most poorly during rearing and in Wickiup Reservoir. The proposed action is similar in effect to Alternative 3; however, it lacks the Conservation Measure DR-2.

Table 8. Effects of Hydrological Changes under the Proposed Action and Alternatives 3 and 4 on Oregon Spotted Frog by Key Life History Period Compared to the No-Action Alternative

	Proposed Action				Alternative 3				Alternative 4			
Reach	**B**	**R**	**P**	**O**	**B**	**R**	**P**	**O**	**B**	**R**	**P**	**O**
CLD-1 and CLD-2 (Little Deschutes River)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
CLD-3 through CLD-6 (Crescent Creek)	NE	BE	**AE**	**AE**	NE	BE	**AE**	**AE**	NE	BE	**AE**	**AE**
Des-8a (Central Oregon Diversion to Colorado Street)	BE	**AE**	BE	BE	BE	**AE**	BE	BE	BE+	**AE+**	BE+	BE+
Des-9 (Lava Island Falls to Central Oregon Diversion)	BE	**AE**	BE	BE	BE	**AE**	BE	BE	BE+	**AE+**	BE+	BE+
Des-10 (Dillon Falls to Lava Island Falls)	BE	**AE**	BE	BE	BE	**AE**	BE	BE	BE+	**AE+**	BE+	BE+
Des-10a (Benham Falls to Dillon Falls)	BE	**AE**	BE	BE	BE	**AE**	BE	BE	BE+	**AE+**	BE+	BE+
Des-11 (Little Deschutes to Benham Falls)	BE	**AE**	BE	BE	BE	**AE**	BE	BE	BE+	**AE**	BE+	BE+
Des-12 (Fall River to Little Deschutes)	BE	**AE**	BE	BE	BE	**AE**	BE	BE	BE+	**AE**	BE+	BE+
Des-12a (Wickiup Dam to Fall River)	BE	**AE**	BE	BE	BE	**AE**	BE	BE	BE+	**AE**	BE+	BE+
Des-13 (Wickiup Reservoir)	**AE**	**AE**	**AE**	**AE**	**AE**	**AE**	**AE**	**AE**	**AE+**	**AE+**	**AE+**	**AE+**
Des-14 (Deschutes River between reservoirs)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Des-15 (Crane Prairie Reservoir)	BE	BE	BE	BE	BE	BE	BE	BE	BE	BE	BE	BE

B=Breeding, R=Rearing, P=Pre-winter, O=Overwintering
BE = beneficial effect, AE = adverse effect, NE = no effect; "+" indicates increased level of effect

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Appendix 3.4-C
Fish and Mollusks Technical Supplement

Appendix 3.4-C

Fish and Mollusks Technical Supplement

Introduction

This appendix provides the technical supplement to the EIS for fish and mollusks, excluding Oregon spotted frog (presented in Appendix 3.4-B, *Oregon Spotted Frog Technical Supplement*). It describes the environmental setting, analysis methods, and environmental consequences for covered and non-covered fish and mollusks in the study area. It also includes summaries used to evaluate effects on fish and mollusks that would result from the proposed action and alternatives.

Study Area

The study area for fish and mollusks consists of waters where fish and mollusks could be affected under the proposed action and alternatives. The proposed action and Alternatives 3 and 4 would affect the hydrology and water quality of certain streams and reservoirs in the Deschutes Basin. These changes may, in turn, affect the survival and ability of fish and mollusks to complete their life cycle.

The study area for fish and mollusks is illustrated in Figure 1. Table 1 lists the 15 water bodies included in the study area for fish and mollusks.

The descriptions of affected environment and environmental consequences are organized into five geographic areas across the study area:

- Crescent Creek/Little Deschutes
- Upper Deschutes
- Middle Deschutes
- Crooked River
- Lower Deschutes

Figure 1. Fish and Mollusks Study Area

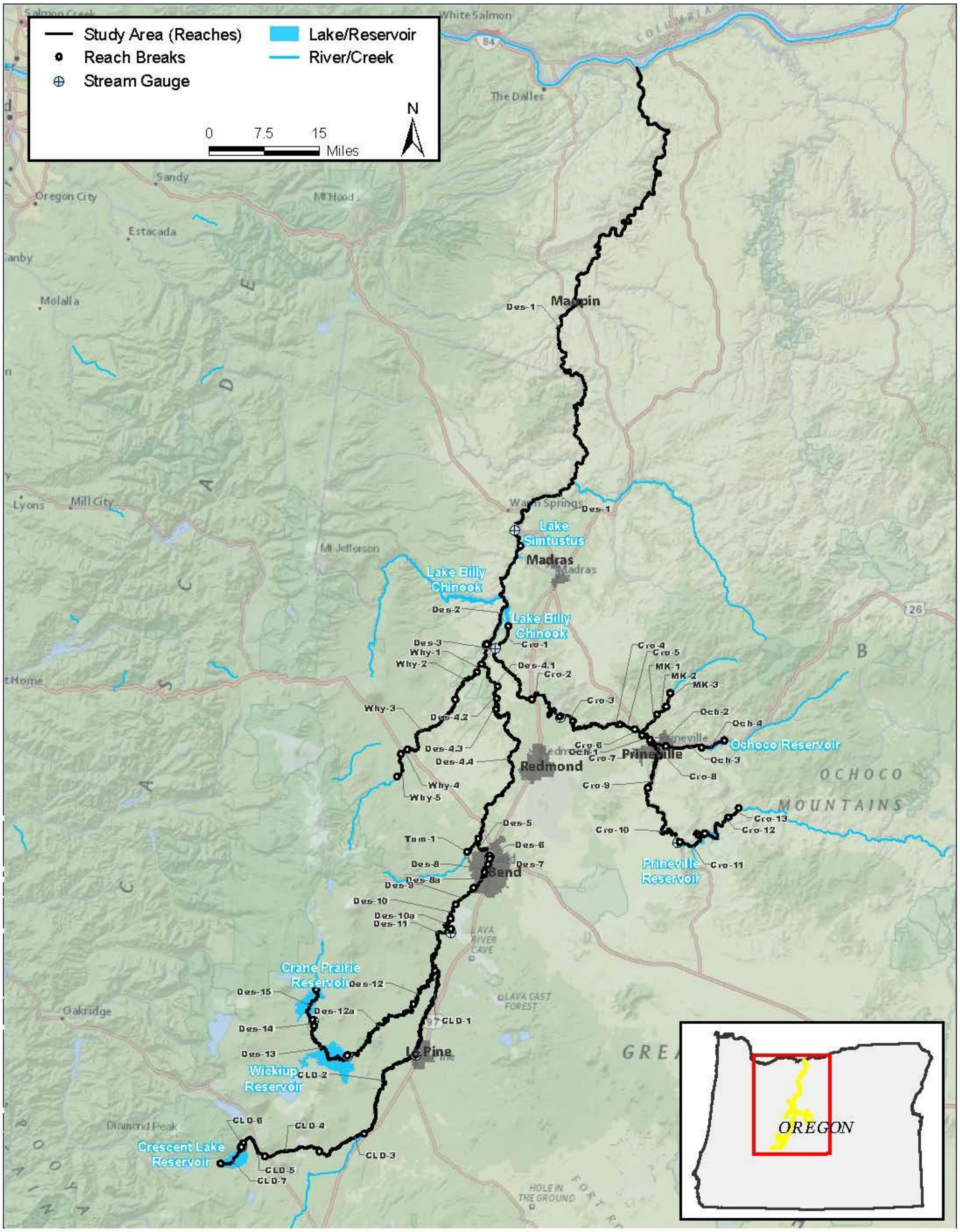


Table 1. Study Area Waterbodies

Geographic Area	Waterbody	Description
Crescent Creek/Little Deschutes	Crescent Lake Reservoir	A large natural body of water that has been increased with an outlet dam to provide irrigation water. In 1922, a small earth and wooden dam was built across the outlet to store water for irrigation via Crescent Creek, Little Deschutes and Deschutes Rivers. In 1956 a 40 foot-high earth and concrete structure was built to raise the reservoir volume. Water volume and elevation often varies dramatically over the year with lowest volumes at the end of the irrigation season in October. Crescent Lake Reservoir has very little riparian or wetland vegetation, some is present in three large embayments (the inflow stream and two slack water areas), these locations have mixed wetland and riparian vegetation.
	Crescent Creek	Tributary to Little Deschutes River; downstream of Crescent Lake Reservoir to the Little Deschutes River. Big Marsh Creek enters downstream of Crescent Lake Reservoir, adding at times significant additional streamflow to Crescent Creek (R2 and Biota Pacific 2016)
	Little Deschutes River	Tributary to Upper Deschutes River; Crescent Creek enters the Little Deschutes at RM 57. Streamflows are largely unregulated as inflows from other sources overwhelm any regulation at Crescent Lake Reservoir.
Upper Deschutes	Crane Prairie Reservoir	A relatively shallow reservoir originally dammed to store irrigation water managed by the Central Oregon Irrigation District. Crane Prairie Reservoir has locally extensive riparian/wetland vegetation on its margins and at its head. The upper limit of potential project effects on the Deschutes River.
	Wickiup Reservoir	A relatively shallow reservoir created to store irrigation water managed by the North Unit Irrigation District. Reservoir volume and elevation often varies dramatically over the year, with the lowest volumes being at the end of the irrigation season in October. The reservoir has little riparian/wetland vegetation but has provided significant sport fishing of several species.
	Upper Deschutes River	The Deschutes River between Crane Prairie and Wickiup Reservoirs, and the Deschutes River from Wickiup Reservoir to city of Bend. Streamflows are strongly influenced by water management at Wickiup Dam. Several tributaries and springs flow into the Deschutes below Wickiup.

Geographic Area	Waterbody	Description
Middle Deschutes	Middle Deschutes River	Deschutes River from Bend to Lake Billy Chinook. The upper section is heavily influenced by irrigation diversions. Groundwater inflows are significant in the lower portion of this section of river.
	Tumalo Creek	A westside tributary that flows into the Middle Deschutes River. Enters Deschutes River upstream of significant groundwater inflow, thus outflow from Tumalo Creek can have an effect on water quality in the Deschutes River during the summer. The Tumalo Diversion, is the upper limit of potential project effects.
	Whychus Creek	A westside tributary that flows into the Middle Deschutes River. Whychus Creek enters downstream of adult salmon and trout migration barriers on the Deschutes River.
	Lake Billy Chinook and Lake Simtustus	Round Butte and Pelton Dam Reservoirs, including the reregulating dam (RM 100).
Lower Deschutes	Lower Deschutes River	Deschutes River from Re-regulating Dam (RM 100) to Columbia River
Crooked River	Prineville Reservoir	A high desert reservoir with large wetland and benches or bars with shrub and herb riparian and wetland vegetation at the upper end and no riparian vegetation at the lower end.
	Crooked River	Bowman Dam (RM 70) to Lake Billy Chinook. The upper section (RM 70 to 48) is in a canyon and supports an important sport fishery on redband trout. Downstream the river flows through broad valley with extensive agriculture. The lower section beginning at about RM 34 is within a canyon and beginning at about RM 8 (Osborne Canyon) receives significant groundwater inflow providing high-quality salmonid habitat in the Lower Crooked River
	Ochoco Reservoir and Creek	Tributary to Crooked River at RM 46; Ochoco Reservoir is the upper extent of projected effects.
	McKay Creek	Tributary to Crooked River at RM 45

Fish and Mollusks

Table 2 lists the species in the study area that are evaluated in the EIS. Fish and mollusks included are those covered by the HCP, special-status species, and species that are of cultural and recreational interest. This appendix does not address Oregon spotted frog.

Table 3 lists the geographic extent within the study area by species.

Table 2. Fish and Mollusks Evaluated in the EIS

Taxonomic Group	Species Common Name	Species Scientific Name	Status	Origin
Species covered in the Deschutes Basin Habitat Conservation Plan				
Fish	Bull trout	*Salvelinus confluentus*	FT (FWS) SS	Indigenous
Fish	Steelhead trout	*Oncorhynchus mykiss*	FT (NMFS) SC	Indigenous, anadromous form
Fish	Spring Chinook salmon	*Oncorhynchus tshawytscha*	SS	Indigenous
Fish	Sockeye salmon	*Oncorhynchus nerka*	NA	Indigenous, anadromous form
Non-covered species evaluated in the EIS				
Fish	Redband trout	*Oncorhynchus mykiss*	NA	Indigenous, non-anadromous form
Fish	Kokanee Salmon	*Oncorhynchus nerka*	NA	Indigenous, non-anadromous form
Fish	Summer - fall Chinook salmon	*Oncorhynchus tshawytscha*	SS	Indigenous
Fish	Mountain whitefish	*Prosopium williamsoni*	NA	Indigenous
Non-native Trout	Brook Trout	*Salvelinus fontinalis*	NA	Introduced
Non-native Trout	Brown trout	*Salmo trutta*	NA	Introduced
Native Non-game Fish	Pacific lamprey	*Entosphenus tridentatus*	SS	Indigenous
Native Non-game Fish	Bridgelip sucker	*Catostomus columbianus*	NA	Indigenous
Native Non-game Fish	Largescale sucker	*Catostomus macrocheilus*	NA	Indigenous
Native Non-game Fish	Chiselmouth	*Acrocheilus alutaceus*	NA	Indigenous
Native Non-game Fish	Northern pikeminnow	*Ptychocheilus oregonensis*	NA	Indigenous
Native Non-game Fish	Dace species	*Rhinichthys* (spp.)	NA	Indigenous
Native Non-game Fish	Sculpin species	Family Cottidae	NA	Indigenous
Mollusks	Crater lake tightcoil	*Pristiloma crateris*	NA	Indigenous
Mollusks	Evening field slug	*Deroceras hesperium*	NA	Indigenous
Mollusks	Floater species mussels	*Anodonta* (spp.)	NA	Indigenous
Mollusks	Western pearlshell mussel	*Margaritifera falcata*	NA	Indigenous
Mollusks	Western ridged mussel	*Gonidea angulata*	NA	Indigenous

FT = Federally listed as threatened
SC = Candidate for listing as threatened or endangered on the Oregon state Threatened and Endangered Species List (Oregon Department of Fish and Wildlife 2016)
SS = A species listed as an Oregon Sensitive Species (Oregon Department of Fish and Wildlife 2016)
NA = Not applicable

Table 3. Geographic Extent of Fish and Mollusks in the Study Area

Species Common Name	Crescent Lake Reservoir	Crescent Creek	Little Deschutes	Crane Prairie Reservoir	Wickiup Reservoir	Upper Deschutes	Middle Deschutes	Tumalo Creek	Whychus Creek	Lake Billy Chinook/Lake	Crooked River	Prineville Reservoir	Ochoco Creek	McKay Creek	Lower Deschutes
Bull trout							X		X	X	X		X	X	X
Steelhead trout							X		X	X	X		X	X	X
Spring Chinook salmon							X		X	X	X		X		X
Sockeye salmon									X	X	X				X
Redband trout	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Kokanee Salmon	X			X	X				X	X					
Summer/Fall Chinook Salmon															X
Mountain whitefish	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pacific lamprey															X
Largescale sucker	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bridgelip sucker	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Chiselmouth	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dace species	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Northern pikeminnow										X	X	X			X
Sculpin species	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Brook Trout	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Brown trout	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Crater lake tightcoil	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Evening field slug	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Floater species mussels											X				
Western pearlshell mussel		X	X			X	X	X	X		X		X	X	X
Western ridged mussel							X		X	X	X	X			

*These species exist in perennially wet forested areas or riparian areas potentially throughout the basin.

HCP Covered Fish Species

This section describes extent and life history for the four covered fish species in the Draft Deschutes Basin Habitat Conservation Plan (HCP). Additional information about these species is in the Chapter 5 of the Draft Deschutes Basin HCP, *Covered Species*.

Bull Trout

Bull trout (*Salvelinus confluentus*) were federally listed as threatened on June 10, 1998 (FR 63; 31647), and critical habitat was designated in the study area in September 2005 (70 FR 185; 56212) and revised on September 30, 2010 (U.S. Fish and Wildlife Service 2010, FR 75(200) 63898). The Deschutes Basin is considered a population stronghold for the species. Within the study area there are four known locations with bull trout: Lower Deschutes River, Lake Billy Chinook, Deschutes River above Lake Billy Chinook upstream to Big Falls, the lower Crooked River upstream to Opal Springs Dam and with upstream with passage at Opal Springs Dam the Crooked River upstream of Osborne Canyon to Bowman Dam, and lower Whychus Creek.

The predominant life history type in the study area is a migratory, adfluvial form, where a large body of water (e.g., reservoir) is used by subadults and adults to increase feeding opportunities and accelerate growth. Adfluvial bull trout in the study area use Lake Billy Chinook where they forage for prey in shallow areas of the reservoir. Bull trout occupy deep areas of the reservoir where water temperatures are cool (7–12°C [45–54°F]) and move to the surface when surface water temperatures drop to or below 12°C (54°F). At other times of the year, these fish may move upstream to forage in the lowermost portions of the Crooked River where water temperatures are cool from substantial groundwater inflow and the middle and upper Crooked River during the winter, Deschutes River, or Whychus Creek.

Bull trout require cold water temperatures, complex stream habitat, connectivity between spawning and rearing areas, and downstream foraging, migration, and overwintering habitats (U.S. Fish and Wildlife Service 2015a). Water temperature is typically the primary limiting habitat characteristic, with temperatures above 15°C (59°F) limiting bull trout distribution (Batt 1996; McCullough et al. 2001). Such temperatures are only found in the uppermost reaches of headwater streams during summer months, or in spring fed systems like the Metolius River.

Steelhead Trout

Middle Columbia River (MCR) steelhead (*Oncorhynchus mykiss*) Distinct Population Segment (DPS) were listed as threatened by NMFS in March 1999 (FR 64:4517) and reaffirmed in January 2006. Final critical habitat designation was published in September 2005, with an effective date of January 2006 (FR 70:52360). Steelhead critical habitat downstream of the Pelton-Round Butte Complex is included in this listing. Efforts are currently underway to reintroduce steelhead upstream of the complex and steelhead in the Deschutes Basin upstream of the complex is designated an experimental population under the Endangered Species Act (ESA) and is subject to different protections under ESA.

Steelhead were historically present upstream of the Pelton-Round Butte Complex to Big Falls (river mile [RM] 131.7) on the Deschutes River, in the Crooked River and tributaries, and throughout Whychus Creek. Multiple fish passage barriers blocked steelhead migration to the upper basin. Migration barriers in the Crooked River are in Ochoco Creek (RM 10) and at Bowman Dam (RM 70) on the Crooked River. Fish passage facilities will be added at Opal Springs Dam on the Crooked River in 2019 providing volitional passage. The Deschutes Reintroduction and Conservation Plan (Oregon Department of Fish and Wildlife and Confederated Tribes of Warm Springs 2008) is underway to re-establish steelhead production within the Crooked River Basin up to Ochoco and Bowman dams. Reintroduction efforts are a combination of hatchery stock from the Round Butte Hatchery and adults that originated from natural spawning upstream of the Pelton-Round Butte Complex.

Deschutes River steelhead are the summer-run variety. Adult steelhead enter freshwater during the summer and migrate up the Deschutes River from June through October. Deschutes River steelhead spawn from the middle of March to the end of May (Zimmerman and Reeves 2000). Major limiting factors for the three summer steelhead populations in the Deschutes Basin are degraded floodplain and channel structure, degraded riparian communities, water quality (temperature, chemical contaminants and nutrients), altered hydrology, altered sediment routing, blocked and impaired fish passage, and limited spawning habitat. Land use has been identified as having the most key concerns of any threat category affecting MCR summer steelhead populations (Interior Columbia Technical Recovery Team 2008). Specific threats related to land use include agriculture, grazing, forestry and road maintenance activities that result in impaired upstream and downstream movement of juvenile and adult steelhead, impaired physical habitat quality, impaired water quality due to elevated water temperatures and agricultural chemicals, and reduced water quantity and/or modified hydrologic processes. For the Crooked River, operation of irrigation systems is included as a land use activity that negatively affects summer steelhead by altering seasonal hydrographs and increasing summer water temperatures.

Spring Chinook Salmon

Deschutes spring Chinook (*O. tshawytscha*) are part of the mid-Columbia spring Chinook Evolutionarily Significant Unit (ESU). This ESU is not listed under ESA.

Spring Chinook salmon are present in the Deschutes River and its tributaries downstream of the Pelton-Round Butte Complex. Historically, they were present upstream of the Complex up to Big Falls on the Deschutes River, which was a natural barrier to migration and spawned in the Deschutes, Crooked, and Metolius Rivers and in lower Whychus Creek (Fies et al. 1996a, 1996b). By 1968 they were extirpated from these areas with construction of the Pelton Round Butte Project completed in 1964. Reintroduction of spring Chinook salmon above the Pelton-Round Butte Complex is currently underway.

Spring Chinook adults enter freshwater during the spring (April through June) and tend to migrate relatively far upstream before they spawn in late summer and early fall. Spring Chinook may also hold through the summer in cooler portions of rivers and streams in deepwater pools before making a final migration to upstream spawning areas. Cool summer water temperatures are critical for adult holding through the summer. In the Crooked River, adult spring Chinook may hold through in the lower river where groundwater inflow maintains cooler temperatures through the summer. These adults may then make a second migration in the fall higher into the Crooked River when water temperatures are cooler and thermal barriers to migration are no longer present. Adult spring Chinook spawn from August to October in accessible areas of the Deschutes River, Whychus Creek, and the Crooked River. Eggs remain in the gravel until spring. Juvenile rearing occurs all months of the year.

Under existing conditions, over 75% of the available habitat in the Upper Deschutes Basin is in river reaches that are inaccessible to fish (Spateholts 2008). Habitat conditions for Chinook salmon in the Lower Deschutes River are not likely to be constrained by flow and temperature conditions due to the relatively stable environment created by controlled water releases. Spawning and rearing habitat for mid-Columbia spring Chinook has been affected by agriculture (water withdrawals, livestock grazing, and agricultural effluents) throughout the range of the ESU, and migration corridors have been affected substantially by hydroelectric development (Myers et al. 1998). The most notable threat to the persistence of the spring Chinook in the Deschutes Basin is the presence of passage barriers that restrict access to historical habitat areas. Water temperatures and degraded habitat are significant stressors affecting spring Chinook. The presumed presence of the fish parasite *Ceratomyxa shasta* in the mainstem Deschutes River below Steelhead Falls (RM 127) and the mainstem Crooked River below the Lone Pine Bridge (RM 30) is also a threat to the successful reintroduction underway of spring Chinook salmon in the Upper Deschutes Basin (Oregon Department of Fish and Wildlife and Confederated Tribes of Warm Springs 2008).

Sockeye Salmon

Anadromous sockeye salmon (*O. nerka*) were historically present in tributaries to the Deschutes Basin upstream of the Pelton-Round Butte Complex. This species was extirpated by tributary passage problems and the construction of Round Butte Dam. Efforts are currently underway to reestablish anadromous sockeye salmon upstream of Pelton-Round Butte in the Metolius River, a tributary not in the study area (Oregon Department of Fish and Wildlife and Confederated Tribes of Warm Springs 2008). Within the study area, sockeye salmon use Lake Billy Chinook for adult migration and juvenile rearing in spring and may also spawn the fall in lower portions of the Crooked River, Whychus Creek, and the Deschutes River upstream of Lake Billy Chinook. Eggs remain in the gravel through the winter.

Sockeye salmon spawn in rivers and streams and in some cases lake beaches. Spawning sockeye typically seek out tributaries to lakes and reservoirs with suitable riffles or areas with smooth flow (Groot and Margolis 1991). Successful sockeye production and survival are dependent on sufficient instream temperature (Bell 1986) and flows for migration, spawning, egg incubation, and juvenile outmigration. In addition, sockeye salmon survival is dependent on stream conditions with minimal siltation, stable stream banks, and overhanging vegetation (Hartman et al. 1962).

Upon emergence from spawning beds sockeye fry migrate to nearby lakes and reservoirs and spend 1 to 2 years before migrating to sea. Sockeye adults return in mid-summer and may hold for short periods in Lake Billy Chinook before continuing to migrate to spawning areas.

Non-Covered Fish and Mollusks

This section describes extent and life history for species not covered in the Deschutes Basin HCP. These species are included in the EIS because of their special status, cultural and recreational significance, and ecological significance.

Redband Trout

Redband trout (*O. mykiss*) are present in all streams, rivers, and reservoirs of the study area, including downstream of the Pelton-Round Butte Complex. Primary redband trout production areas above Lake Billy Chinook include the mainstem Deschutes River, Tumalo Creek, Whychus Creek, the

Metolius River, and the Deschutes River above Crane Prairie Reservoir, Crooked River below Bowman Dam and tributaries to the Crooked River. They appear to be reproductively isolated from steelhead when sympatric.

Redband trout are present in the rivers throughout the study area year-round. They spawn in the spring and early summer; spawning timing varies across the Deschutes River Basin, with peak spawning occurring from January through May in the Upper Deschutes (and March through May in the Lower Deschutes (Zimmerman and Reeves 2000). Redband trout fry may emerge from the gravel from June through August, depending on spawn timing and water temperatures during egg incubation.

Redband trout are often called “desert trout” because they show a greater tolerance for high water temperatures, low dissolved oxygen levels, and extremes in streamflows that frequently occur in desert climates. Instream flow modifications and changes in water quality have the potential to affect redband trout in the study area.

Kokanee Salmon

Kokanee salmon are not listed on the state or federal sensitive species lists. They are a biologically significant species in Lake Billy Chinook, Wickiup Reservoir and Crane Prairie Reservoir, and support a substantial sport harvest in these locations. There historically has been a significant sport harvest of kokanee salmon in Wickiup Reservoir and until recently Wickiup Reservoir kokanee were abundant and sport harvest had very liberal (25 fish) daily catch limits for kokanee.

Kokanee are a non-anadromous (remain in freshwater) life history form of sockeye. They are smaller in size compared with sockeye and reach sexual maturity at 3 years of age. Similar to sockeye, adult kokanee spawn in the fall and die after spawning. Kokanee from Lake Billy Chinook migrate upstream each fall to spawn in the first 2 miles of Whychus Creek (Fies et al. 1996a) and within the tributaries of the Metolius River (Schulz and Thiesfeld 1996). A few fish also spawn in the Crooked River below Opal Springs, the Deschutes River, and other small tributaries (Stuart et al. 1996).

Kokanee eggs hatch in the Metolius River Basin from early December through early February, with emergence occurring from January through April. Most fry migrate downstream to a lake in late March and early April, where they rear for 4 years, at which point they return to their stream and spawn. Successful kokanee production and survival are dependent on sufficient instream temperature (Bell 1986) and flows for migration, spawning, egg incubation, and juvenile outmigration.

Kokanee populations currently exist in the reservoirs of Lake Billy Chinook, Wickiup, Crescent Lake Reservoir, and Crane Prairie. Most kokanee in the Deschutes Basin are associated with Lake Billy Chinook and the Metolius River.)

In the Upper Deschutes kokanee in Wickiup Reservoir migrate and spawn in the short segment of the Deschutes River below Crane Prairie Dam. Due to an unscreened outlet of the reservoir, kokanee are often found immediately downstream in the Deschutes River and as far as Bend, as evidenced by Central Oregon Irrigation District’s fish trap (Fies et al. 1996b). Kokanee in Crane Prairie Reservoir migrate and spawn in the headwaters of the Deschutes River above Crane Prairie.

Summer/Fall Chinook Salmon

The Deschutes River Summer/Fall-run Chinook ESU includes naturally spawning populations of summer/fall Chinook salmon from the Deschutes River downstream of the Pelton-Round Butte Complex. Nehlsen (1995) concluded this life history form occurred in portions of the basin upstream of the Pelton-Round Butte Complex based on historic accounts of Chinook observations at the Pelton Dam trap.

Non-Native Trout Species (Brook and Brown Trout)

Brook *S. fontinalis* and brown trout *Salmo trutta* were introduced into the Deschutes Basin in the early 1900s. Brook trout are now widely distributed thought the Deschutes Basin upstream of the Pelton-Round Butte Complex. Brown trout are found in the Deschutes River mainstem downstream of Crane Prairie Dam, in Wickiup Reservoir, East Lake, Crescent Lake Reservoir, Spring River, Tumalo Creek, and the Fall River. They are also present in the Little Deschutes River Basin, where they occur high in the system above Highway 58 (U.S. Fish and Wildlife Service 2002). These non-native fish compete with native fish, like redband and bull trout, for resources.

Brook trout prefer clear, cool, well-oxygenated streams and lakes. As temperatures rise, they migrate to deeper waters in lakes or reservoirs (ODFW 2018). Brown trout are more tolerant of warm water temperatures that occur downstream of the city of Bend in the summer and low water conditions below Wickiup in the winter. Young brown trout can be found in open riffle waters. As they mature, they prefer deeply undercut banks, log or brush jams, and areas under overhanging stream brush. Both species spawn in the fall and fry would emerge from the gravel from February through March.

Native Non-Game Fish Species

Native non-trout species and non-game species in the study area include, mountain whitefish (*Prosopium williamsoni*), Pacific lamprey (*Entosphenus tridentatus*), Bridgelip sucker (*Catostomus columbianus*), largescale sucker *(C. macrocheilus*), chiselmouth (*Acrocheilus alutaceus*), northern pikeminnow (*Ptychocheilus oregonensis*), and multiple species of dace (*Rhinichthys*) and sculpin (family Cottidae). Except for Pacific lamprey, which is anadromous, these fish have the potential to occur in all life stages in the rivers and reservoirs throughout the study area.

Mountain Whitefish

Mountain whitefish (*Prosopium williamsoni*) are large native game fish found in lakes, reservoirs, and streams with large pools, preferring clear, cold water. Within the study area, mountain whitefish can be found in the Deschutes River mainstream from the headwaters to Lake Billy Chinook, the Crooked River, and in Crane Prairie and Wickiup Reservoirs.

Mountain whitefish spawn November through early December, with eggs hatching 5 months later at temperatures above 35°F. They reach sexual maturity at 3 to 4 years and live up to 8 years. Mountain whitefish feed on aquatic and terrestrial insects and occasional other fish (NatureServe 2018).

Pacific Lamprey

Pacific lamprey (*Entosphenus tridentatus*) is a federal Species of Concern and is an Oregon sensitive species in the Deschutes Basin. Their historical range has been greatly reduced as they no longer occur above impassable barriers in the West and their numbers have declined thought the Columbia River Basin. Current distribution within the study area is limited to the Deschutes River downstream of the Pelton-Round Butte Complex.

Pacific lamprey are anadromous. They spawn in gravel nests in stream riffles, like salmon, with eggs hatching in approximately 19 days. After hatching the larva drift downstream and bury themselves in low velocity habitats where they live as filter feeders for the next 3 to 7 years. Larva then transform to juveniles and begin to move downstream between late fall and spring where they mature into adults and enter the ocean. Adults live in the ocean for 1 to 3 years before returning to streams between February and June to spawn between March and July of the following year.

Bridgelip Sucker

Bridgelip sucker (*Catostomus columbianus*) is a sucker with an overall range as far north as the Fraser River in British Columbia and as far south as the Snake River in Nevada; the taxonomy of this species is somewhat unclear (NatureServe 2018). In the Deschutes Basin, the bridgelip sucker has been found from Steelhead Falls downstream to Lake Billy Chinook, and has also been found in Whychus Creek and Indian Ford Creek (Deschutes National Forest 2018). Bridgelip Sucker are also found in the Crooked River, Ochoco Creek, and McKay Creek.

This species is considered secure by NatureServe (Global Status: G5/ National Status: N5), and has an IUCN rating of least concern. In Oregon, its rating is S4 (apparently secure) (NatureServe 2018).

Bridgelip suckers range from 5 inches at maturity to as long as 17 inches. Bridgelip suckers are thought to spawn in late spring and are broadcast spawners. It is a non-migrant, and feeds by scraping algae from rocks in addition to likely supplementing its diet with insect larvae or other aquatic invertebrates.

The preferred habitat of bridgelip suckers is small or medium swift rivers with cold water and gravelly bottoms. They can also be found in rivers with more moderate flow and sandy or silty bottoms, as well as reservoirs, indicating they have a wide range of adaptability to aquatic environments.

No major threats are known to this species, and there is little known about its biology.

Largescale Sucker

The overall range of the largescale sucker includes many areas of western North America, as far north as the Peace River drainage in British Columbia and the Smokey River drainage in Alberta, to as far south as the Snake River drainage in Nevada. In the Deschutes Basin, the largescale sucker resides in the mainstem Deschutes from Steelhead Falls to Lake Billy Chinook, Crooked River, McKay Creek and Ochoco Creek.

The largescale sucker is ranked as secure globally and nationally by NatureServe (G5/N5), and is ranked S4 in Oregon (apparently secure). IUCN categorizes the largescale sucker as of least concern (NatureServe 2018).

Largescale suckers can reach 2 feet in length, can reach up to 7 pounds in weight, and can live longer than 8 years. Becoming reproductively mature by 4 or 5 years of age, largescale suckers spawn in the spring with females depositing as many as 20,000 eggs that hatch in approximately 2 weeks. Fry remain in the gravel or on the sand surface for a few weeks, and as they grow move toward deeper water and toward the bottom. Adults generally live at depths of a few feet, but can be found at depths as great as 80 feet. Largescale suckers primarily eat small invertebrates and insect larvae, and eat larger food items as they grow. Food items can also include mollusks, fish eggs, detritus, diatoms, and algae. Largescale suckers may consume trout eggs, and may also compete with trout species for food.

Largescale suckers are non-migrants, and primarily inhabit medium to large rivers near the stream bottom in pools and runs, and also can be found in lakes near stream mouths, shorelines with aquatic vegetation, or backwaters.

Chiselmouth

The chiselmouth (*Acrocheilus alutaceus*) is a cyprinid with a spotty distribution in British Columbia, Washington, Oregon, Idaho and Nevada (NatureServe 2018). In the Deschutes Basin, it is found in the mainstem from Big Falls to Lake Billy Chinook, and also in the lower reaches of Whychus Creek and Paulina Lake (Deschutes National Forest 2018).

The chiselmouth is considered nationally and globally secure with NatureServe ratings of G5 and N5, and an IUCN rating of Least Concern, though it has a rating of S4 (apparently secure) in Oregon.

In a study of a population in British Columbia, it was found that spawning generally occurred in mid-summer. Individuals are thought to become mature at 3 or 4 years of age, reaching a maximum age of about 6 years (NatureServe 2018). Chiselmouth can reach a length of about 20 centimeters. Chiselmouth are local migrants; there is evidence that lake populations migrate to tributaries to spawn. While young chiselmouth primarily feed on insects and invertebrates, adults primarily feed on diatoms that they scrape from rocks or other substrate (NatureServe 2018).

Chiselmouth prefer warmer areas of small to medium rivers in moderately fast to fast water. They have been found in pools and runs over sand or gravel substrate, and in margins of lakes. Juvenile chiselmouth rear in calmer areas of water (NatureServe 2018).

While no major threats are known to this species, it could be threatened by habitat loss in relation to impoundments. There is little known about this species (NatureServe 2018).

Northern Pikeminnow

Northern pikeminnow (*Ptychocheilus oregonensis*) are large fish with a large overall range that includes drainages as far north as the Nass River in British Columbia to as far south as the Columbia River drainage of northern Nevada (NatureServe 2018). In the Deschutes Basin, northern Pikeminnow can be found in Lake Billy Chinook as well as Lake Simtustus and the Prineville Reservoir (Deschutes National Forest 2018).

Northern pikeminnow are considered secure at a global and national level by NatureServe (G5 ranking) and are considered apparently secure in Oregon with a S4 ranking. IUCN ranks northern pikeminnow as of least concern (NatureServe 2018).

Northern pikeminnow become sexually mature at 3 to 4 years of age, and gather in large numbers up to 8,000 fish in lakes or streams to broadcast spawn in summer months. Adhesive eggs sink to gravel where they only incubate for about a week before hatching. These fish are long-lived with a lifespan of up to 15 to 20 years. Northern pikeminnow feeds on other fish, insects and other invertebrates, and plankton. While they generally are lake species, young fish move to inshore waters during the summer and spawners may also move to nearby streams (Deschutes National Forest 2018; NatureServe 2018).

Dace Species

Multiple species of dace (*Rhinichthys*) are indigenous to Central Oregon. In the Deschutes Basin, they are present the Crooked River, in lower Whychus Creek and in the Deschutes River downstream of Steelhead Falls (Deschutes National Forest 2018).

Dace require water that is above 50°C and are generally 4 to 6 inches in length. They spawn in the spring in shallow, gravely areas. Instead of constructing a nest, males selectively guard territories and females select which males to spawn near. Dace maintain positions near the stream bottom of even, fast-flowing streams; they have wedge shaped heads and reduced air bladders that aid them in staying in this habitat. Dace primarily consume insect larvae (Deschutes National Forest 2018).

Sculpin species

Multiple species of sculpin (family Cottidae) can be found in the mainstem Deschutes and tributaries downstream of Wickiup Reservoir (Deschutes National Forest 2018).

Reaching a length of 6 to 7 inches, sculpin spawn in the spring. They primarily feed on aquatic insect larvae and can be piscivorous (i.e., prey on other fish species) and are often prey items themselves of piscivorous fish. They prefer streams with cobble, boulder, or flat rock bottoms (Deschutes National Forest 2018).

Freshwater Mollusks

This species group includes the Crater Lake tightcoil snail, evening field slug, and several species of freshwater mussels present in the study area.

Crater Lake Tightcoil

The Crater Lake tightcoil (*Pristiloma crateris*) is an air-breathing, non-migrant terrestrial snail that is associated with aquatic habitats, primarily wet meadows or riparian areas along small streams (Blackburn 2017). It is known to occur along streams within the study area. The most records of this species in Oregon occur in the Deschutes National Forest (Blackburn 2017), with other documentations in the Fremont-Winema forest, Mt. Hood, Willamette, Umatilla, and Umpqua National Forests.

The Crater Lake tightcoil is ranked as imperiled at the global, national, and state levels by NatureServe (G2, N2, and S2). It was petitioned for federal listing as endangered in 2011 but the petition was considered unwarranted (Blackburn 2017). One of the most important habitat features for Crater Lake tightcoil is that its riparian habitat has perennially moist soil. Thus, decreases in the water table or riparian and wetlands areas inundated can impact its survival. One survey for this species discovered that snails were not found in grazed areas in meadows, while they were found in nearby ungrazed areas (Blackburn 2017), suggesting grazing may pose a threat to population persistence. Any actions that cause soil compaction could be detrimental to this species, as could actions that alter groundwater levels or affect canopy cover. Water diversions or impoundments, construction and heavy equipment use, logging and recreation are all potential threats (Blackburn 2017). Because of their patchy distribution, 1-year life cycle, and limitations on reproduction due to seasonal events at higher elevations, this species may be vulnerable to stochastic disturbances (Blackburn 2017).

Evening Field Slug

The evening field slug (*Deroceras hesperium*) is a terrestrial mollusk associated with moist habitats specifically in areas where soil is consistently saturated. It is patchily distributed throughout Oregon, with records on both sides of the Oregon Cascades. It has been found in and surrounding Portland, Oregon, as far east as Hood River; in Klamath River (Jackson County); and in the Elliot State Forest, and it is believed to occur in patches throughout the Cascade and Klamath Basin. Most current records are on the eastern slopes of the Cascades; this species' historical range also extends into western Washington and Vancouver Island, B.C. though it may be extirpated in these areas (Burke and Duncan 2005; NatureServe 2018).

The evening field slug is rated N2 at a national level and S2 for the state of Oregon, which is considered imperiled (NatureServe 2018). This species is most threatened due to habitat loss and especially loss of moisture. Draining of their habitat or conversion of habitat from wet meadows to agricultural uses, urban uses, or forest management would all be detrimental. Hydrological alterations that reduce inundation of wetlands are a threat to this species, and activities that lower the water table would be harmful (Burke and Duncan 2005).

Freshwater Mussels

Three species of native freshwater mussels reside in the Deschutes River Basin: the California floater (*Anodonta californiensis*, treated the same as the winged floater *Anodonta nuttalliana* in the same clade), the western pearlshell (*Margaritifera falcata*), and the western ridged mussel (*Gonidea angulata*, also known as the Rocky Mountain ridged mussel). All three species are recognized as Species of Greatest Conservation Need within the state of Oregon and are protected under scientific take permits by the State of Oregon (Blevins et al. 2018).

Overall, freshwater mussel adults are benthic organisms that live in a number of freshwater environments. Mussels are fairly immobile as adults, and depending on the species may exist singly; in sparsely concentrated groups; or in large, concentrated groups known as mussel beds. Mussels filter water with their gills both for oxygen and for food (Blevins et al. 2018).

California Floater and Winged Floater Mussels

The California floater can be difficult to identify (along with other floater mussels) due to its lack of obvious shell characteristics; genetic studies are currently being developed to aid in distinguishing between the species. Currently, the winged floater (*Anodonta nuttalliana*) is treated along with the California floater as one clade (*Anodonta* clade 1) for conservation purposes (Blevins et al. 2018).

Floater species overlap in range and often co-occur (Blevins et al. 2018). Floaters are usually found at low elevations in floodplain ponds, reservoirs and lakes, and rivers or creeks with muddy or sandy substrate where burrowing is possible (Blevins et al. 2018). In the Deschutes Basin, the

California Floater has observed records in the Crooked River near Smith Rock State Park, including confirmed recent sightings (Xerces and CTUIR 2018).

The California floater is currently ranked as vulnerable (G3/N3) at a global and national level due to its patchy distribution and decreased range. The California floater is ranked S2 (imperiled) at the state level for Oregon (NatureServe 2018). IUCN ranks *A. nuttalliana* as vulnerable due to a decrease in watershed area size and extent of occurrence (Blevins et al. 2016c).

Western Pearlshell Mussel

The western pearlshell is the longest-lived of these three mussel species; some individuals have been found to live up to 100 years or more (Blevins et al. 2018). The habitat of western pearlshell is usually in perennial rivers and streams, and at a variety of elevations from sea level to approximately 8,000 feet. Areas in river that have low velocity, shear stress, and gradient, plus a variety of sediment types, are generally preferred (Blevins et al. 2018). In the Deschutes Basin, the western pearlshell has been found in the mainstem Deschutes as far downstream as the Lower Deschutes downstream of the White River and as far upstream as near Bend. It has also been found in the Little Deschutes River, the lower Crooked River, and Ochoco Creek (Xerces and CTUIR 2018).

While the western pearlshell is in decline, both in overall distribution and number of specific sites and individuals, it is still ranked as secure by NatureServe at the global and national levels due to its widespread distribution with hundreds of occurrences (NatureServe 2018). However, IUCN ranks the western pearlshell as near threatened due to its decreasing population trend (Blevins et al. 2016a). At a state level in Oregon it is ranked as vulnerable by NatureServe (S3).

Western Ridged Mussel

The monospecific western ridged mussel is a long-lived freshwater mussel (up to 30 years or more). They prefer well-oxygenated environments generally in stable areas with boulders, sand, silt, or cobble substrate. In the Deschutes Basin, the western ridged mussel has been found in the mainstem Deschutes just upstream of Whychus Creek and in many portions of the Crooked River upstream to near Swartz Canyon. The most recent records are all in the Crooked River, especially near Smith Rock State Park (Xerces and CTUIR 2018).

NatureServe ranks the western ridged mussel as G3 globally and N3 nationally (vulnerable) due to decline in range and in number of sites and individuals; it is ranked S2S3 at a state level for Oregon (imperiled/vulnerable). IUCN ranks the western ridged mussel as vulnerable due to a decreasing population trend and decline in number of mature individuals (Blevins et al. 2016b). The western ridged mussel is more pollution- and disturbance-tolerant than many western freshwater mussels, though it is still sensitive (NatureServe 2018).

Methods

The description of the affected environment relied on best available information in existing publications describing conditions in the study area and the biology and ecology of habitats and species potentially occurring in the study area.

The analysis of effects on fish and mollusks relied on evaluation of predicted hydrologic data for specific reaches and representative sites with detailed information on seasonal patterns of channel inundation at known flow. Alternatives were evaluated using a combination of flow summaries.

These summaries included annual hydrologic data and monthly median flows. Additional information used were results of results of habitat and water temperature modeling in support of the Deschutes Basin HCP.

RiverWare

RiverWare model simulations for the EIS alternatives were generated for a 29-year period using water years to October 1, 1980, to September 30, 2009. Appendix 3.2-A, *Water Resources Technical Supplemental*, provides an overview of the RiverWare model, description of inputs to the simulation, and information on how RiverWare was used to generate daily streamflow across the study area for each alternative, and analysis years.

Effects were evaluated by comparing modeled outputs for the proposed action, Alternative 3, and Alternative 4 to outputs for the no-action alternative.

Reach-level analysis of effects was based on modeled results for RiverWare nodes, which are locations with a USGS or OWRD gauge. For reaches without nodes or locations of particular interest (e.g., Crooked River streamflow below the North Unit ID pump), internode locations in RiverWare were used to evaluate reach level effects. RiverWare modeled output for internode locations are based on the nearest upstream node and assumptions for gains and losses associated with diversions, surface- and groundwater exchange, and tributary inputs. The internode outputs are a less reliable predictor of streamflow; however, they provide a valuable understanding of conditions at these ungauged locations.

The effects analysis considered the following types of RiverWare outputs.

- Annual hydrographs of daily streamflow combined across all 29 years with median, 20% and 80% daily flows.
- Median monthly streamflows by water year with summaries of change in median flow relative to the No-action alternative and frequency of increase and decrease in monthly median flow across the simulation years
- Occasionally daily streamflows within timeframes relevant to fish and mollusks that are shorter than a month
- Annual and monthly reservoir elevations

Each output type is described in the sections below using examples.

Annual Hydrograph

The annual hydrograph provides an overall assessment of differences in daily streamflow across all 29 analysis years. The median, 20% and 80% streamflows are calculated for each day of the year and plotted. The annual hydrograph provides a generalized picture of how median flows vary between alternatives and the range of variability in daily streamflow. The 20% and 80% range was used in these plots to exclude the extreme range of daily streamflow produced by RiverWare and provide a more reasonable projection of potential variation in streamflow across the analysis years.

Figure 2 shows the annual hydrograph for the Crescent Lake Reservoir outlet (CREO). In this example winter flows are stable across years based on a release schedule from Crescent Lake Reservoir. The median, 20% and 80% daily flows do not vary among years. In contrast, spring and summer daily flows are much more variable by day and among years. Overall there is little difference under the proposed action across the implementation phases over the course of the 30-year permit term at this node. The proposed action median flows in October and November are approximately 25% and 10% lower than the no-action, respectively, and proposed action median streamflows in March and April are approximately 20% lower than the no-action. In other months the proposed action median streamflows tend to be slightly higher (~20%) than the no-action. The proposed action streamflows appear to be slightly more variable across years in August compared to the no-action.

Figure 3 shows the annual hydrograph at the LAPO node in the Little Deschutes River. This node includes outflow from Crescent Lake Reservoir (CREO), contribution of tributary inflow, groundwater, and inflow from the Little Deschutes River. In this example winter streamflows are more variable across years from differences in Little Deschutes River streamflow and spring daily streamflows are much more variable. Overall there is little difference across the proposed action phases over the 30-year permit term at this node. In addition, there are very minor differences (<10%) in daily median streamflow between the no-action, proposed action, and Alternatives 3 and 4. Differences in streamflow at the Crescent Lake Reservoir outlet are masked by inflows from unregulated tributaries and the Little Deschutes River. There is no evidence that the proposed action streamflows substantially different or are more variable across years compared to the no-action.

Figure 2. Example Annual Hydrograph for Crescent Lake Reservoir Outlet for Crescent Lake Reservoir Outlet (CREO node)

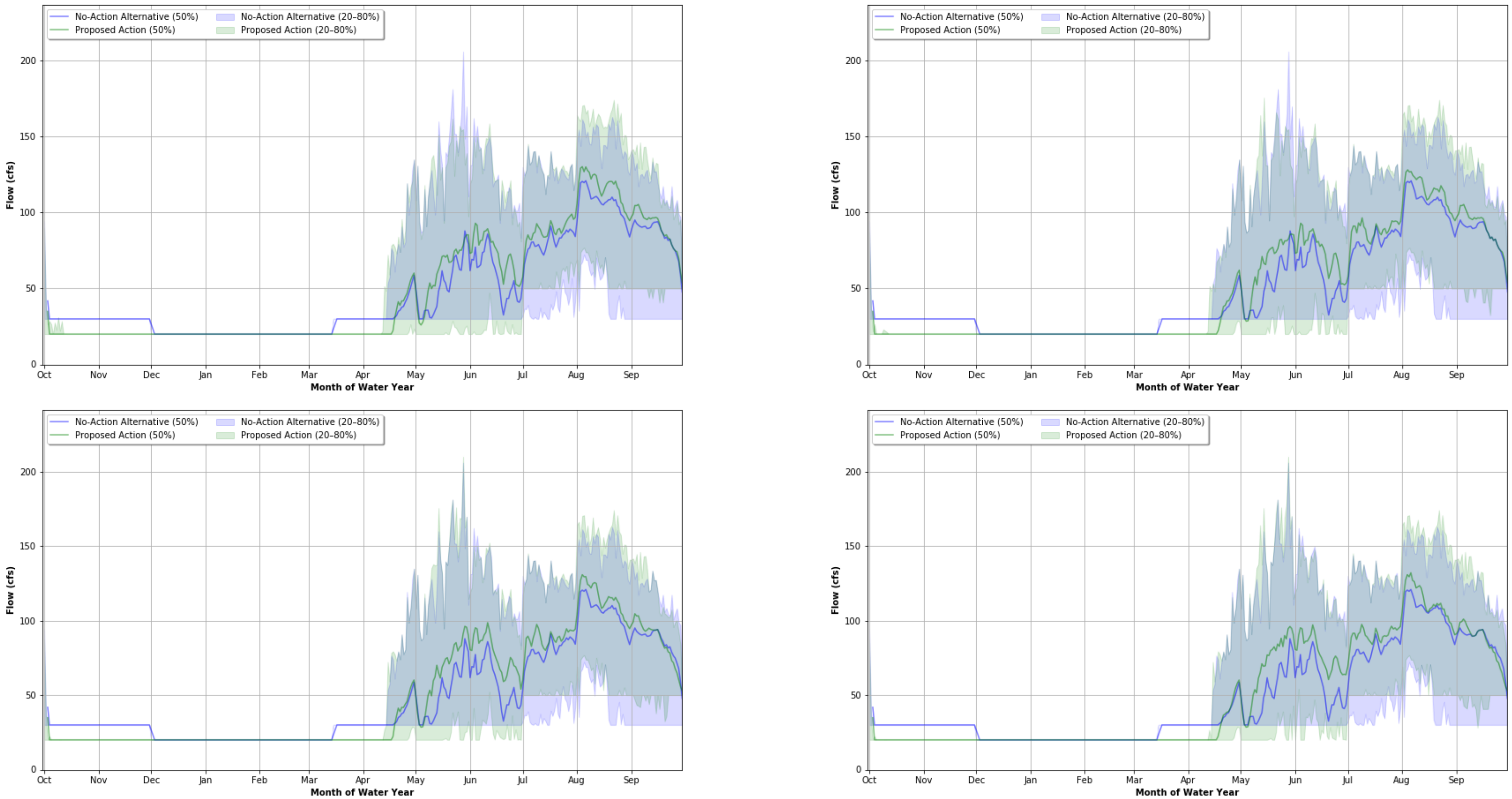
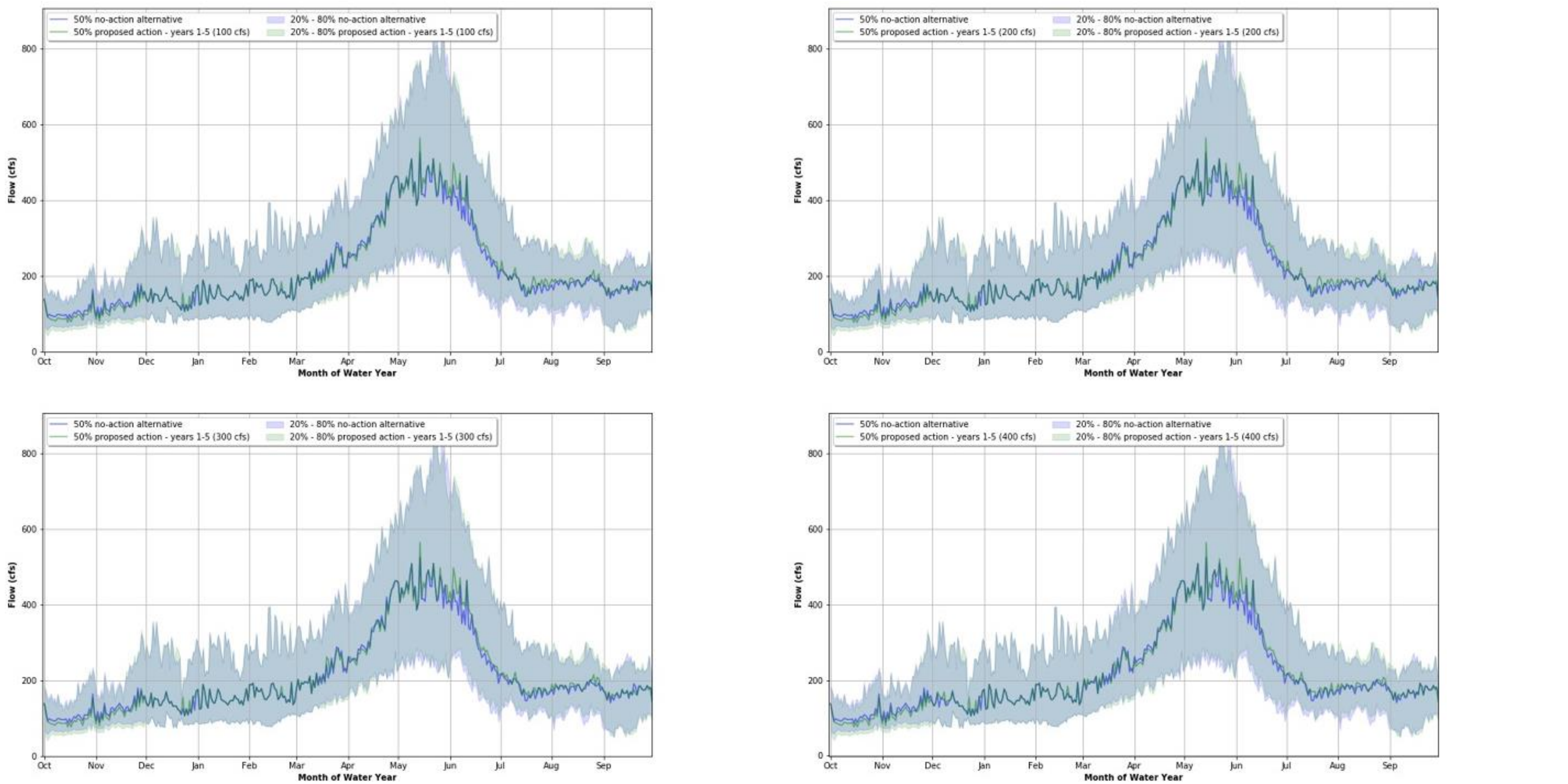


Figure 3. Example Annual Hydrograph for Little Deschutes River (LAPO node)



Monthly Median Streamflows

A more detailed analysis of differences and species impacts was made by comparing monthly median streamflows among water years. These summaries provided an understanding of streamflow variability across the RiverWare simulation years and how the alternatives differ by water year. Table 4 and Table 5 present summaries of differences in median streamflow by month at the CREO and LAPO nodes. These summaries are the percentage difference in median streamflow calculated as:

$$\%Diff = \frac{(PA\ Month\ Median\ Flow - NA\ Month\ Median\ Flow)}{NA\ Month\ Median\ Flow} * 100$$

Median monthly streamflow was calculated for each year of the RiverWare simulation. In the tables the average difference is the average for all years. The tables also include the range in differences in median streamflow by month across the RiverWare modeled years. Years with median streamflow that was higher or lower under the alternative relative to the no-action alternative were summarized separately.

For example, at the CREO node in nearly a majority of years (12 of 29 years) median streamflow was higher in June, an average increase of 48% across years. In contrast, median streamflows under the proposed action were lower in March and April in most years (25 and 21 years respectively), approximately 30% lower.

The same pattern of higher and lower median streamflows is observed at the LAPO node. However, the differences in median streamflow between the no-action alternative and proposed action are not as great because of the influence of the Little Deschutes River inflow and differences might be deemed not significant with respect to fish and mollusks. The percentage difference between the no-action alternative, the proposed action, Alternative 3, and Alternative 4 changes at different nodes depending on the no-action median streamflow. For example, the percentage change between the no-action and proposed action at Bowman Dam on the Crooked River may be between 200 and 300% downstream at the CAPO node for the same month. The proposed action streamflow may not change between the two locations, but the greater percentage difference at CAPO is because the no-action alternative streamflow at CAPO is lower relative to the proposed action streamflow at Bowman Dam.

The frequency of change in streamflow was evaluated by month across the RiverWare modeled analysis years. A “majority of years” is more than 50% of the years in the analysis period. The term “most years” designates 75% of the years in the analysis period fall in a certain category, and the term “few years” designates less than 25% of the years in the analysis period. These categories were used to categorize the frequency of years with different streamflow conditions.

The assessment also considered the magnitude of change in streamflow relative to habitat conditions. Median streamflow and the 20% to 80% range of daily streamflows in a month and water year were summarized and put into bar charts to better understand the potential for effects related to differences under an alternative.

Figure 4 is an example water year at the Crescent Lake Reservoir outlet (CREO). Median streamflow in the April and May are lower under the proposed action in years 1 through 5 and slightly higher in July and August. In contrast, median streamflow under the proposed action in years 21 through 30 are the same as the no-action alternative in most months.

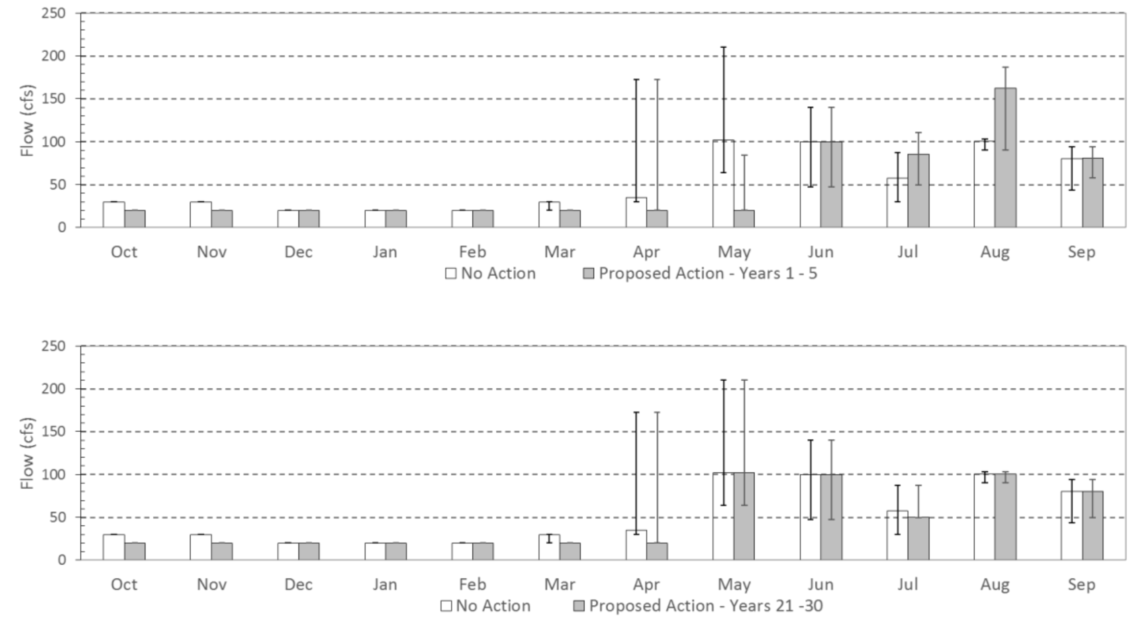
Table 4. Monthly Median Streamflows for Crescent Lake Reservoir Outlet (CREO node) in Example Analysis Year under the No-Action Alternative and Proposed Action (Years 1–5 and 21–30)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
Average diff. median flow (%)	-25%	-22%	21%	0%	0%	-24%	-18%	1%	10%	16%	20%	9%
Range diff. in monthly median flow (%)	-80–233%	-33–233%	0–300%	0–0%	0–0%	-75–167%	-42–86%	-80–125%	-87–151%	-1–180%	-6–67%	-80–67%
# Years no diff. in median flow	0	2	27	29	29	3	5	11	10	22	17	20
# Years increase in median flow	1	1	2	0	0	1	3	8	12	7	11	7
Range increase in monthly median flow (%)	233%	233%	300%	NA	NA	167%	7–86%	17–125%	6–151%	8–180%	6–67%	9–67%
Average increase median flow (%)	233%	233%	300%	NA	NA	167%	35%	47%	48%	65%	51%	49%
# Years decrease in median flow	28	26	0	0	0	25	21	10	7	0	1	2
Range decrease in monthly median flow (%)	-80–-25%	-33–-33%	NA	NA	NA	-75–-33%	-42–-15%	-80–-15%	-87–-30%	NA	-6–-6%	-80–-18%
Average decrease median flow (%)	-36%	-33%	NA	NA	NA	-36%	-30%	-40%	-48%	NA	-6%	-59%

Table 5. Summary Monthly Median Streamflows for Little Deschutes River (LAPO node) under the No-Action Alternative and Proposed Action (Years 1–5)

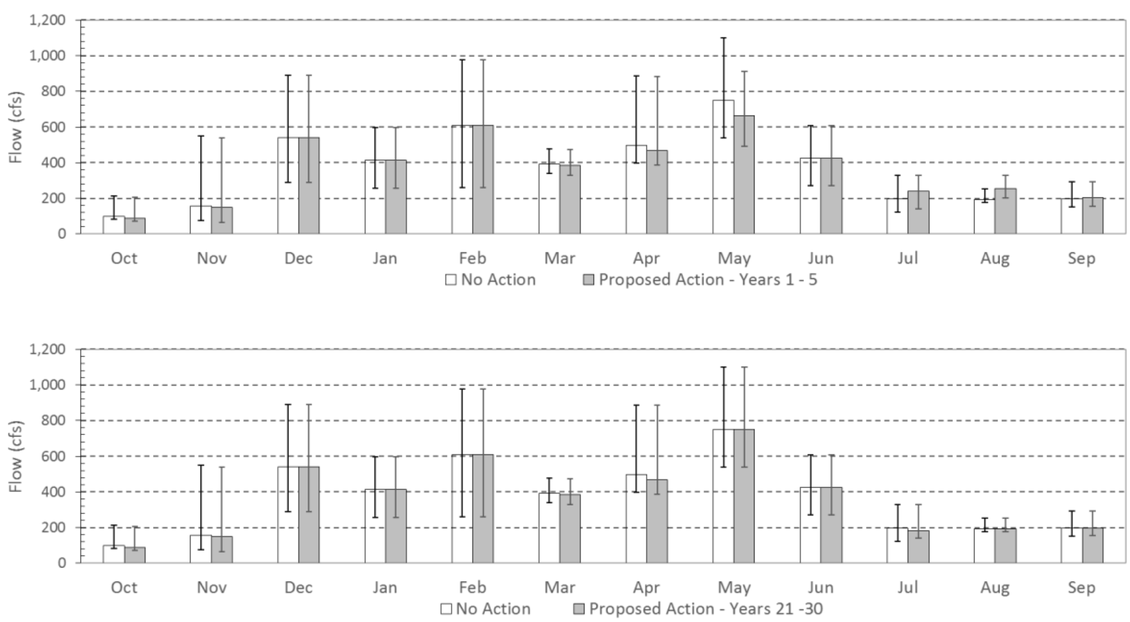
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
Average diff. median flow (%)	-8%	-7%	2%	0%	0%	-3%	-1%	0%	3%	8%	11%	6%
Range diff. in monthly median flow (%)	-29–15%	-13–13%	0–38%	0–0%	-8–0%	-10–11%	-6–11%	-12–9%	-18–20%	-10–53%	-2–52%	-24–76%
# Years no diff. in median flow	6	4	27	29	28	23	25	25	18	19	16	19
# Years increase in median flow	2	1	2	0	0	1	3	2	10	9	13	8
Range increase in monthly median flow (%)	13–15%	13%	34–38%	NA	NA	11%	8–11%	6–9%	6–20%	5–53%	5–52%	9–76%
Average increase median flow (%)	14%	13%	36%	NA	NA	11%	9%	8%	11%	23%	25%	26%
# Years decrease in median flow	21	24	0	0	1	5	1	2	1	1	0	2
Range decrease in monthly median flow (%)	-29–-6%	-13–-5%	NA	NA	-8–-8%	-10–-6%	-6–-6%	-12–-8%	-18–-18%	-10–-10%	NA	-24–-7%
Average decrease median flow (%)	-12%	-9%	NA	NA	-8%	-8%	-6%	-10%	-18%	-10%	NA	-18%

Figure 4. Monthly Median Streamflows at Crescent Lake Reservoir Outlet (CREO) in Water Year 1996: No-Action Alternative vs. Proposed Action, Years 1–5 (top) and 21–30 (bottom). Vertical lines indicate the 20% to 80% range of streamflows in the month.



Further downstream in the Little Deschutes River (LAPO) the differences in monthly median streamflows in the spring are much less for the water year represented by 1996 (Figure 5). There remains a slight reduction in median streamflow in May and a slight increase in July and August under the proposed action in years 1 through 5.

Figure 5. Monthly Median Streamflows in the Little Deschutes River (LAPO node) in Water Year 1996: No-Action Alternative vs. Proposed Action, Years 1–5 (top) and 21–30 (bottom). Vertical lines indicate the 20% to 80% range of streamflows in the month.



Daily Streamflow Patterns

Modeled daily streamflows extreme variation in some months and water years. The substantial variability in daily streamflows reported from RiverWare occurs more often when reservoir storage is low during the irrigation season. This is because of limitations in the RiverWare model logic and its simplification of a complex set of interactions between water delivery, and reservoir volume and inflow. The analysis of daily predictions assumes actual water management would smooth daily water management to provide a more predictable daily irrigation delivery. Because of this limitation of RiverWare logic and extreme variability in the daily results in some cases, the effects analysis examined variability using a 7-day running average.

However, there are years and periods in the RiverWare time series simulation when the proposed action and Alternatives 3 and 4 result in substantially lower streamflows during the irrigation period (May through September) compared to the no-action alternative. Although RiverWare results include in some years substantial flow regulation from Wickiup Reservoir (WICO node) under the no-action alternative and proposed action in years 1 through 5, regulation was more common in later years of the permit term under the proposed action and Alternatives 3 and 4 when winter releases from Wickiup Reservoir are higher and storage during the irrigation season is insufficient to supply irrigation water through the entire summer (Figure 6).

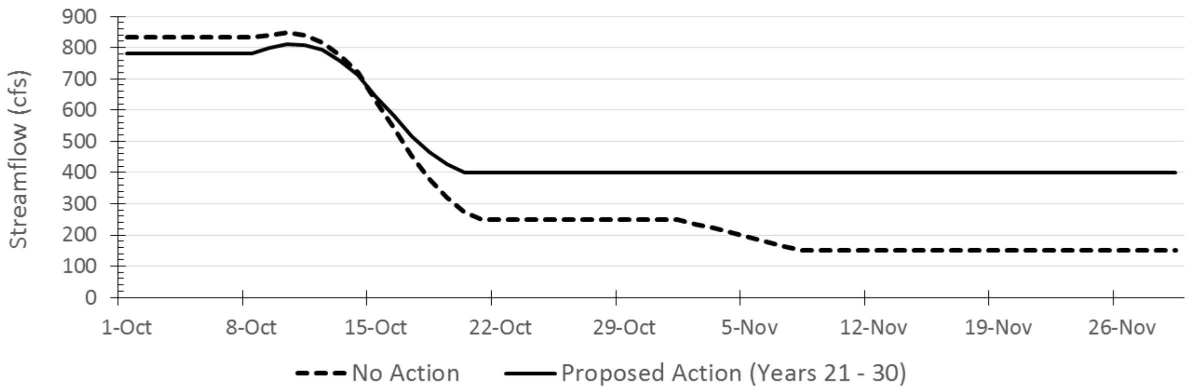
Potential effects on fish and mollusks were based on two metrics: 1) identification of magnitude of variability in streamflows relative to the no-action alternative, and 2) timing of the variability with respect to species life stage. Magnitude of variability was evaluated using coefficient of variation (CV) of the 7-day smoothed daily streamflow (the standard deviation of daily streamflow divided by average streamflow over the month), the daily rate of decline in streamflow in the month, and the number of days streamflow declined in the month.

Differences in streamflow ramping at the end of the irrigation season were considered in the effects analysis for species. Figure 7 shows an example of two ramping events extracted from the daily time series at the outlet of Wickiup Reservoir (WICO node). In this case, the daily streamflows are smoothed by taking a 7-day running average. The decline in streamflow in October at the end of the irrigation season is less under the proposed action in years 21 through 30 than under the no-action alternative. This is likely a beneficial effect on some fish and mollusks.

Another example of differences in daily streamflow patterns is in the Crooked River and the predicted shifts in timing of water released to supply the North Unit Irrigation District (NUID) pumps. The analysis considered the effect of these shifts in timing on water temperatures in the Crooked River during the summer. This effect is discussed in more detail in the next section under water quality.

Figure 6. Example of Daily Predicted Streamflow for Three Water Years for the outlet of Wickiup Reservoir (WICO node) under the No-Action Alternative and Proposed Action (Years 1–5 and 21–30)

Figure 7. Example Daily Predicted Streamflow for the outlet of Wickiup Reservoir (WICO node) under the No-Action Alternative and Proposed Action (Years 21–30)



Analysis of Storage Reservoirs

Analysis of storage reservoirs considered RiverWare modeled reservoir elevations across the model years.

An example of RiverWare predicted elevations used to evaluate effects of alternatives on fish and mollusks is shown in Figure 8 for Crane Prairie Reservoir and Wickiup Reservoir. In this example elevations in Crane Prairie are higher from October to May, are more variable from year to year, and do not differ by permit term. In contrast, Wickiup Reservoir elevations are lower under the proposed action, are more variable from year to year, and median elevations are much lower toward the end of the permit term in all months (years 21–30).

Figure 8. Modeled Elevations in Crane Prairie and Wickiup Reservoirs under the No Action Alternative and Proposed Action

Crane Prairie

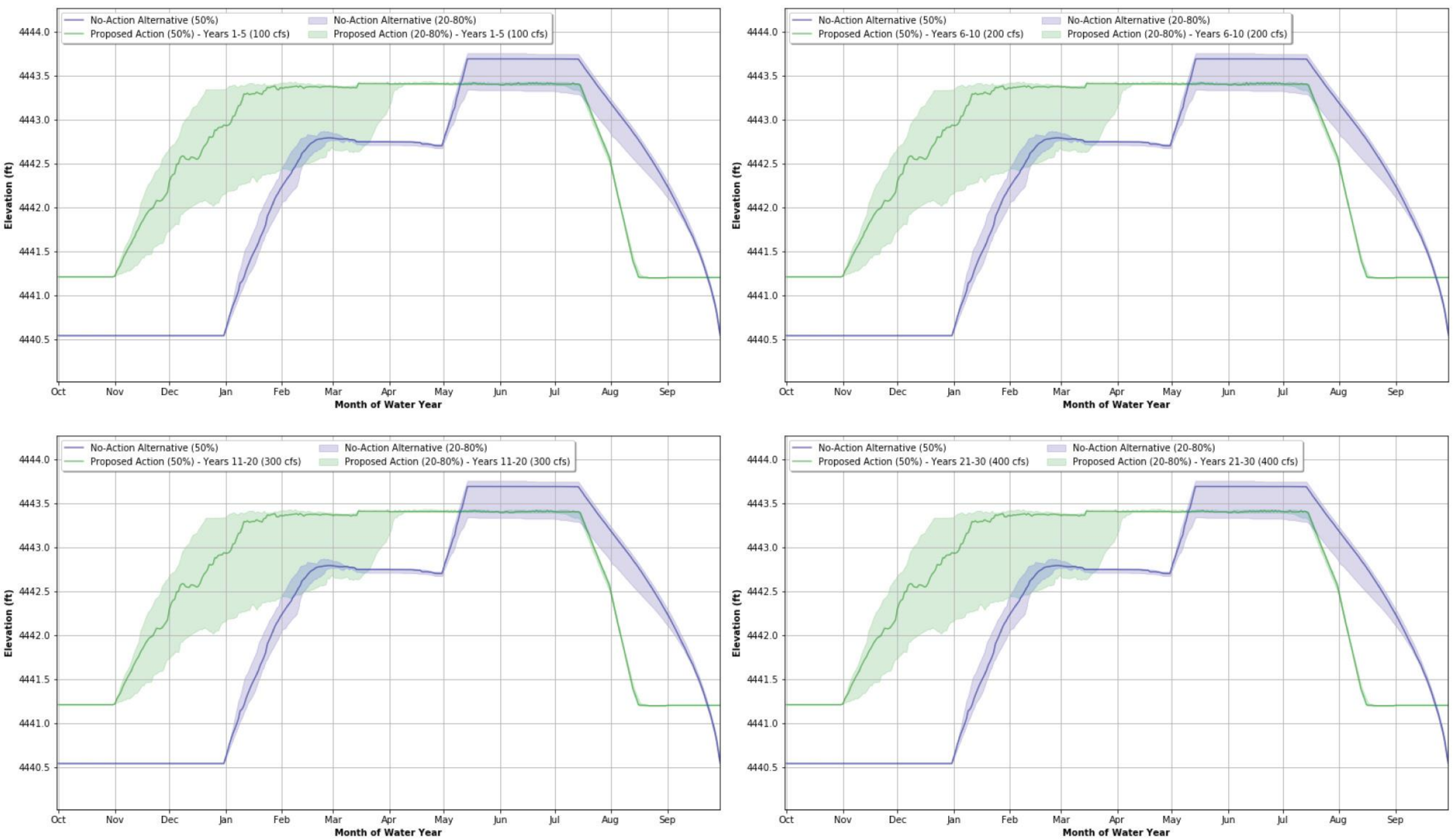
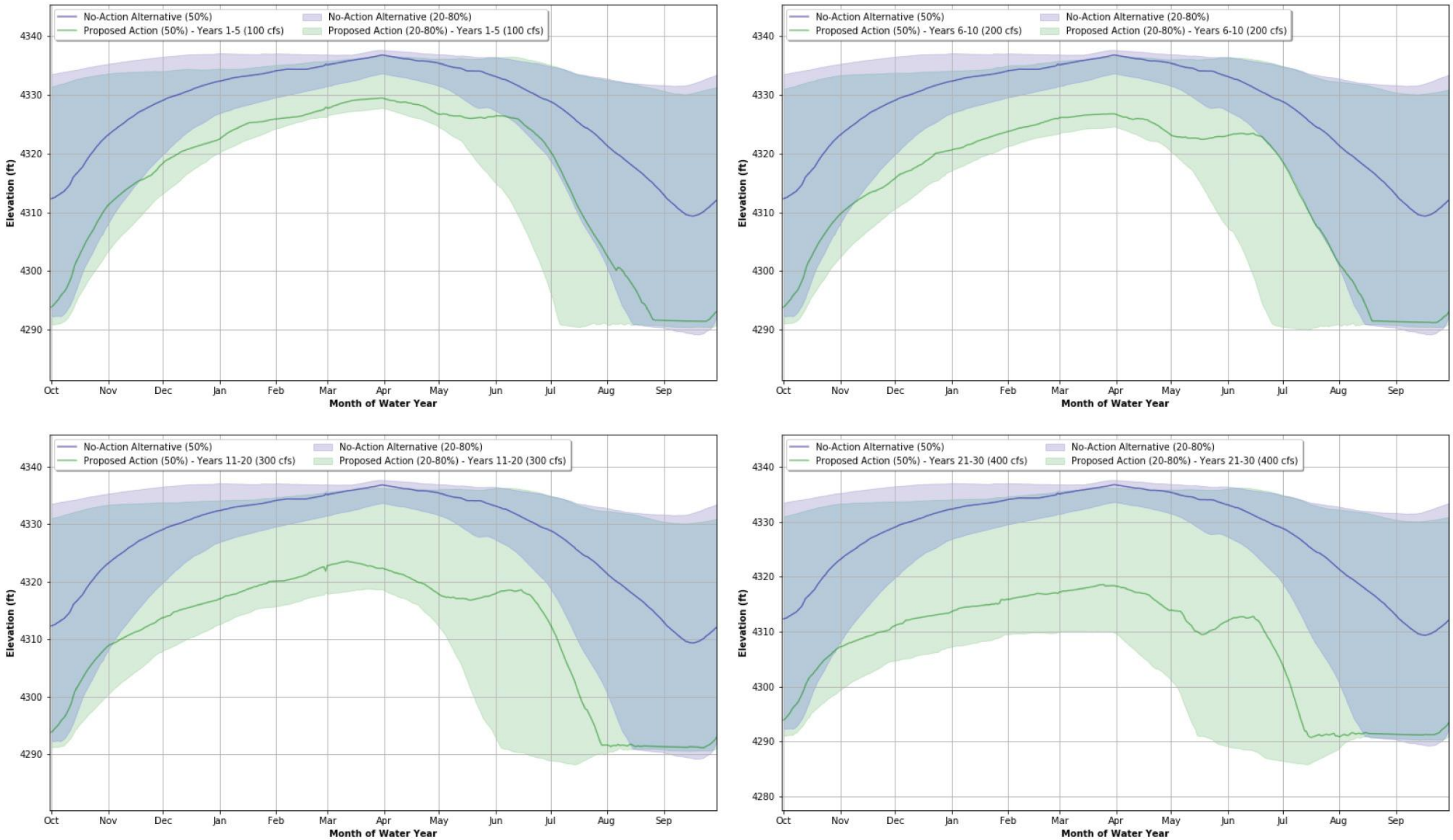


Figure 8 Continued

Wickiup



Water Quality

Changes in seasonal streamflows under the alternatives have the potential to alter a variety of water quality variables. Alternatives that increase streamflow typically provide beneficial responses to water quality affecting fish and mollusks; conversely, reductions in streamflow are more typically associated with water quality changes that adversely affect fish and mollusks habitats. Reductions in streamflow during the summer are generally more likely to degrade water quality with increased water temperatures and pH, and greater extremes in dissolved oxygen.

Most of the assessment of effects on water quality were qualitative because quantitative models were not available or unnecessary. The following describes quantitative modeling in the Upper Deschutes and in the Crooked River.

Upper Deschutes Water Quality Model – Wickiup Reservoir to Tumalo Creek

A quantitative analysis of water quality parameters was completed for the Upper Deschutes River from Wickiup Reservoir to Tumalo Creek using a numerical model (QUAL2Kw). Development and application of the QUAL2Kw model is described in detail in the water quality analysis (Appendix 3.3 *Water Quality Technical Supplement*). The model was developed to utilize input data from the RiverWare simulations, along with local climate data and water quality data provided by the U.S. Bureau of Reclamation, Oregon Department of Environmental Quality, and the City of Bend. The more significant factor potentially affecting water quality parameters in the Upper Deschutes River is the drawdown of Wickiup Reservoir to an elevation of 4,290 feet (approximately 7,600 acre-feet) for long durations during the summer under the proposed action and alternatives.

Predicted changes in water quality from the QUAL2Kw model were used to evaluate effects of alternatives on fish and mollusks from Wickiup Reservoir to Tumalo Creek.

Crooked River Water Temperature Model

The effects analysis for the Crooked River was also based on water temperature modeling developed by Portland State University (PSU) (Berger et al. 2019), described below. The analysis of effects in this appendix were based on analysis independent of any conclusions of effects made by the authors of the water temperature study.

The water temperature model covers the Crooked River from the City of Prineville to the gaging station at Smith Rock (Station ID: OWRD 14087300, Crooked River near Terrebonne, OR). This lower river model was linked to a previously developed model of Prineville Reservoir and the Crooked River from Prineville Reservoir downstream to the City of Prineville (Berger et al. 2019; Berger and Wells 2017). The linked models were calibrated based on 2016 conditions, and water temperature predictions were made using predictions of streamflow from RiverWare for the each of the alternatives. The linked models covered 14.0 miles in Prineville Reservoir, 23.3 miles from Bowman Dam to the City of Prineville and 20.3 miles from the City of Prineville to the gauge at Smith Rock. Water temperature predictions were made for 3 years in the RiverWare analysis period; 2005 was identified as an average (normal) water year, 1993 was chosen as a representative wet water year, and 2001 was chosen as a representative dry water year. Year type was based on Prineville Reservoir volume in April at the start of the irrigation season.

The water temperature model reported predictions of daily minimum, maximum, and average water temperatures for 49 segments in Prineville Reservoir, 75 segments from Bowman Dam to the City of Prineville, and 76 segments from the City of Prineville to the gaging station at Smith Rock (Berger et al. 2019). The running 7-day average of daily maximum (7DADM) water temperatures was used to evaluate water temperature effects on fish species in the Crooked River. The predicted 7DADM temperature was calculated for a single segment in Crooked River reaches 2 through 10 (see Table 6) and was compared to species and life stage specific temperature thresholds described in R2 and Biota Pacific (2013). Temperature thresholds were reported for preference, avoidance, stress/disease, delay, and lethality. Not all thresholds were provided for all species and life stages.

The effect analysis was based the number of days the 7DADM temperature was within the appropriate threshold ranges by reach for the proposed action and alternatives. This approach quantified shifts in timing and duration of warm and cool temperature events by species life stage and critical temperature thresholds. For example, the release of water from Prineville Reservoir as predicted in the normal year (2005) under the no-action alternative occurred in late July through mid-August compared to a release in mid-May through the end of June under the proposed action in years 21 through 30 (Figure 9). The shift in timing to May extended the period of warm water in the Crooked River at CAPO by several weeks (Figure 10). The consequence of this shift is under the proposed action water temperatures are cooler in late spring and early summer, and warm rapidly when streamflows are lower in July. The maximum summer 7DADM water temperature was not affected by the shift in timing. The maximum 7DADM temperature for the summer season is approximately the same between the no-action alternative and proposed action and Alternatives 3 and 4. However, the consequence of the shift in streamflow timing is a more protracted period of warm temperatures. The number of warm days during the summer increased substantially indicating a less suitable environment for temperature sensitive species.

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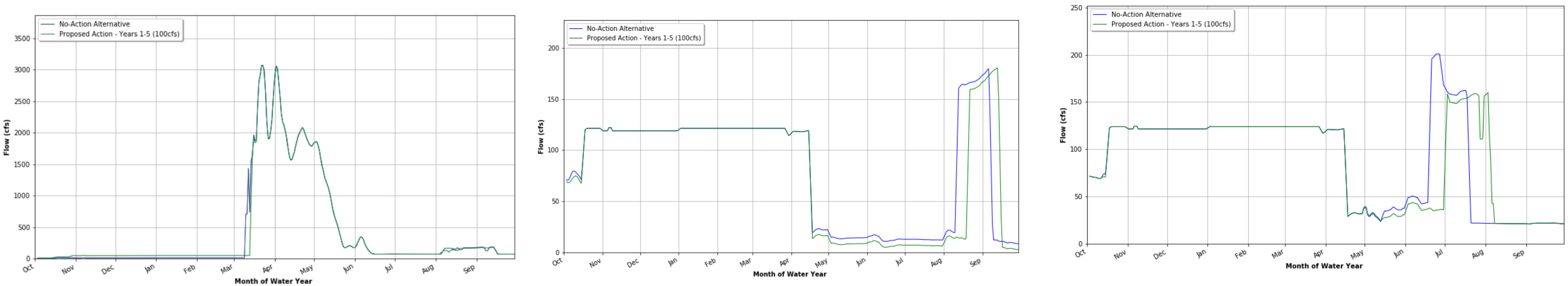
Figure 9. Annual Hydrograph for the Crooked River near Highway 126 (CAPO node) for Wet (left), Dry (center), and Normal (right) Water Years under the Proposed Action in Years 1–5 (top), 6–10 (upper middle), 11–20 (lower-middle), and 21–30 (bottom)

Years 1–5



Years 6–10

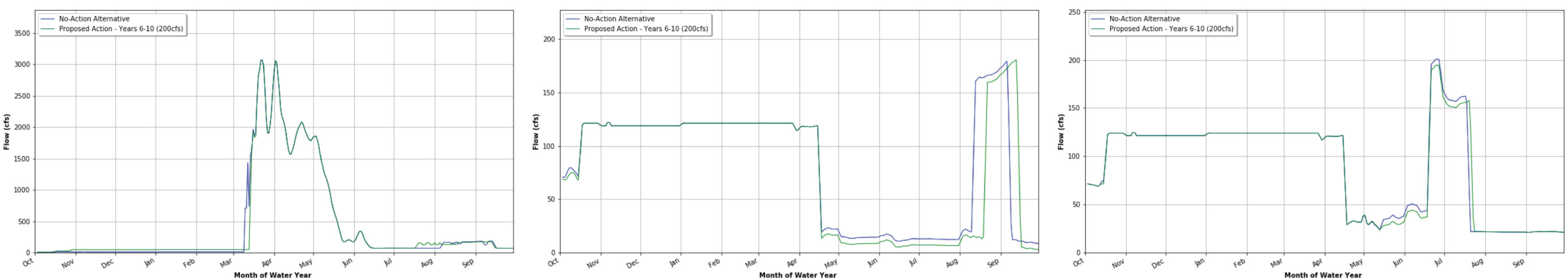
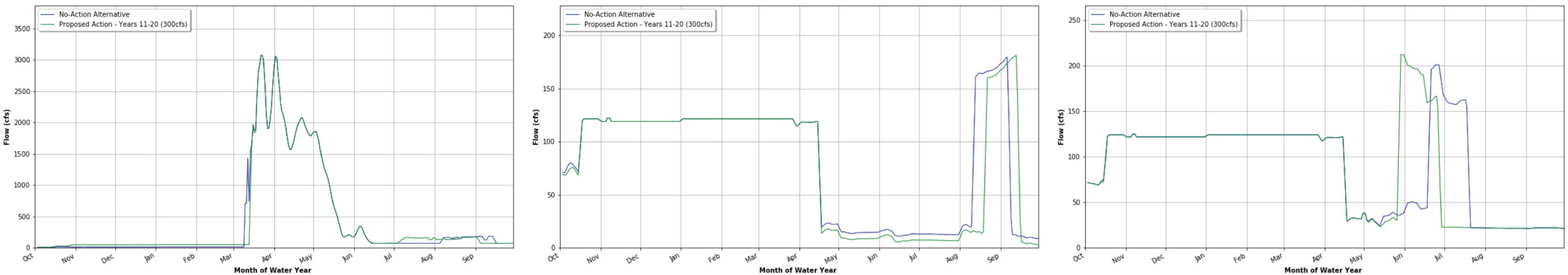


Figure 9 Continued

Years 11–20



Years 21–30

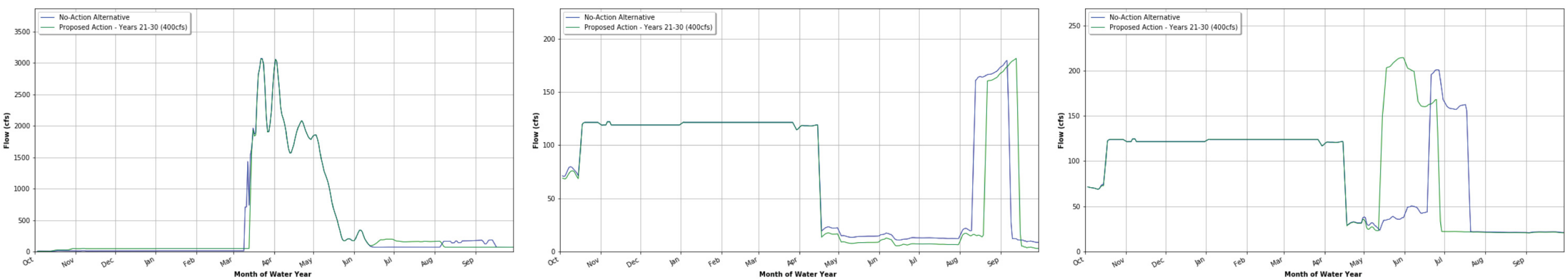
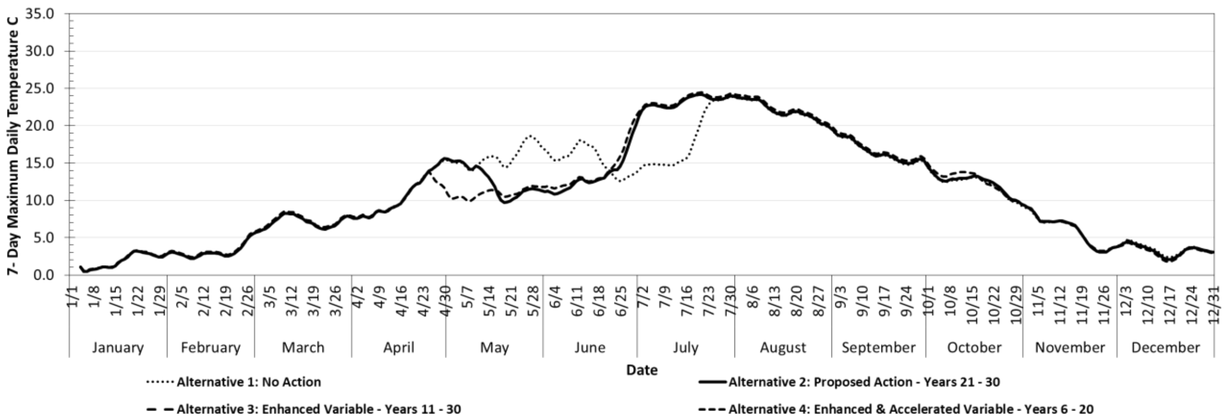


Figure 10. Annual Water Temperature Predictions for the Crooked River (CAPO node) for an Normal Year under the No Action, Proposed Action (Years 21–30), Alternative 3 (Years 11–30), and Alternative 4 (Years 6–20)



Crooked River Steelhead and Chinook Habitat Models

The effects analysis for the Crooked River was also based on results of the steelhead trout and Chinook salmon juvenile habitat capacity models developed by Mount Hood Environmental described below. The analysis of species effects is this appendix were based on results from this study independent of any conclusions of effects made by the authors of the study.

These models are an extension of previous modeling by Mount Hood Environmental (Courter et al. 2014). Updates were made to the steelhead model to include winter habitat predictions and data on juvenile steelhead densities and habitat use from snorkel surveys in August and December 2018 (Mount Hood Environmental 2019a, 2019b).

The steelhead model produces an estimate of capacity in number of fish supported by the environment. The Chinook model is a numeric estimate of the amount of suitable rearing habitat area (square miles) for juvenile Chinook salmon.

The models include habitat unit types from Oregon Department of Fish and Wildlife habitat surveys, stream unit width and depths for a range of predicted streamflows, and maximum weekly average water temperatures (MWAT) observed during the 2018 summer snorkel surveys.

Both models were used to evaluate change in capacity (steelhead) and suitable habitat (Chinook) under the proposed action and each of the alternatives. Streamflows were taken from the RiverWare results in both models. MWAT values for the proposed action and each alternative and reach were based on water temperature predictions provided by PSU for the 3 years in the RiverWare analysis period (Berger et al. 2019).

Estimates of winter steelhead capacity were highly influenced by summer water temperatures. An additional analysis was completed that held the water temperature parameter constant to evaluate effects of streamflow on capacity independent of water temperatures.

Affected Environment

Each geographic area is presented upstream to downstream and includes tributaries and reservoirs.

- Crescent Creek/Little Deschutes
    - Crescent Lake Reservoir
    - Crescent Creek
    - Little Deschutes River downstream of confluence with Crescent Creek to Deschutes River
- Upper Deschutes
    - Crane Prairie Reservoir
    - Deschutes River between Crane Prairie and Wickiup Reservoirs
    - Wickiup Reservoir
    - Deschutes River downstream of Wickiup Dam to the DEBO gauge in the city of Bend
- Middle Deschutes
    - Deschutes River from the DEBO gauge in the city of Bend downstream to Lake Billy Chinook
    - Tumalo Creek
    - Whychus Creek
    - Lake Billy Chinook and Lake Simtustus
- Lower Deschutes
    - Deschutes River downstream of Pelton-Round Butte Complex to confluence with the Columbia River
- Crooked River
    - Prineville Reservoir
    - Crooked River downstream of Bowman Dam (RM 70) to confluence with the Deschutes River
    - Ochoco Reservoir
    - Ochoco Creek
    - McKay Creek

For the purposes of the fish and mollusks effects analysis, the large and environmentally diverse study area and geographic areas described in Table 1 were further subdivided into 47 reaches shown and labeled in Figure 11 through Figure 15 and listed in Table 6. The demarcation of river reaches was performed according to the following principles.

- Reaches identified by FWS (2017)
- Reaches identified by Courter et al. (2014)
- Reach breaks located at dams and major diversions
- Each reservoir containing one or more reaches

- Reaches selected to have relatively uniform topography, channel conditions, hydrological gain or loss characteristics, and riparian and wetland vegetation

RiverWare model locations (nodes) representative of streamflow by reach are reported in Table 6.

Table 6. Study Area Reaches by Geographic Area

Geographic Area	Feature	Reach	RiverWare Output Node	Description
Crescent Creek/Little Deschutes	Crescent Lake Reservoir	CLD-7	Crescent Lake Reservoir Elevation and Volume	Crescent Lake Reservoir
	Crescent Creek	CLD-6	CREO	A pool-riffle channel flowing through a mostly unforested riverine wetland wetland/riparian vegetation corridor with a total width of 99–164 feet, flanked by ponderosa pine-dominated upland forest.
	Crescent Creek	CLD-5	CREO	Upper end channel is constricted by road and railroad crossing; downstream low-gradient meandering channel within a mostly unforested riverine wetland corridor with a total width of 164–328 feet, flanked by ponderosa pine-dominated upland forest.
	Little Deschutes River	CLD-4	Walker Canal Internode	Upper end Crescent Creek/Little Deschutes River confluence; moderately meandering underfit channel with glide morphology in an unforested wetland/riparian vegetation corridor with a total width of 164–328 feet.
	Little Deschutes River	CLD-3	Walker Canal Internode	Low-gradient underfit channel with glide morphology in an unforested wetland/riparian vegetation corridor with a total width of 328–984 feet.
	Little Deschutes River	CLD-2	LAPO	Low-gradient underfit channel with glide morphology in an unforested wetland/riparian vegetation corridor with a total width of 328–984 feet.
	Little Deschutes River	CLD-1	LAPO	Upper end LAPO gauge; low-gradient underfit channel with glide morphology in an unforested wetland/riparian vegetation corridor with a total width of 328–984 feet.
Upper Deschutes	Crane Prairie Reservoir	DR-15	Crescent Lake Reservoir Elevation and Volume	Locally extensive riparian/wetland vegetation on its margins and at its head. This is the upper limit of potential project effects on the Deschutes River
	Deschutes River	DR-14	CREO	Crane Prairie and Wickiup Reservoir; pool-riffle reach with narrow bands of riparian vegetation, mostly located on point bars.
	Wickiup Reservoir	DR-13	Wickiup Reservoir Elevation and Volume	Little riparian/wetland vegetation, is less often inundated and has substantial areas of both herb and shrub wetland and riparian vegetation

Geographic Area	Feature	Reach	RiverWare Output Node	Description
	Deschutes River	DR-12a	WICO	Downstream of Wickiup Reservoir to Fall River (OSF Reach 1)
	Deschutes River	DR-12	WICO + Fall River inflow	Fall River to Little Deschutes River (OSF Reach 2)
	Deschutes River	DR-11	WICO + Fall River inflow +Spring River inflow+LAPO	Little Deschutes River to Benham Falls (BENO node) (OSF Reach 3); Spring River inflow near top of this reach
	Deschutes River	DR-10a	BENO	Benham Falls (BENO node) to Dillon Falls
	Deschutes River	DR-10	Arnold Canal inflow internode	Dillon Falls to Lava Island Falls (Arnold Canal diversion)
	Deschutes River	DR-9	COID inflow internode	Lava Island Falls (Arnold Canal diversion) to COID diversion (OSF Reach 6)
	Deschutes River	DR-8a	COID outflow internode	COID Diversion to Colorado Street Bridge (OSF Reach 7)
	Deschutes River	DR-8	COID outflow internode	Colorado Street Bridge to Bend Feeder Canal diversion in Bend
	Deschutes River	DR-7	North Unit inflow internode	Bend Feeder Canal diversion in Bend to North Unit Irrigation diversion
	Deschutes River	DR-6	DEBO	North Unit Irrigation Diversion to DEBO node
Middle Deschutes	Deschutes River	DR-5	DEBO	DEBO node downstream of Bend to Tumalo Creek
	Deschutes River	DR-4.4	DEBO + TUMO	Tumalo Creek to Big Falls (upper extent historical anadromous species).
	Deschutes River	DR-4.3	DEBO + TUMO	Big Falls (upper extent historical anadromous species) to RM 130 (reach break delineated for covered species modeling)
	Deschutes River	DR-4.2	DEBO + TUMO	RM 130 (reach break delineated for covered species modeling) to Steelhead Falls
	Deschutes River	DR-4.1	DEBO + TUMO	Steelhead Falls to Whychus Creek
	Deschutes River	DR-3	CULO	Whychus Creek to Lake Billy Chinook
	Lake Billy Chinook/ Simtustus, & Re-Regulating	DR-2	NA	Lake Billy Chinook, Lake Simtustus, and Re-regulating reservoirs
	Tumalo Creek	TC-1	TUMO	Tumalo Feed Canal diversion to Deschutes River
	Whychus Creek	Why-5		Plainview diversion to upstream of Sisters.

Geographic Area	Feature	Reach	RiverWare Output Node	Description
	Whychus Creek	Why-4		Upstream of Sisters to downstream of Sisters (consistent with W-4 reach in Courter et al. 2014)
	Whychus Creek	Why-3	Whychus blw TSID	Downstream Sisters to beginning confined section of creek (consistent with W-3 reach in Courter et al. 2014)
	Whychus Creek	Why-2	Whychus blw TSID	Top confined section of creek to Alder Springs (consistent with W-2 reach in Courter et al. 2014)
	Whychus Creek	Why-1	Whychus blw TSID	Alder Springs to Deschutes River (consistent with W-1 reach in Courter et al. 2014)
Crooked River	Prineville Reservoir	CR-13	Prineville Elevation and Volume	The headwaters of Prineville Reservoir, includes a large wetland and benches or bars with shrub and herb riparian and wetland vegetation. This is the upper limit of potential project effects on the Crooked River.
	Prineville Reservoir	CR-12	Prineville Elevation and Volume	Upper Prineville Reservoir, where seasonally exposed areas have some riparian or wetland vegetation.
	Prineville Reservoir	CR-11	Prineville Elevation and Volume	Lower Prineville Reservoir, which has no riparian or wetland vegetation.
	Crooked River	CR-10	PRVO	Bowman Dam (RM 70) to Crooked River Feed/Rice Baldwin diversion (RM 57); consistent with reach C-5 in Courter et al. 2014.
	Crooked River	CR-9	PRVO	Crooked River Feed/Rice Baldwin diversion (RM 57) to Peoples Canal diversion (RM 48); consistent with reach C-4 in Courter et al. 2014.
	Crooked River	CR-8	PRVO	Peoples Canal diversion to near Highway 126 in Prineville
	Crooked River	CR-7	CAPO	Near Highway 126 in Prineville to Ochoco Creek
	Crooked River	CR-6	CAPO	Ochoco Creek to Central Canal diversion (McKay Creek enters this reach)
	Crooked River	CR-5	CAPO	Central Canal diversion to Low Line Canal diversion
	Crooked River	CR-4	CAPO	Low Line Canal diversion to Lone Pine Road
	Crooked River	CR-3	CAPO	Lone Pine Road to North Unit Irrigation pump diversion
	Crooked River	CR-2.2	NUID Crooked Divert.Outflow internode	North Unit Irrigation pump diversion to CSRO node near Smith Rock; this internode approximates streamflow below the NUID pump to Osborne Canyon
	Crooked River	CR-2.1	NUID Crooked Divert.Outflow internode	CSRO node near Smith Rock to Highway 97; reach affected by NUID Pumps

Geographic Area	Feature	Reach	RiverWare Output Node	Description
	Crooked River	CR-1.3	NUID Crooked Divert.Outflow internode	Highway 97 to Osborne Canyon; reach affected by NUID Pumps
	Crooked River	CR-1.2	Opal	Osborne Canyon to Opal Springs Dam, start of gaining reach
	Crooked River	CR-1.1	Opal	Opal Springs Dam to Lake Billy Chinook; significant gaining reach
	Ochoco Reservoir	Och-4	Ochoco Elevation and Volume	Ochoco Reservoir
	Ochoco Creek	Och-3	OchMin	Ochoco Reservoir to Route 380 Bridge; reach O-1 in Courter et al. (2014)
	Ochoco Creek	Och-2	OchMin	Route 380 Bridge to Prineville; reach O-1 in Courter et al. (2014)
	Ochoco Creek	Och-1	OchMin	Prineville city/urban landscape to Crooked River; reach O-1 in Courter et al. (2014)
	McKay Creek	Mck-3	No data	Jones Dam to Reynolds Siphon; consistent with reach MK-3 in Courter et al. (2014)
	McKay Creek	Mck-2	No data	Dry Creek to Reynolds Siphon; consistent with reach MK-2 in Courter et al. (2014)
	McKay Creek	Mck-1	No data	Reynolds Siphon to Crooked River; consistent with reach MK-1 in Courter et al. (2014)
Lower Deschutes	Deschutes River	Des-1	MADRAS	Re-regulating Dam at RM 100 to Columbia River

Figure 11. Fish and Mollusks Study Area Reaches—Upper Deschutes and Crescent Creek/Little Deschutes

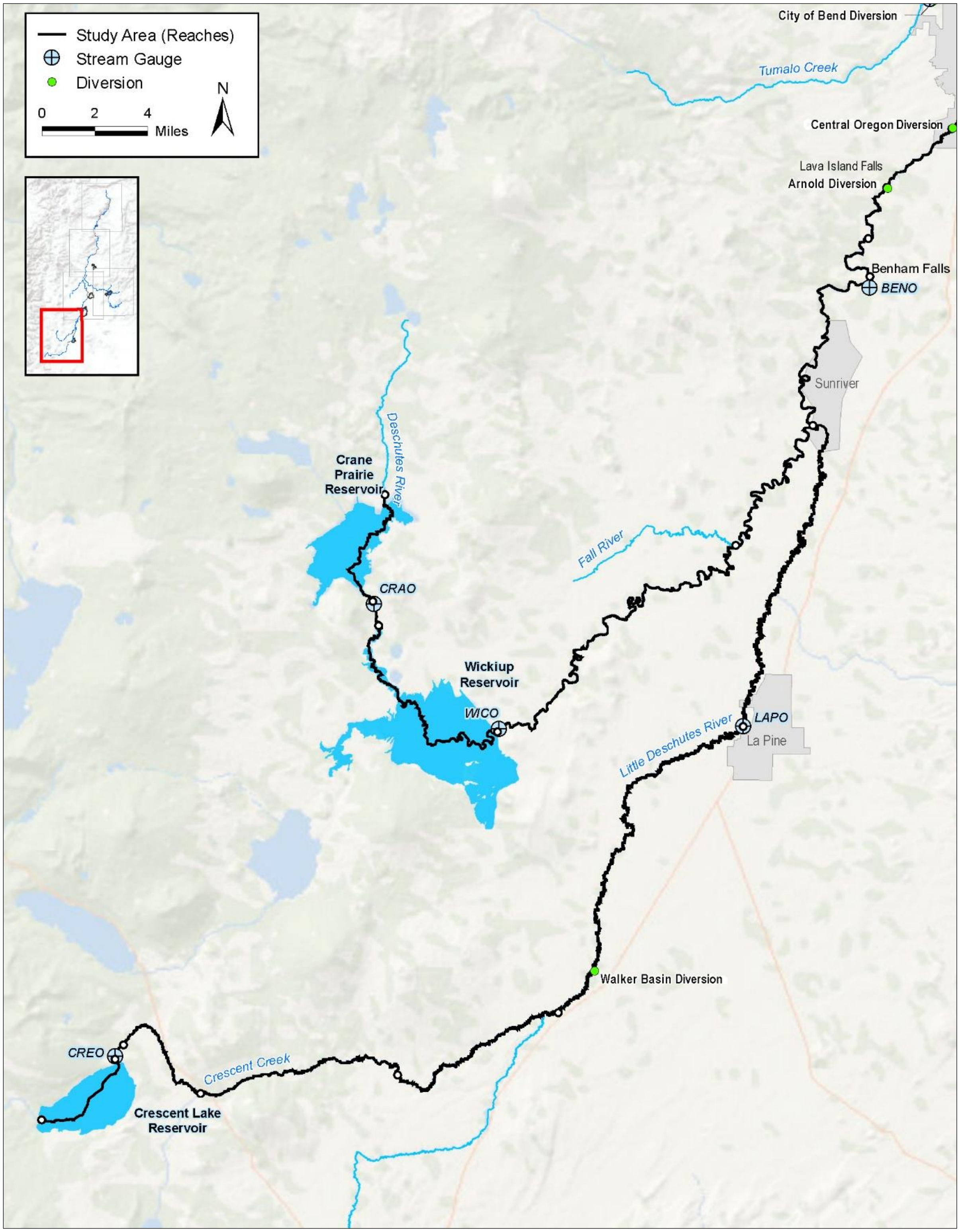


Figure 12. Fish and Mollusks Study Area Reaches—Middle Deschutes and Lower Crooked River

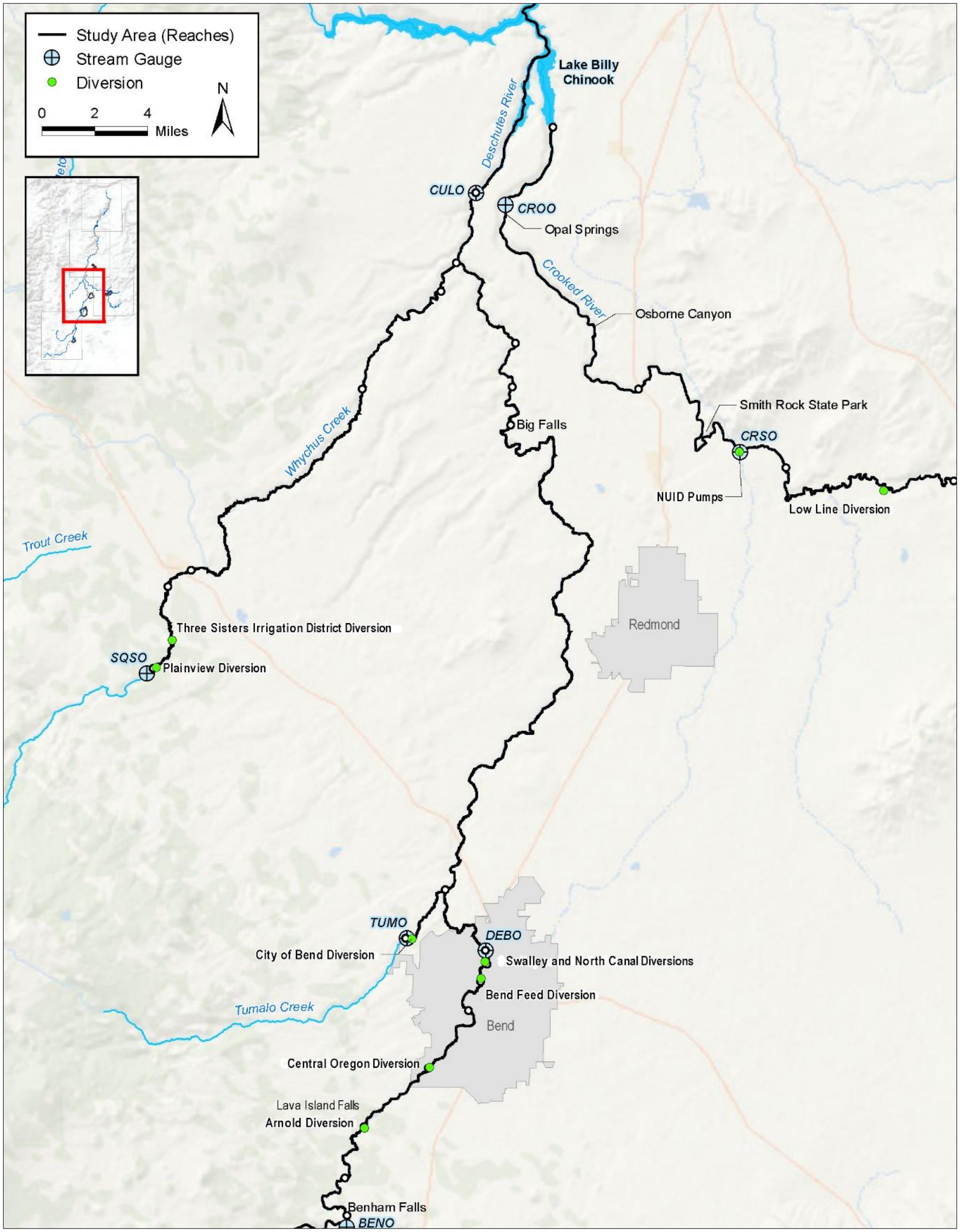


Figure 13. Fish and Mollusks Study Area Reaches—Upper Crooked River

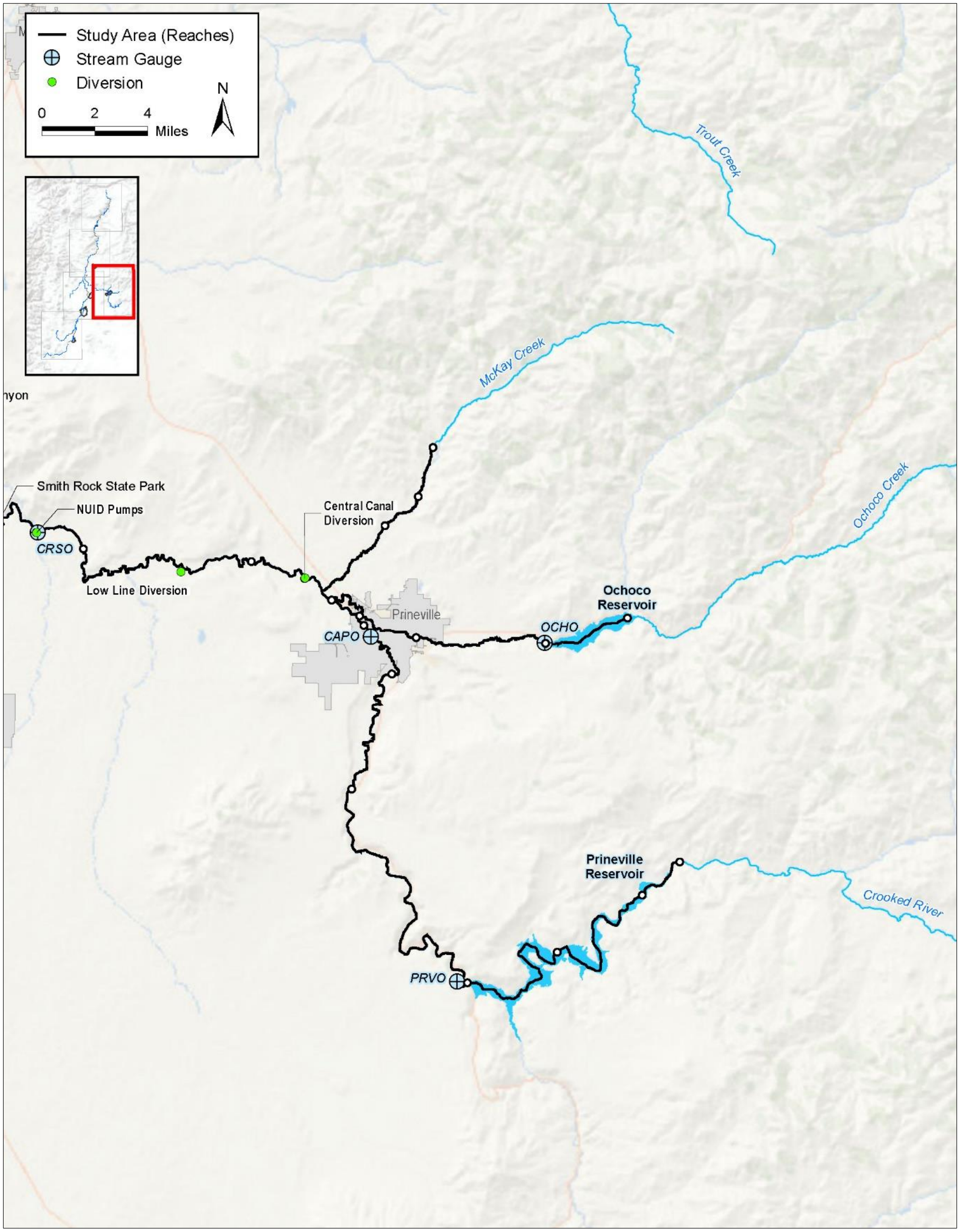


Figure 14. Fish and Mollusks Study Area Reaches—Lake Billy Chinook, Lake Simtustus, and Lower Deschutes

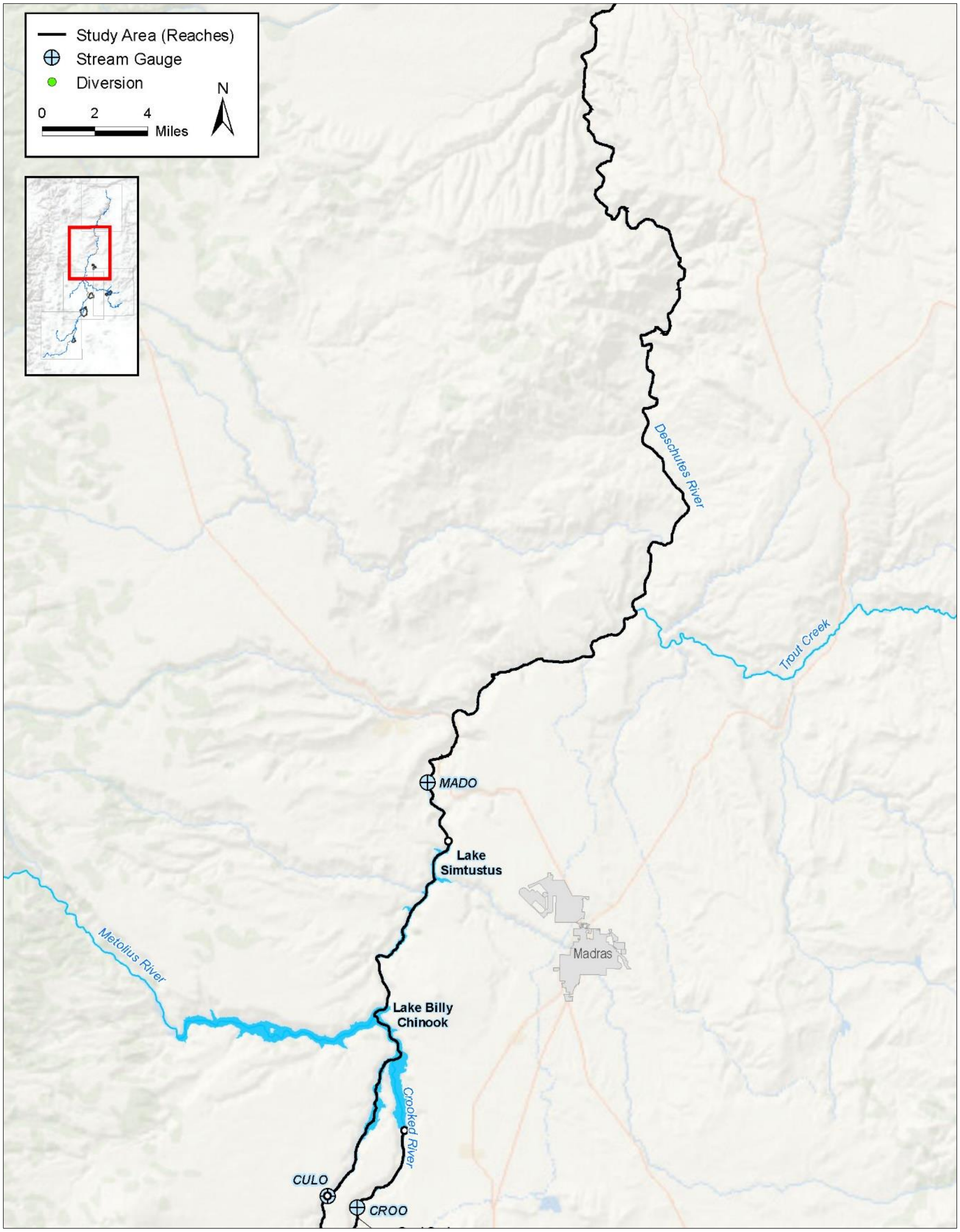
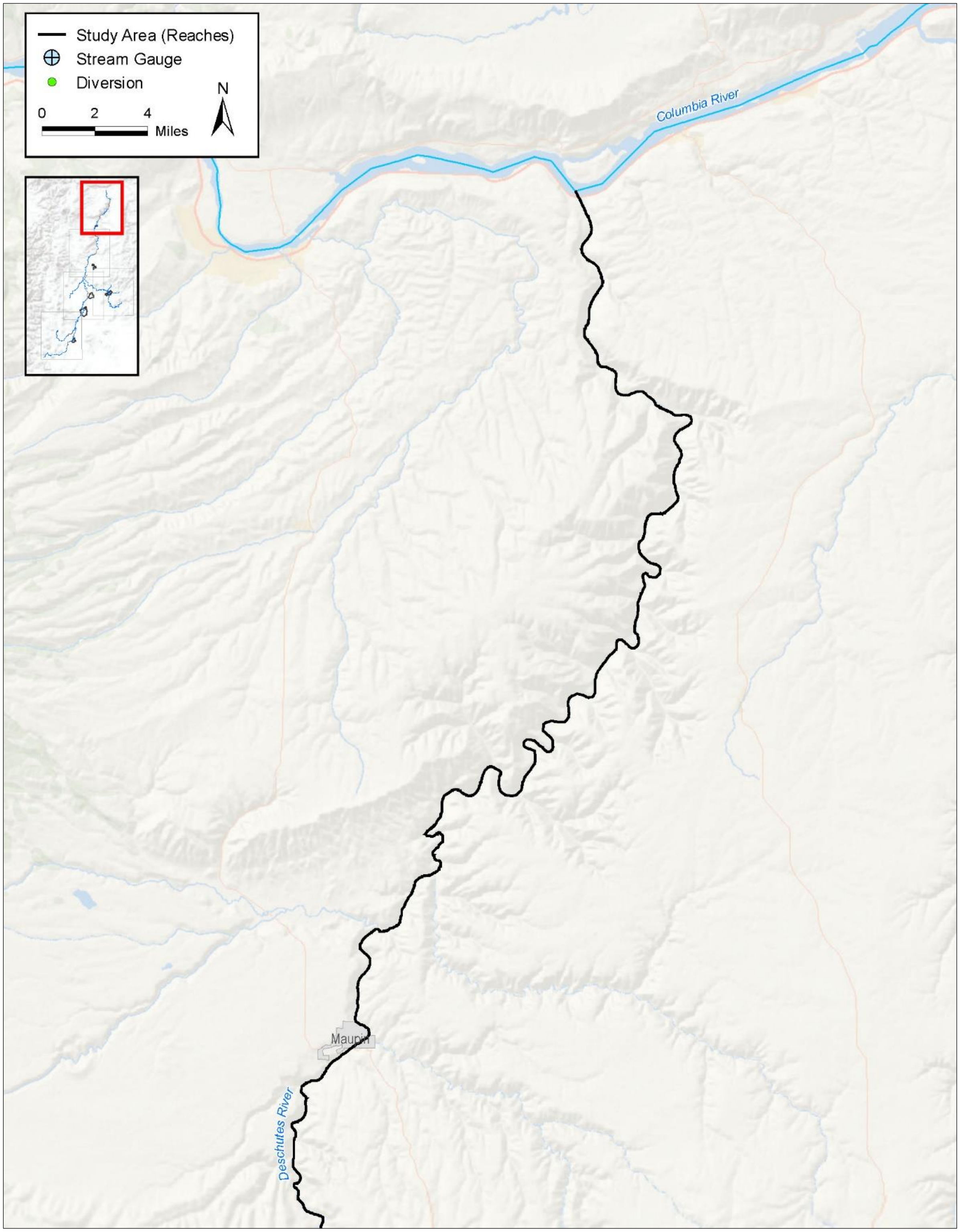


Figure 15. Fish and Mollusks Study Area Reaches—Lower Deschutes



Environmental Consequences

Species impacts are evaluated by geographic area listed in Table 1 across the study area.

Effects Determination Thresholds

Effects of the proposed action and alternatives on fish and other aquatic resources would be considered adverse if they would result in any of the following conditions.

- Cause a decline in fish or mollusk population productivity, abundance, or diversity that may result in a substantial effect, either directly or through habitat modifications, on recovery, persistence, or reintroduction of the species population.
- Cause direct mortality of any fish or mollusks identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations of by ODFW, FWS, or the National Marine Fisheries Service (NMFS).
- Substantially reduce the habitat or windows for life stage expression in geographies for any fish or mollusks identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations of ODFW, FWS, or NMFS, including essential fish habitat (EFH) under the Magnuson-Stevens Act in the Lower Deschutes (EFH does not extend above the Pelton-Round Butte Complex Re-regulating dam).
- Permanently reduce the acreage or alter the value of any sensitive aquatic natural community identified in local or regional plans, policies, or regulations or by ODFW or FWS.
- Interfere substantially with the movement of any native resident or migratory fish species.

Alternative 1: No Action

Continuation of current water management operations under the no-action alternative, described in Chapter 2, *Proposed Action and Alternatives*, would result in no changes in streamflows for fish and mollusk habitat compared to existing conditions. Continuation of existing operations under the no-action alternative would result in slightly less seasonal and year-to-year flow variation in the Deschutes River upstream of Bend, relative to the past hydrology that established the existing environmental conditions. These conditions include summer flows so high that riparian vegetation is inundated and winter flows so low that riparian vegetation is generally dewatered and is vulnerable to seasonal drying and freezing. It is possible that over the analysis period, in some locations along the Deschutes River upstream of Bend, the continued implementation of reduced flow variation under the no-action alternative would allow a small improvement in the extent and functional value of riparian and wetland vegetation benefiting fish habitat. However, data are not adequate to identify those locations or to quantify the magnitude of the habitat quality improvement. Similarly, continued implementation of existing water management rules and agreed minimum streamflow requirements on the Crooked River (i.e., Crooked River Act, Deschutes River Conservancy/North Unit Water Supply Program on the Crooked River) as described in Chapter 2, would improve habitat for fish and mollusks in the Crooked River.

Other variables, such as climate change, habitat restoration and fish enhancement projects, and water conservation projects that increase streamflows, would affect fish and mollusks over the analysis period.

Implementation of the existing plans for water conservation projects assumed under the no-action alternative, as described in Chapter 2, would increase streamflows below irrigation diversions in the Deschutes River, Tumalo Creek, and Whychus[1] Creek. Benefits to fish and mollusk habitat would be higher summer streamflows and potentially cooler water temperatures with higher streamflows. Habitat restoration projects, listed in Appendix 2-B, *No-Action and Cumulative Scenario*, would result in overall, but unquantifiable, improvements to fish and mollusk habitats in the study area over the analysis period. Fish enhancement projects to support reintroduction of steelhead trout, sockeye salmon, and spring Chinook salmon above the Pelton-Round Butte Complex and restore fish passage[2] to the Crooked River at Opal Springs Dam would result in additional improvements to fish habitats, access to blocked habitat, and benefits to fish species.

Climate change will likely affect stream water temperatures and streamflows in the study area over the permit term. Climate models predict that average air temperatures in south central Oregon, which includes the study area, will increase by 1.3 to 4.0°C by 2050 (Halofsky et al. 2018). Climate change effects on hydrology will include decreased snowpack, earlier snowmelt, earlier runoff, and potentially slightly more precipitation. Peak flows will be higher and summer low flows lower compared to existing conditions. Winter snowpack residence time is anticipated to decrease by 7 to 8 weeks in the Cascade Range. The greatest reduction in summer streamflows is anticipated for the eastern slope of the Cascade Range, which includes the western flank of the Upper Deschutes Basin. Earlier snowmelt could result in summer streamflow losses of 40 to 60% by 2040.

Extreme climate events, such as drought, and ecological disturbances, such as flooding, wildfire, and insect outbreaks, are expected to increase. The timing of these changes is uncertain, but summer streamflow reductions of 40 to 60% are forecast by 2040, approximately 20 years into the permit term. Changes in precipitation patterns and precipitation type (e.g., a shift from snowpack to rain) due to climate change could affect the wetland vegetation distribution and communities, as well as individual site hydrology.

Under a climate change scenario that includes more precipitation and more precipitation that falls as rain, peak runoff is expected to shift to earlier in the year (Halofsky et al. 2018). Earlier runoff would be expected to reduce water storage and streamflows later in the summer. However, in the Upper Deschutes Basin, the groundwater system and the study area reservoirs' storage capacities would moderate the effects of decreased snowfall and runoff timing on streamflows. The Crooked River reservoirs and Crooked River and Ochoco Creek may be affected more due to the area's lack of a groundwater system and flood control requirements. Under such a scenario, study area reservoirs are expected to be equally likely to fill to capacity. However, higher evaporation rates that are anticipated under climate change, would reduce available stored water and have a potential impact on late summer streamflows downstream of reservoirs.

Although the continuation of existing restoration and protection strategies under the no-action alternative could result in the improvements to fish and mollusk habitat, climate change could result in adverse effects on the covered species that would negatively affect the distribution and quality of habitat available in the study area. The resulting outcome (adverse, beneficial, or no effect) and

[1] Three Sisters ID has completed piping of their canals; therefore, the addition of 3.0 cfs to Whychus Creek (included under Conservation Measure WC-1) is accounted for in the RiverWare model for the no-action alternative as well as the proposed action and Alternatives 3 and 4.

[2] The fish passage structure at Opal Dam in the Crooked River, which is anticipated to be operational beginning late fall or early winter 2019, will greatly improve access to this river for all fish species and will support the reintroduction of steelhead and Chinook in this area, and recolonization by bull trout in the Crooked River.

magnitude of this combination of effects on fish and mollusks cannot currently be forecast reliably. However, not addressing water management and effects on streamflows in a comprehensive manner likely would have an adverse effect on the ability to manage for future changes in climate.

In conclusion, a continuation of existing water management operations may be beneficial to fish habitat in the Deschutes River upstream of Bend, and plans for habitat restoration, fish enhancement, and water conservation projects in the study area under the no-action alternative would result in unquantifiable improvements to fish and mollusk habitat. In addition, continued water management operations on the Crooked River would have no effect compared to existing conditions, but fish access and habitat restoration projects could be beneficial to the covered fish species. However, the effect of climate change assumed over the analysis period has the potential to adversely affect the distribution and quality of the covered fish species habitat that is available in the study area. Therefore, effects under the no-action alternative are expected to be adverse because of the anticipated effects of climate change to reduce habitat quality and quantity for cold-water fish species such as trout and salmon. Effects would likely be greatest in the Crooked River because of relatively less influence of groundwater inflow to portions of the river.

Alternative 2: Proposed Action

Modeled changes in streamflows, reservoir volumes and elevations, and water quality conditions under the proposed action compared to the no-action alternative are described below in the *Modeled Environmental Conditions* section followed by descriptions of how these changes would affect individual species in the *Species Impacts* section.

Modeled Environmental Conditions

This section describes important changes in reservoir storage and elevation, seasonal river and creek streamflows, and relevant water quality information in the study area by geographic area and subarea under the proposed action. Effects are evaluated based on changes in modeled results for the proposed action compared to the no-action alternative.

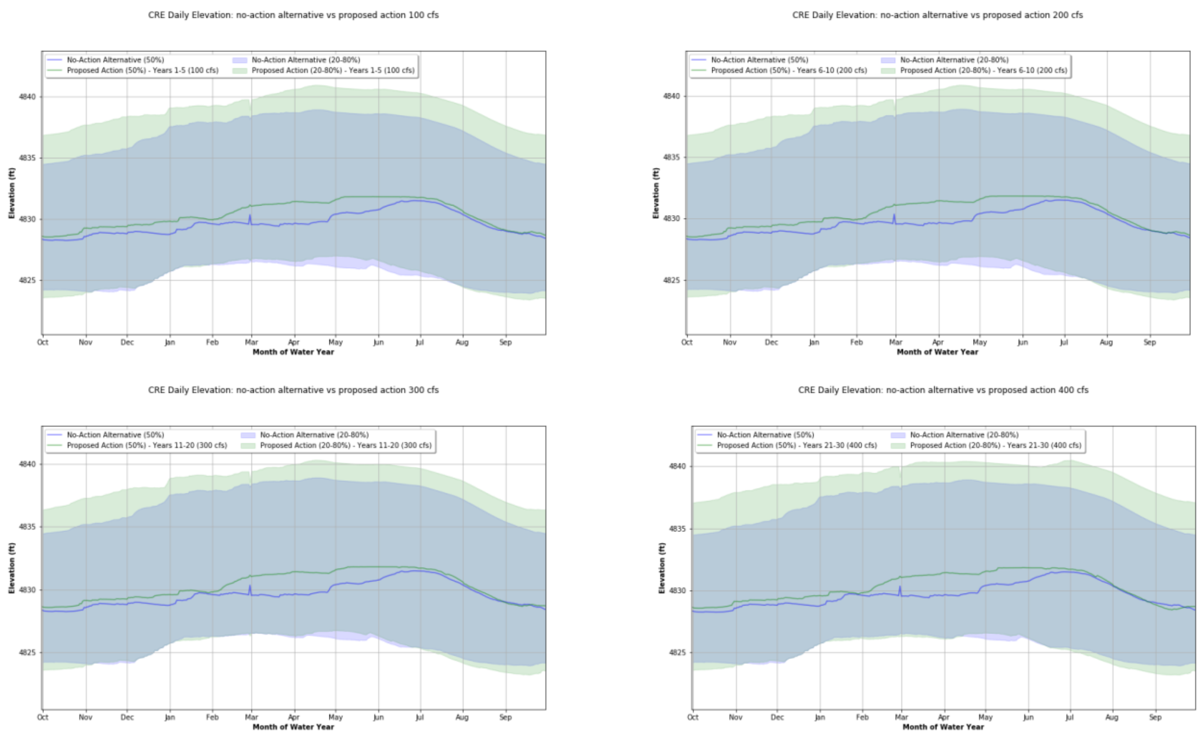
Crescent Creek/Little Deschutes

Crescent Lake Reservoir

RiverWare based modeled results for the Crescent Lake Reservoir node (CRE), illustrated in Figure 16, the following would occur:

- Median reservoir elevations would be generally similar in all months with slightly higher elevation in the spring (March–May).
- Reservoir elevations would not differ over the permit term.
- Variability would increase from year to year in the low and high range of elevations.

Figure 16. Modeled Elevations for Crescent Lake Reservoir (CRE node) under the No-Action Alternative and Proposed Action



Crescent Creek

Based on modeled results for the Crescent Lake Reservoir outlet node (CREO), streamflows in Crescent Creek would be lower over the permit term.

- In most years, streamflows would decrease in October and November, and March and April.
- Streamflows would either increased slightly or not change from June through September.
- However increases in streamflows from June through September tended to be slightly more pronounced in years 21 through 30 of the permit term.

Little Deschutes River

Based modeled results for the Walker Diversion internode and LAPO node, there are minimal changes in the median and range of streamflows in the Little Deschutes under the proposed action. There is a tendency for a slight increase in median streamflows in May and June across all years modeled in RiverWare, consistent with more water originating from Crescent Creek during the same months.

- In the upper reaches (Walker Internode)
  - In October and November, streamflows would decrease in the majority of years; however, overall the average decrease would be small (<10%).
  - From December to April, streamflows would not differ in most years or changes would be negligible.

- In May through September, streamflows would increase slightly in some years, an average of 5% or less during these months across all years.

- Further downstream at the LAPO node, there would be a similar pattern of change. In October and November, a majority of years have a decrease in streamflows. The overall average decrease by end of permit term is small (<10%)

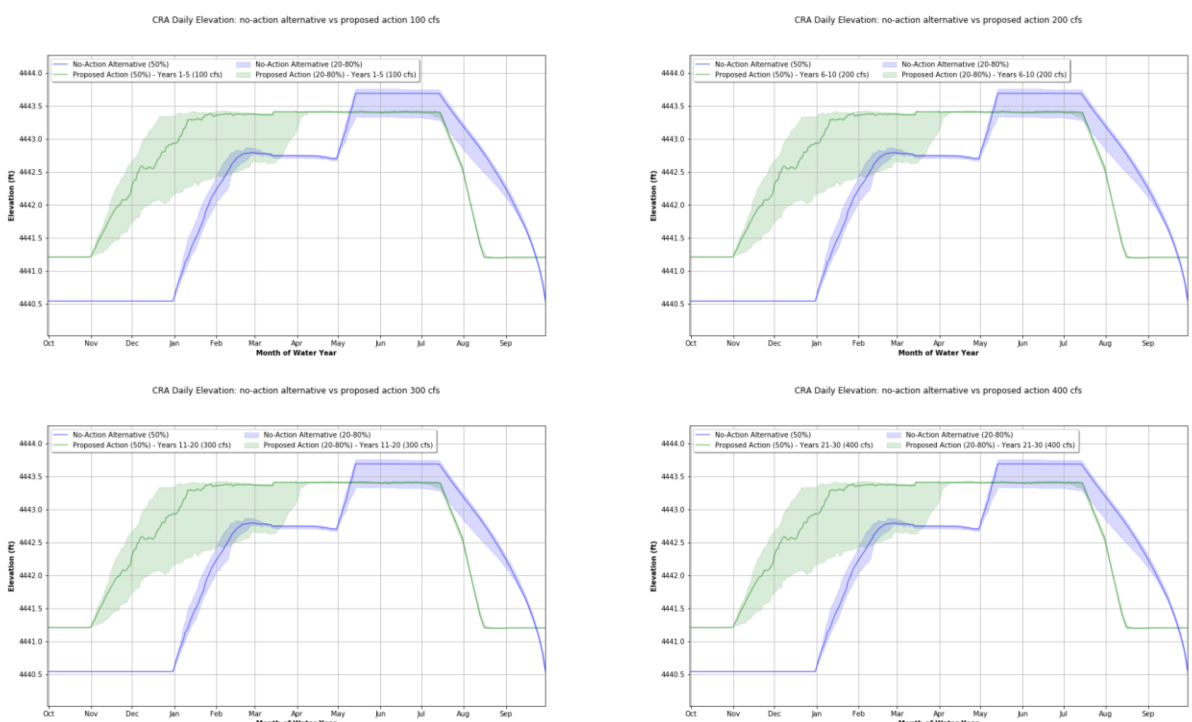
Upper Deschutes

Crane Prairie Reservoir

Based on modeled results for the Crane Prairie Reservoir node (CRA), illustrated in Figure 17, elevations would change as follows:

- Median elevations would be higher from October to April and lower from May to approximately the end of September.
- Elevations would not differ over the permit term.
- Minimum and maximum elevations would be more variable from year to year beginning in November to March and less variable from April to the end of September.
- However, within a year minimum and maximum mean monthly and daily reservoir elevations and volumes would be less variable.

Figure 17. Modeled Elevations for Crane Prairie Reservoir (CRA node) under the No-Action Alternative and Proposed Action



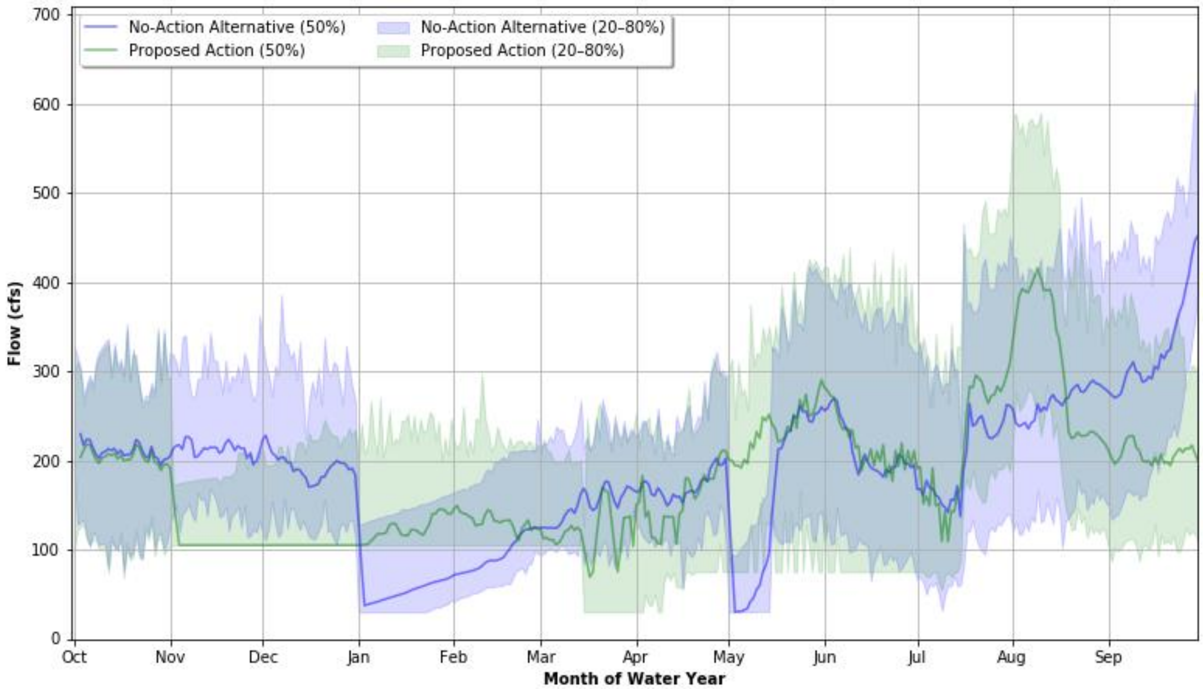
Upper Deschutes River between Crane Prairie and Wickiup Reservoirs

Based on modeled results for the Crane Prairie Reservoir Outlet (CRAO), streamflows in the Upper Deschutes River between Crane Prairie Reservoir and Wickiup Reservoir would be less variable over the year (Figure 18). Furthermore, differences in monthly median streamflow would vary over the year. The pattern of high and low monthly differences would be consistent over the permit term.

The following changes would occur at the Crane Prairie Reservoir outlet node through the permit term.

- In most years, streamflows would decrease in November and December by 40% and 30%, on average, respectively.
- In most years, streamflows would be higher in January and February by twice as much and 66%, on average, respectively.
- In March of most years, streamflows would decrease by one-third, on average. In April, streamflows would not change in about half the years and would decrease by 40%, on average, in the other half of the years.
- In May of most years, streamflows would be higher by 45%, on average and June streamflows would vary across years: in a majority of years they would not change; in a quarter of the years would decrease by 14%, on average; and would increase by about 29%, on average, during the other quarter of the years.
- In July and August in nearly all years, streamflows would increase by about 40%, on average. In September in all years, streamflows would decrease by 37%, on average.
- Steep decreases in streamflow in January and May would be eliminated reducing variability in these months. There would be more variability in daily streamflows in August.

Figure 18. Modeled Streamflows Upper Deschutes River at Crane Prairie Outlet (CRAO node) under the No-Action Alternative and Proposed Action

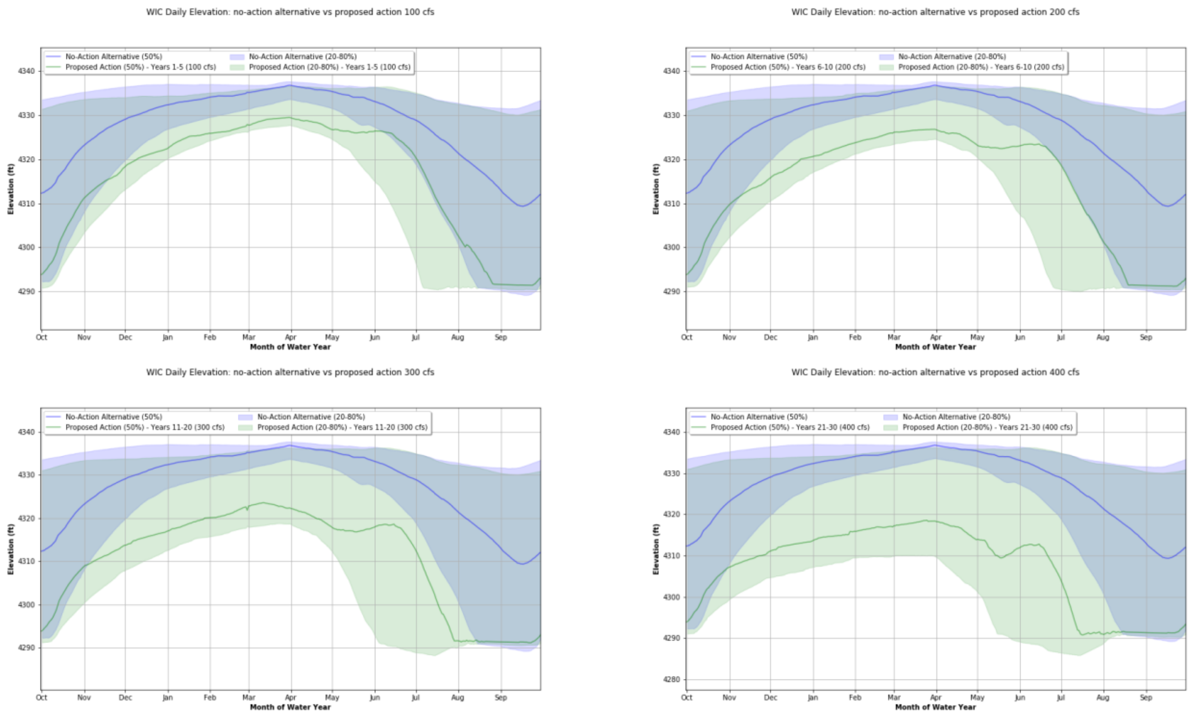


Wickiup Reservoir

Based on modeled results for Wickiup Reservoir node (WIC), illustrated in Figure 19, reservoir elevations would change as follows:

- Median elevations would be lower in all months with differences greatest in late summer (August and September).
- Differences in elevations would increase over the permit term with difference greatest in years 21 through 30 of the permit term from approximately December to mid-July.
- Minimum and maximum reservoir elevations would be more variable from year to year in all months.

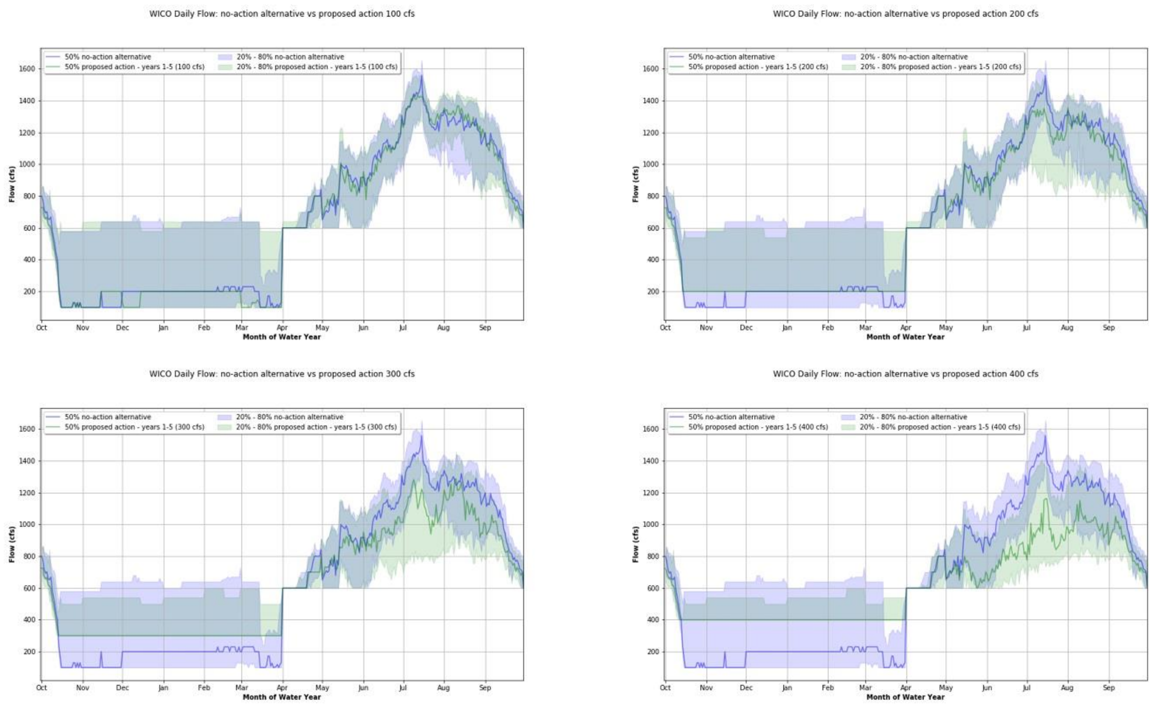
Figure 19. Modeled Elevations for Wickiup Reservoir (WIC node) under the No-Action Alternative and Proposed Action



Upper Deschutes River downstream of Wickiup Dam

Based on modeled results for the Wickiup Reservoir Outlet (WICO) and Benham Falls (BENO) nodes and internodes between Benham Falls and the city of Bend, streamflows in the Upper Deschutes River downstream of Wickiup Dam would be variable over the year. At WICO, the general pattern across the year and permit term is increasing streamflows from mid-October through March, decreasing streamflows from May through September, and a tendency for more variable streamflows from May through September through the permit term (Figure 20).

Figure 20. Modeled Streamflows for Wickiup Reservoir Outflow (WICO) under the No-Action Alternative and Proposed Action



The following changes would occur at the Wickiup Reservoir outlet node through the permit term.

- In about a quarter of the years, streamflows would increase from October through March by about 30% early in the permit term. Through the permit term, streamflows would increase in most of the years by about 70%. Daily median streamflows at the end of the permit term would be 400 cfs.
- Streamflows in April would not change in nearly all years. This pattern would be consistent through the permit term.
- Streamflows in May would not change in a majority of years during years 1 through 10 of the permit term. By years 21 through 30 of the permit term, streamflow would decrease by 30%, on average, in about half of the years.
- In April and May, streamflows would increase in some years during the start of irrigation demand and then sharply decline in May and June when reservoir storage has reached a critically low level. This pattern would be more prevalent toward the end of the permit term. By years 21 through 30 of the permit term, streamflows in about half the years would decline by approximately 30% (see Figure 7). Daily streamflows may exceed 1,000 cfs in early May with the increase in irrigation demand, and then would decline sharply mid-May with reduction in storage at Wickiup Reservoir.
- Streamflows from June through September would not change in a majority of years early in the permit term. However, toward the end of the permit term, streamflows would decrease in June by approximately 40%, on average, and by approximately 10% in September in about half the years. Median daily streamflows toward the end of the permit term would vary from 750 cfs early in the summer and 1,000 cfs in August.

The following changes would occur at the Benham Falls outlet node through the permit term.

- Surface and groundwater inflow upstream of this location would reduce the effects of water management upstream of this location at WICO. Generally, streamflows would not change in a majority of the years early in the permit term. Toward the end of the permit term, streamflows in approximately half the years would increase from October through March by approximately 10%, on average.
- Streamflows from June through September would not change in a majority of years early in the permit term. Toward the end of the permit term, streamflows would decrease by 27% in June, on average, and by approximately 6% in September. Median daily streamflows toward the end of the permit term would vary between 1,700 cfs early in the summer and 1,500 cfs in August.
- In May through July, streamflows would decline sharply in some years when reservoir storage has reached a critically low level. This pattern occurs under the no action alternative but would occur earlier in the summer and would be more prevalent under the proposed action toward the end of the permit term. Daily streamflow may approach 2,000 cfs in early summer and then decline to less than 1,500 cfs over a one week period.

Between Benham Falls and the city of Bend, a similar pattern would occur. Irrigation demand and limited available reservoir storage would increase variability in streamflows during the summer and would result in rapid declines in streamflows when storage would reach a critically low level.

Middle Deschutes

Middle Deschutes River

Based on modeled results for the city of Bend (DEDO) node and the Culver City internode (CULOGauge.Outflow), winter streamflows would be higher.

- Increasing minimum winter streamflows through the permit term would increase streamflows from October through March by approximately 20%, on average, by the end of the permit term.
- Streamflows in May and June would decline by 25%, on average, in a majority of years through the permit term. By the end of the permit term, May and June streamflows would decline by 30% in a majority of years.
- Streamflows in July and August would not change in nearly all years.

The following changes would occur at the Culver City internode through the permit term.

- Surface and groundwater inflows upstream of this location would reduce the effects of water management and changes in streamflow upstream of this location at DEDO.
- Higher minimum winter streamflows in the Upper Deschutes River would increase streamflows from October through March in the Middle Deschutes River by approximately 15%, on average, by the end of the permit term.
- Streamflows in May and June would not change in a majority of years. However, streamflows in June would decrease by 13%, on average, in about one-third of the years.
- Streamflows in July through September would not change in a nearly all years.

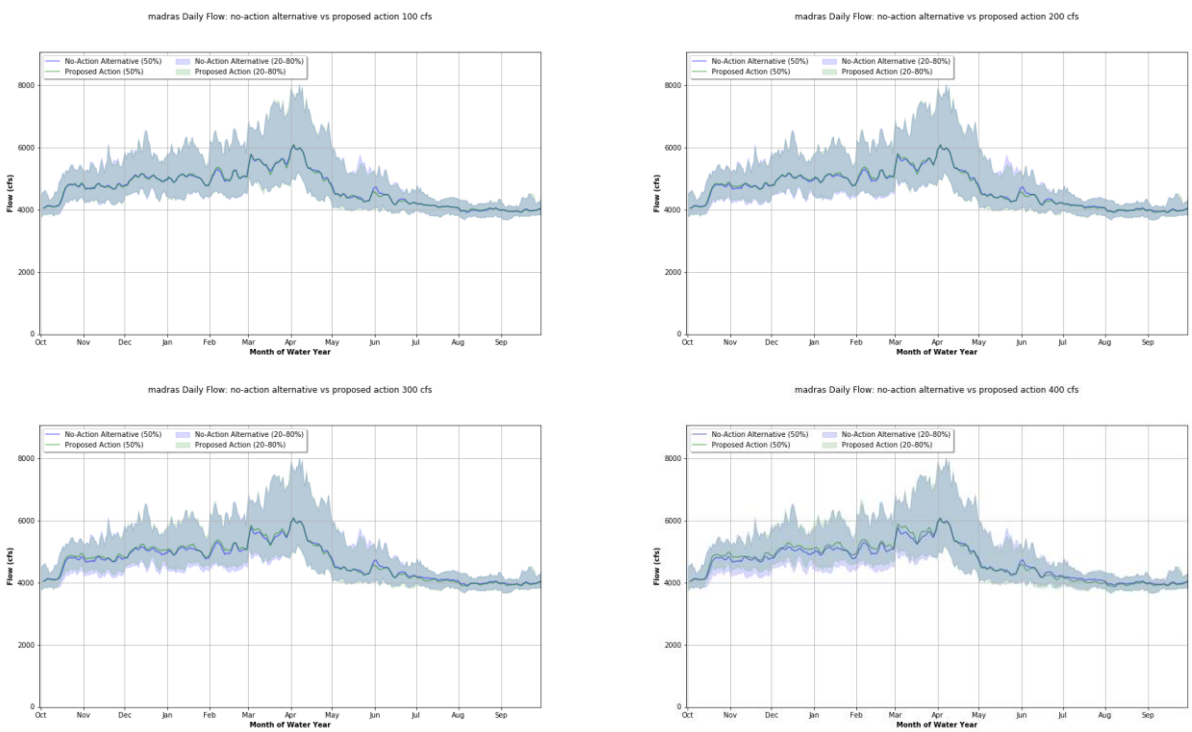
Tumalo and Whychus Creeks

Based on modeled results, streamflows in Tumalo and Whychus Creeks would be unchanged. Streamflow increases from TID water conservation projects assumed under the no-action alternative would continue.

Lower Deschutes

Based on modeled results for the Madras node (MADO), illustrated in Figure 21, median winter (October to March) streamflows would increase very slightly in years 21 through 30.

Figure 21. Modeled Streamflows for the Lower Deschutes River near Madras (MADO) for Years 1–5 (top-left), 6–10 (top-right), 11–20 (bottom-left) and 21–30 (bottom-right) for the No-Action Alternative and Proposed Action (median and 20 to 80% range)



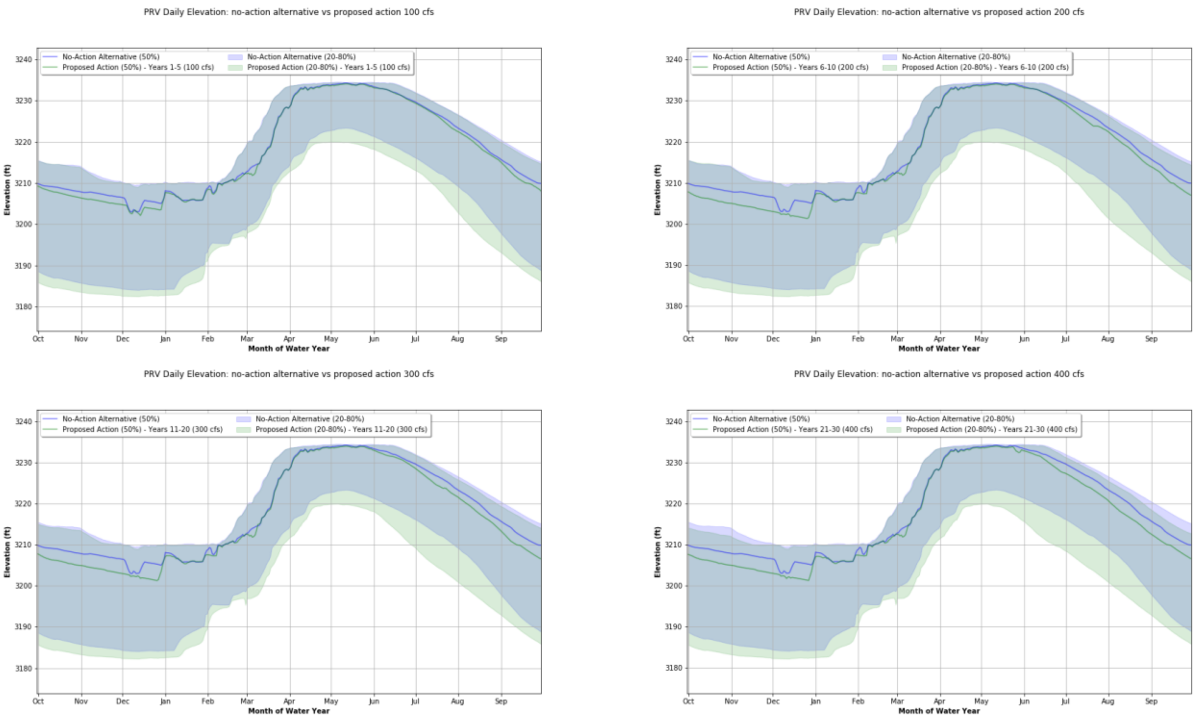
Crooked River

Prineville Reservoir

Based on modeled results for Prineville Reservoir node (PRV), illustrated in Figure 22, elevations would change as follows.

- Median elevations would be lower from October to January and June to September with differences greatest in October and November. Median elevations would be unchanged from January to June.
- Differences in median elevations would tend to be greater toward the end of the permit term (years 21–30).
- Year to year variability would tend to occur in the low and high range of elevations.

Figure 22. Modeled Elevations for Prineville Reservoir (PRV node) under the No-Action Alternative and Proposed Action



Crooked River

Modeled environmental conditions in the Crooked River are described below based on median monthly streamflows and modeled water temperatures.

Median Monthly Streamflow

Differences in median monthly streamflow are summarized below for the following locations (nodes): Prineville Outlet (PRVO), near Highway 126 (CAPO), below the NUID pumps (NUID), and below Opal Springs Dam (OPAL).

Prineville Outlet (PRVO):

- October through March: Average increases of over 100% in median monthly streamflows in about 20% of the years; no change in winter streamflows in the majority of years.
- April: No change in median streamflows.
- May and June: No change in median streamflows in years 1 through 5 and 6 through 10 of the permit term. An increase in median streamflows in June in years 11 through 20 of 50% in about 25% of the years.
- July through September: Median streamflows decrease in about 25% of the years by an average of 38% in July, 39% in August, and 69% in September in years 21 through 30.

Near Highway 126 and the City of Prineville (CAPO) with change in monthly median streamflows at the end of the permit term summarized in Table 7.

- October through March: Average increases of approximately 200% in median monthly streamflows in about 20% of years; no change in winter streamflows in the majority of years.
- April: No change in median streamflows.
- May and June: No change in median streamflows in years 1 through 5 and 6 through 10 of the permit term. An increase in median streamflows in June in years 21 through 30 of over 500% in about 25% of the years.
- July through September: Median streamflows decrease in a majority of years by years 21 through 30 of the permit term by an average of 60%.

Below the NUID pumps (NUID.outflow):

- October through March: In most years, there was no change in monthly median streamflows; in about 10% of years there was an average increase in median streamflows of 40%; and in about 5% of years, an average decrease in median streamflows of approximately 20%.
- April: No change in median streamflows.
- May through September: Average decrease across all months of 25% in a majority of the years.

Below Opal Springs Dam (OPAL):

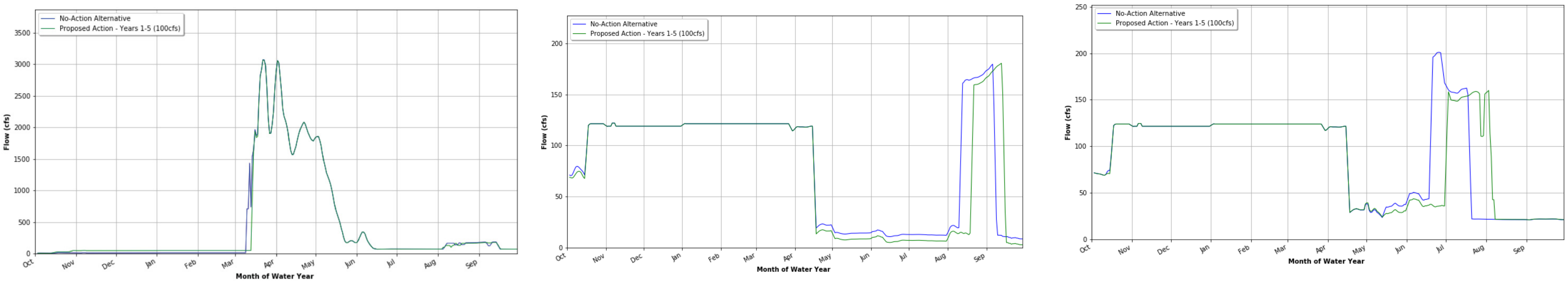
- No discernable differences in streamflow.

Water Temperature Modeling

The annual hydrograph for the three representative water year types (wet, normal and dry) is shown in Figure 23 for the CAPO node. Differences between the no-action alternative and proposed action are influencing habitat availability and water temperatures. Shifts in streamflow timing are most pronounced under the normal water year.

Figure 23. Annual Hydrograph for Crooked River (CAPO node) for Wet, Dry, and Normal Water Years (left to right columns) under the No-Action Alternative and Proposed Action in Years 1–5 (top), 6–10 (upper middle), 11–20 (lower-middle), and 21–30 (bottom)

Years 1–5



Years 6–10

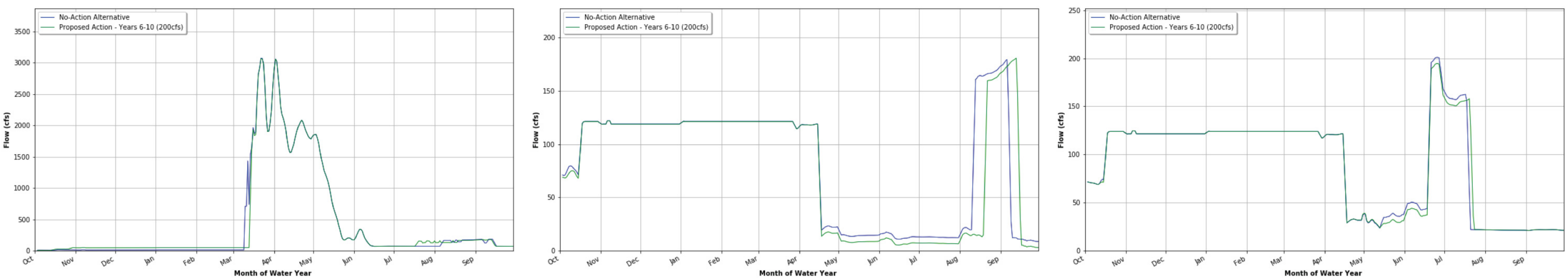
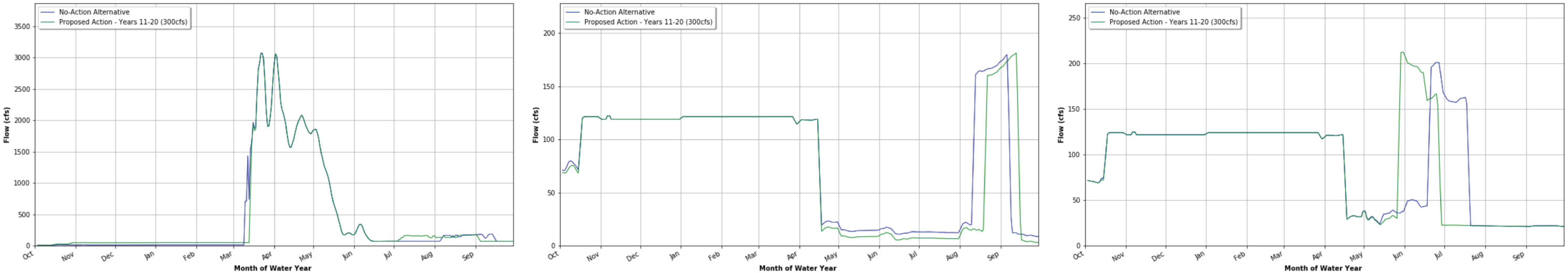
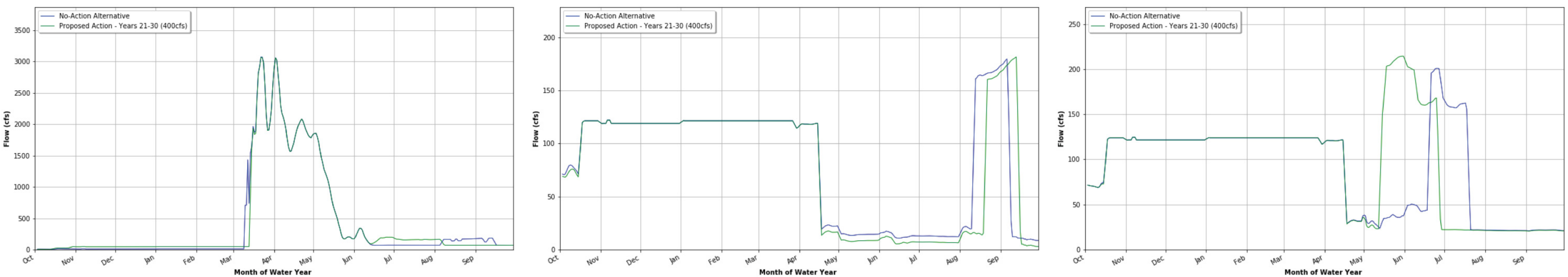


Figure 23 Continued

Years 11–20



Years 21–30



The shift in timing of water released from Prineville Reservoir has consequences to timing and duration of warm water temperatures in the Crooked River (Berger et al. 2019). The 7-day average of the daily maximum (7DADM) water temperature was used to evaluate habitat suitability for species in the Crooked River from May through September.

An example of the shift in predicted 7DADM water temperatures at the Crooked River CAPO node is shown in Figure 24. Under the proposed action, water temperatures are cooler in early summer and warm rapidly when streamflows are lower in July. The maximum summer 7DADM water temperature was not affected by water management and the shift in timing at Bowman Dam. The maximum for the summer season is approximately the same between the no-action alternative and proposed action. However, the consequence of the shift in streamflow timing is a longer period of warm temperatures. The number of warm days during the summer increased substantially in the normal water year type indicating a potentially less suitable environment for temperature sensitive salmonids.

Analysis of modeled streamflows at the CAPO node suggest the normal water year temperature scenario is not that unusual across the analysis period in years 21 to 30 of the permit term. The shift toward higher streamflows in May and June and lower streamflows in July and August under the proposed action occurs in about 40% of the analysis years (12 of 29 years modeled) by the end of the permit term (Figure 25).

The predicted 7DADM results were compared to species preferences, sublethal, stress/disease, and lethal temperature thresholds summarized from a literature review (R2 and Pacific Biota 2013). The threshold analysis is discussed in the *Species Impacts* section by alternative.

Figure 24. Annual Water Temperature Predictions for the Crooked River (CAPO node) for a Wet (top), Dry (middle), and Normal (bottom) Year under the No-Action Alternative and Proposed Action

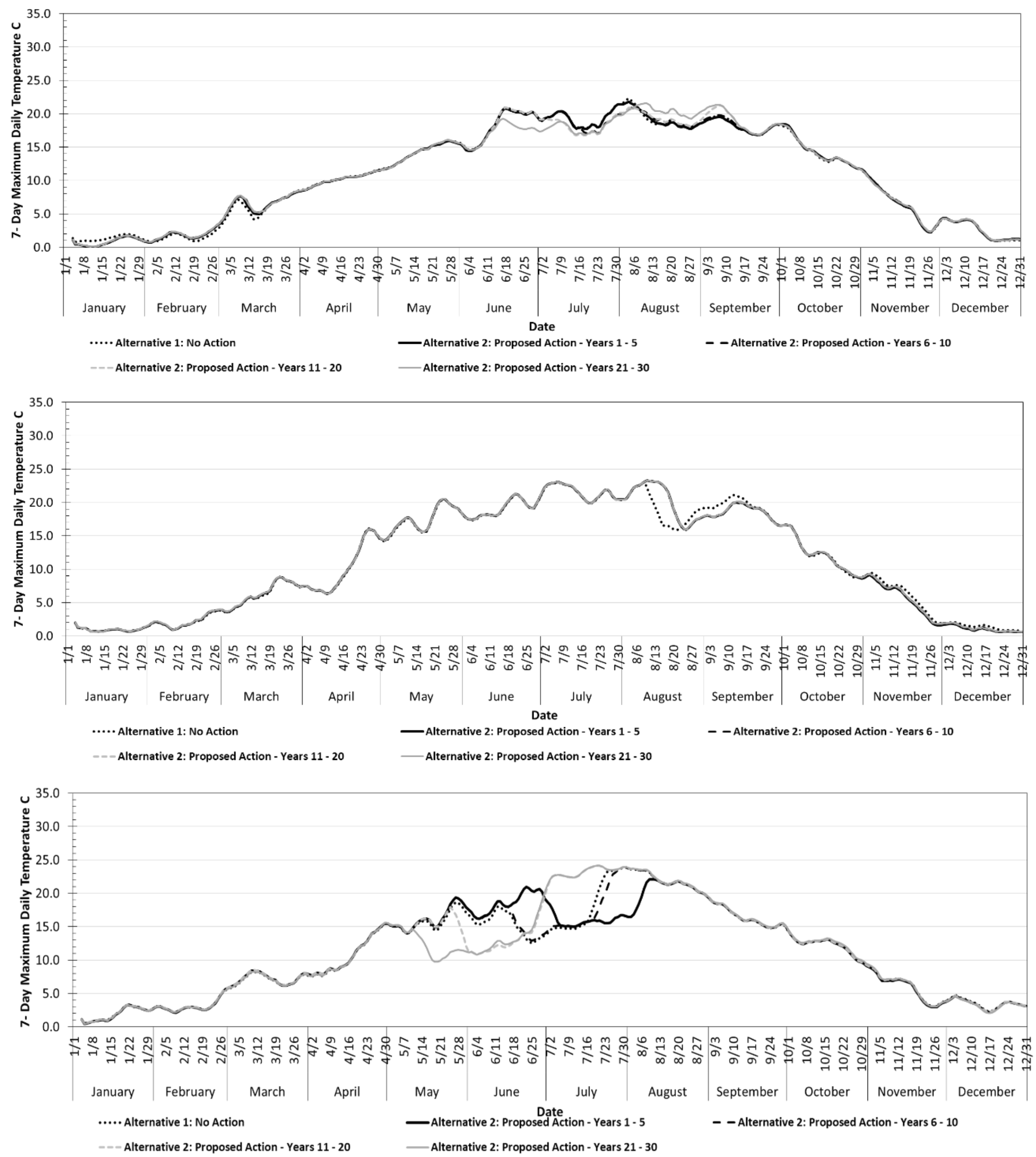


Figure 25. May through August Difference in Median Monthly Streamflow for the Crooked River (CAPO node) for No-Action Alternative and Proposed Action (Years 21–30)

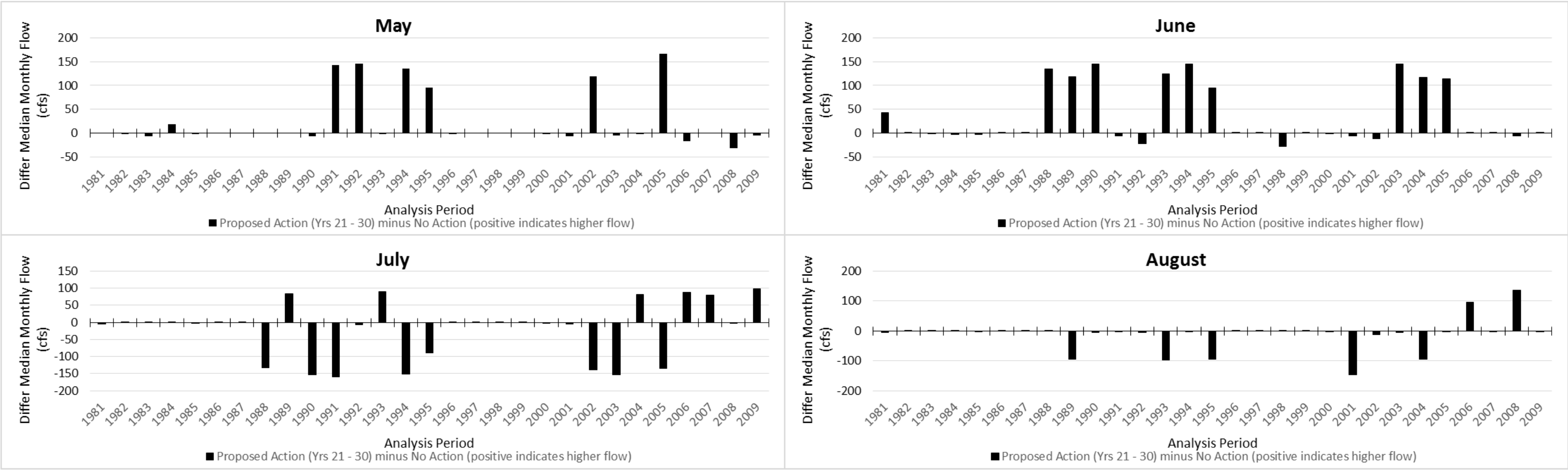


Table 7. Summary Monthly Median Streamflows for the Crooked River near Highway 126 (CAPO node) under the No-Action Alternative and Proposed Action (Years 21–30)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
Average diff. median flow (%)	20%	37%	37%	31%	32%	23%	-3%	136%	142%	-2%	5%	-14%
Range diff. in monthly median flow (%)	-16–296%	-62–440%	-43–440%	-17–342%	-14–342%	-14–342%	-32–4%	-43–1216%	-80–1060%	-96–186%	-90–608%	-100–1%
# Years no diff. in median flow	21	20	21	21	22	24	25	19	13	12	16	20
# Years increase in median flow	5	6	5	5	5	3	0	6	10	6	2	0
Range increase in monthly median flow (%)	14–296%	6–440%	13–440%	12–342%	12–342%	93–342%	NA	79–1216%	58–1060%	110–186%	139–608%	NA
Average increase median flow (%)	121%	194%	232%	189%	189%	230%	NA	680%	437%	130%	374%	NA
# Years decrease in median flow	3	3	3	3	2	2	4	4	6	11	11	9
Range decrease in monthly median flow (%)	-16–-5%	-62–-15%	-43–-13%	-17–-14%	-14–-11%	-14–-5%	-32–-8%	-43–-14%	-80–-13%	-96–-16%	-90–-33%	-100–-13%
Average decrease median flow (%)	-12%	-42%	-29%	-15%	-14%	-11%	-23%	-35%	-45%	-77%	-56%	-48%

Ochoco Reservoir

Based on modeled results for the Ochoco Reservoir node (OCH), there would be no change in reservoir elevation or volume.

Ochoco and McKay Creeks

The proposed action would have small increases in streamflow in Ochoco Creek, from slightly higher seasonal minimum and maximum median streamflows under Conservation Measure CR-2, and in McKay Creek, from higher minimum streamflows during the active irrigation season under Conservation Measure CR-3.

Species Impacts

Species impacts in this section are discussed by geographic area and include only those geographic areas where each species occurs or has the potential to occur. Species impacts are compared to the no action alternative. This means impacts of water management on streamflow, for example low or highly variable streamflows under the no action, were not evaluated as an adverse effect.

BIO-4: Affect Bull Trout Habitat

The proposed action would have no effect on bull trout habitat in Whychus[3] Creek, the Lower Deschutes River, Lake Billy Chinook, or Lake Simtustus because changes in streamflows and reservoir volumes and elevations would either not change or changes would be minor over the permit term compared to the no-action alternative. The proposed action would have small beneficial effects on bull trout habitat in Ochoco Creek, from slightly higher seasonal minimum and maximum median streamflows under Conservation Measure CR-2, and in McKay Creek, from higher minimum streamflows during the active irrigation season under Conservation Measure CR-3. Effects in the remaining reaches relevant to the species are described.

Middle Deschutes

Increased fall and winter streamflows under Conservation Measure DR-1 and WR-1 would result in median streamflows in the Middle Deschutes River increasing by approximately 20% from October to March. This would have a beneficial effect on the quantity and connectivity of bull trout habitat for foraging subadults and adults (increasing wetted channel area and adding more depth to pool habitat) over the permit term in the portion of the reach accessible to the species.

Crooked River

The Crooked River is critical habitat for bull trout up to RM 18 (Highway 97). Bull trout presence in the Crooked River is seasonally limited because of water temperatures during summer rearing and fall spawning. Daily maximum temperatures in the Crooked River during the fall spawning period exceed the upper limits of temperature preference for spawning (9.0°C) in all reaches (Table 8) and exceed the preference threshold for egg incubation during much of the egg incubation period (Table 10). Bull trout are currently encountered at Opal Springs Dam (FWS unpublished observations 2016–2019) and foraging subadult bull trout are expected to migrate upstream Opal Springs Dam with construction of fish passage facilities in 2019. They may occupy habitats throughout the river

[3] Conservation Measure WC-1, the addition of 3 cfs to the existing 28.18 cfs to instream flows by Three Sisters ID, is assumed under the no-action alternative.

up to Bowman Dam during the winter when temperatures are favorable. Summer daily maximum temperatures exceed the temperature thresholds for subadult bull trout under the no-action alternative, with the exception of the reach downstream of Bowman Dam (CR-10). Daily maximum water temperatures in this reach are within the preference threshold during much of the year and are dependent on water release from Bowman Dam (Table 11). In addition, although the water temperature model did not extend to reaches CR-1.2 and 1.1 from Osborne Canyon at RM 8 downstream to the Crooked River confluence with Lake Billy Chinook, this section of the river is also within preference thresholds for bull trout due to spring inflows (Torgerson et al. 2007).

The analysis of potential effects of temperatures included all reaches of the Crooked River based on the assumption that subadults may move higher into the river during the winter and water management may result in bull trout encountering additional days with adverse temperatures in other times of the year.

Water Temperature Results

Streamflows under the proposed action would be expected to affect bull trout habitat with potential distribution up to Bowman Dam upon the completion of a fish passage structure at Opal Springs Diversion Dam.

Tables 8 and 9 summarize temperature thresholds predicted temperatures for bull trout spawning and egg incubation, respectively. Results support conclusions that current condition water temperatures do not support bull trout spawning in the Crooked River upstream of Smith Rock (modeled portion of the Crooked River or in any other accessible area of the Crooked River or its tributaries).

Table 10 summarizes temperature thresholds and predicted temperatures for juvenile and subadult rearing. These temperatures support the potential use of the Crooked River by foraging bull trout during the winter in all modeled reaches and in the summer in the reach downstream of Bowman Dam (CR-10; RM 70-48) and reported temperatures favorable to bull trout in the reach from Osborne Canyon to Lake Billy Chinook (CR 1.2 and 1.1; RM 8 -0)(Torgerson et al. 2007).

Under the no-action alternative, water temperatures during the summer exceed the preference threshold for nearly 2 months in the normal water year and longer in the wet and dry years in reach downstream of Bowman Dam (differences among years because of differences in streamflows and meteorological conditions during the summer). However, temperature heterogeneity created by inflow of cooler subsurface flow may allow bull trout to avoid the warmest temperatures during this period in this reach. Bull trout that do not emigrate prior to summer from the approximately 40 miles of the Crooked River encompassed by reaches CR-9 to CR-2 would experience potentially lethal temperatures of 23˚C and higher under the no action alternative.

At the end of the permit term under the proposed action, water temperatures for the dry and normal water years are predicted to exceed the stress/disease threshold by an additional 12 and 19 days, respectively (Table 10). Under water management in the normal year at the end of the permit term, 70 days above the preference threshold would occur compared to 49 days under the no-action alternative. In wet and dry water years the number of preference days would not change.

Table 8. Predicted Number of Days within Water Temperature Thresholds for Spawning Bull Trout under the No-Action Alternative and Proposed Action

		Wet Water Year					Dry Water Year					Normal Water Year				
Reach	Life Stage Thresholds	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)
Bull Trout Spawning Temperature Thresholds																
	Preference <=9.0 C	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
CR - 10	Suboptimal >9 C & <=11 C	0	0	0	0	0	9	3	3	3	3	0	0	0	0	0
	Avoidance > 11.0 C	92	92	92	92	92	81	89	89	89	89	92	92	92	92	92
	Preference <=9.0 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 9	Suboptimal >9 C & <=11 C	0	0	0	0	0	0	6	6	6	6	1	2	2	2	2
	Avoidance > 11.0 C	92	92	92	92	92	92	86	86	86	86	91	90	90	90	91
	Preference <=9.0 C	0	0	0	0	0	3	6	6	6	6	1	2	1	1	0
CR - 8	Suboptimal >9 C & <=11 C	0	0	0	0	0	7	6	6	6	6	7	7	8	8	9
	Avoidance > 11.0 C	92	92	92	92	92	82	80	80	80	80	84	83	83	83	85
	Preference <=9.0 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 7	Suboptimal >9 C & <=11 C	0	0	0	0	0	0	2	2	2	2	0	1	1	1	1
	Avoidance > 11.0 C	92	92	92	92	92	92	90	90	90	90	92	91	91	91	92
	Preference <=9.0 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 6	Suboptimal >9 C & <=11 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Avoidance > 11.0 C	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92
	Preference <=9.0 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 5	Suboptimal >9 C & <=11 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Avoidance > 11.0 C	92	92	92	92	92	92	92	92	92	92	92	92	92	92	92
	Preference <=9.0 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 4	Suboptimal >9 C & <=11 C	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
	Avoidance > 11.0 C	92	92	92	92	92	92	92	92	92	92	91	91	91	91	91
	Preference <=9.0 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 3	Suboptimal >9 C & <=11 C	7	5	5	6	6	11	10	10	10	10	6	6	6	6	6
	Avoidance > 11.0 C	85	87	87	86	85	81	82	82	82	82	86	86	86	86	86
	Preference <=9.0 C	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
CR - 2	Suboptimal >9 C & <=11 C	5	5	6	6	6	11	11	11	11	11	6	6	6	6	6
	Avoidance > 11.0 C	87	87	86	86	85	78	78	78	78	78	86	86	86	86	86

Table 9. Predicted Number of Days within Water Temperature Thresholds for Egg Incubation Bull Trout under the No-Action Alternative and Proposed Action

		Wet Water Year					Dry Water Year					Normal Water Year				
Reach	Life Stage Thresholds	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)
Bull Trout Egg Incubation Temperature Thresholds																
CR - 10	Preference <=6.0 C	104	108	106	106	106	110	105	105	105	105	82	87	87	87	84
	Stress/Disease >6 C	136	132	134	134	134	130	135	135	135	135	158	153	153	153	156
CR - 9	Preference <=6.0 C	99	106	106	106	107	96	107	106	106	106	97	96	95	95	97
	Stress/Disease >6 C	141	134	134	134	133	144	133	134	134	134	143	144	145	145	143
CR - 8	Preference <=6.0 C	109	110	109	109	109	107	110	109	109	109	99	98	98	98	99
	Stress/Disease >6 C	131	130	131	131	131	133	130	131	131	131	141	142	142	142	141
CR - 7	Preference <=6.0 C	108	108	108	108	108	88	111	111	111	111	108	107	107	107	108
	Stress/Disease >6 C	132	132	132	132	132	152	129	129	129	129	132	133	133	133	132
CR - 6	Preference <=6.0 C	109	108	107	107	107	87	107	107	106	107	105	104	103	104	105
	Stress/Disease >6 C	131	132	133	133	133	153	133	133	134	133	135	136	137	136	135
CR - 5	Preference <=6.0 C	102	101	98	98	98	68	78	80	78	78	84	85	85	85	86
	Stress/Disease >6 C	138	139	142	142	142	172	162	160	162	162	156	155	155	155	154
CR - 4	Preference <=6.0 C	107	103	103	103	103	94	95	95	95	96	94	94	94	94	94
	Stress/Disease >6 C	133	137	137	137	137	146	145	145	145	144	146	146	146	146	146
CR - 3	Preference <=6.0 C	118	117	112	113	113	108	108	108	108	108	101	101	101	101	101
	Stress/Disease >6 C	122	123	128	127	127	132	132	132	132	132	139	139	139	139	139
CR - 2	Preference <=6.0 C	118	117	113	113	114	108	107	107	107	107	99	100	100	100	100
	Stress/Disease >6 C	122	123	127	127	126	132	133	133	133	133	141	140	140	140	140

Table 10. Predicted Number of Days within Water Temperature Thresholds for Juvenile and Subadult Bull Trout under the No-Action Alternative and Proposed Action

		Wet Water Year					Dry Water Year					Normal Water Year				
Reach	Life Stage Thresholds	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)
Bull Trout Juvenile and Subadult Rearing Temperature Thresholds																
CR - 10	Preference <=15.0 C	223	225	223	223	223	259	258	258	258	258	313	335	321	300	292
	Avoidance >15 C and <= 16 C	13	11	13	13	13	43	33	33	33	32	13	19	20	30	15
	Stress/Disease >16 C & <=23 C	126	126	126	126	126	60	71	71	71	72	36	8	21	32	55
	Lethal >23.0 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 9	Preference <=15.0 C	220	220	219	219	219	181	187	187	187	186	266	258	258	248	248
	Avoidance >15 C and <= 16 C	17	17	18	18	18	24	12	13	13	14	5	8	10	3	3
	Stress/Disease >16 C & <=23 C	125	125	125	125	125	111	107	106	107	106	73	92	74	78	78
	Lethal >23.0 C	0	0	0	0	0	46	56	56	55	56	18	4	20	33	33
CR - 8	Preference <=15.0 C	225	224	225	225	225	199	198	198	198	198	272	258	266	257	266
	Avoidance >15 C and <= 16 C	16	17	16	16	16	17	8	8	8	8	25	29	22	21	9
	Stress/Disease >16 C & <=23 C	121	121	121	121	121	129	130	130	131	131	47	75	59	55	55
	Lethal >23.0 C	0	0	0	0	0	17	26	26	25	25	18	0	15	29	32
CR - 7	Preference <=15.0 C	224	225	224	224	225	231	235	234	234	234	236	222	233	249	249
	Avoidance >15 C and <= 16 C	16	13	14	14	13	21	16	17	17	17	33	30	38	11	8
	Stress/Disease >16 C & <=23 C	122	124	124	124	124	110	111	111	111	111	93	110	91	102	105
	Lethal >23.0 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 6	Preference <=15.0 C	213	214	213	213	213	215	221	221	221	221	214	216	216	238	242
	Avoidance >15 C and <= 16 C	13	11	12	12	12	23	17	17	17	17	33	16	25	22	17
	Stress/Disease >16 C & <=23 C	132	137	137	137	130	124	124	124	124	124	113	130	118	94	92
	Lethal >23.0 C	4	0	0	0	7	0	0	0	0	0	2	0	3	8	11
CR - 5	Preference <=15.0 C	207	208	208	208	208	175	181	181	181	181	180	180	180	181	188
	Avoidance >15 C and <= 16 C	12	11	11	12	12	7	3	3	3	3	5	5	5	17	22
	Stress/Disease >16 C & <=23 C	114	112	117	121	122	132	122	122	122	122	127	138	130	95	83
	Lethal >23.0 C	29	31	26	21	20	48	56	56	56	56	50	39	47	69	69
CR - 4	Preference <=15.0 C	208	208	207	207	207	181	182	182	182	182	176	176	176	175	175
	Avoidance >15 C and <= 16 C	4	3	4	4	4	7	7	7	7	7	4	5	5	6	8
	Stress/Disease >16 C & <=23 C	102	103	103	99	94	80	82	81	81	80	100	80	95	104	106
	Lethal >23.0 C	48	48	48	52	57	94	91	92	92	93	82	101	86	77	73
CR - 3	Preference <=15.0 C	217	216	216	216	217	200	199	199	199	200	201	202	202	202	202
	Avoidance >15 C and <= 16 C	6	8	8	8	7	9	8	8	8	7	11	7	7	7	12
	Stress/Disease >16 C & <=23 C	97	96	96	97	98	95	91	91	91	91	90	82	93	88	83
	Lethal >23.0 C	42	42	42	41	40	58	64	64	64	64	60	71	60	65	65
CR - 2	Preference <=15.0 C	223	224	223	223	223	198	198	198	198	198	207	209	209	209	215
	Avoidance >15 C and <= 16 C	7	7	8	8	8	9	9	9	9	9	9	7	7	12	13
	Stress/Disease >16 C & <=23 C	113	113	116	116	124	131	128	128	128	128	106	100	105	85	78
	Lethal >23.0 C	19	18	15	15	7	24	27	27	27	27	40	46	41	56	56

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Summary

Under Conservation Measure CR-4, funds would be available to support Crooked River habitat restoration measures and would benefit bull trout habitat. Conservation Measure CR-5 would provide funds for screening to National Oceanic and Atmospheric Administration (NOAA) fish screen standards of Ochoco Irrigation District (ID) patron diversions, and maintenance and operation of fish screens on all Ochoco ID-controlled diversions and would likely have a minor benefit on bull trout habitat because bull trout may only be present in the river at the beginning of the irrigation season.

Bull trout would be exposed to a range of water management effects under the proposed action, including differences in streamflow across the year affecting the amount of habitat available and water management affecting water temperatures during critical life stages.

Conservation Measure CR-6 would ensure minimum streamflows are maintained when the North Unit ID pumps are operating, which would have a beneficial effect on bull trout habitat by reducing intra-daily streamflow variations downstream of the North Unit ID pumps to Osborne Canyon.

Conservation Measure CR-1 would supplement storage season streamflows to ensure the 50 cfs minimum flows on the Crooked River during storage season (as prescribed under the Crooked River Act) are met and additional winter streamflows would benefit bull trout habitat. Water management and associated water temperatures in the wet water year shows no effect on bull trout juvenile and subadult habitat over the permit term. However, water management in dry and normal water years indicate a potential for adverse effect on bull trout that may attempt to rear through the summer in the reach downstream of Bowman Dam (CR-10). The number of preference days declines from 313 days under the no-action alternative to 292 days under the proposed action by the end of the permit term, and the number of stress/disease days increases from 36 to 55 days.

The analysis assumes potential bull trout occupancy in multiple reaches during the winter. Bull trout may attempt to rear through the summer in the upper reach or those that fail to emigrate in the spring would encounter warmer temperatures in reaches CR-9 through CR-2 under the proposed action.

In the Crooked River, Conservation Measures CR-4, CR-5, and CR-6 would result in beneficial effects on bull trout habitat. Water management under the proposed action at full implementation (years 21–30) compared to the no-action alternative would result in no effect on bull trout habitat conditions in wet water years, but habitat quantity and quality during bull trout critical life stages could decline in dry and normal water years depending on annual water management practices. Water supply modeling assumes early irrigation season diversions from the Crooked River would increase as water supply availability on the Deschutes River declines. The frequency of this outcome would depend on specific, annual water supply management decisions and water supply availability that are not captured fully by modeling results. This effect on bull trout habitat would be adverse in the Crooked River because the potential exists for early season irrigation diversions to affect bull trout habitat in dry and normal water year types in years 21 through 30.

BIO-5: Affect Bull Trout Migratory Life Stages

The proposed action would have no effect on bull trout migratory life stages in Whychus Creek, the Lower Deschutes River, Lake Billy Chinook, or Lake Simtustus because streamflows and reservoir volumes and elevations would either not change or changes would be minor compared to the no-action alternative over the permit term. The proposed action would have small beneficial effects on bull trout migratory life stages in Ochoco Creek, from slightly higher seasonal minimum and maximum median streamflows and in McKay Creek from higher minimum streamflows during the active irrigation season. Effects in the remaining reaches relevant to the species are described.

Middle Deschutes

Increased median streamflows by 20% in the Middle Deschutes from October to March (Conservation Measures DR-1 and WR-1) would have a beneficial effect on bull trout migratory life stages over the permit term in the portion of the reach accessible to the species. Higher winter streamflows would likely improve access of foraging bull trout moving upstream into the Middle Deschutes River from Lake Billy Chinook.

Crooked River

The proposed action would have no effect on bull trout migratory life stages in Crooked River because migration windows for entering and moving upstream in the fall and for subadults to leave the Crooked River in the spring before temperatures exceed preference thresholds would not be affected.

BIO-6: Affect Steelhead Trout Habitat

The proposed action would have no effect on steelhead trout habitat in Whychus Creek, the Lower Deschutes River, Lake Billy Chinook, or Lake Simtustus because changes in streamflows and reservoir volumes and elevations would either not change or changes would be minor over the permit term compared to the no-action alternative. The proposed action would have small beneficial effects on steelhead trout habitat in Ochoco Creek, from slightly higher seasonal minimum and maximum median streamflows under Conservation Measure CR-2, and in McKay Creek, from higher minimum streamflows during the active irrigation season under Conservation Measure CR-3. Effects in the remaining reaches relevant to the species are described.

Middle Deschutes

Increased median streamflows by 20% in the Middle Deschutes River from October to March (Conservation Measure DR-1 and WR-1) would have a beneficial effect on the quantity and connectivity of steelhead trout rearing and adult holding habitat over the permit term. Higher winter streamflows would increase wetted channel area and add more depth to pool habitat used by steelhead trout.

Overall the proposed action would have a beneficial effect on steelhead trout habitat.

Crooked River

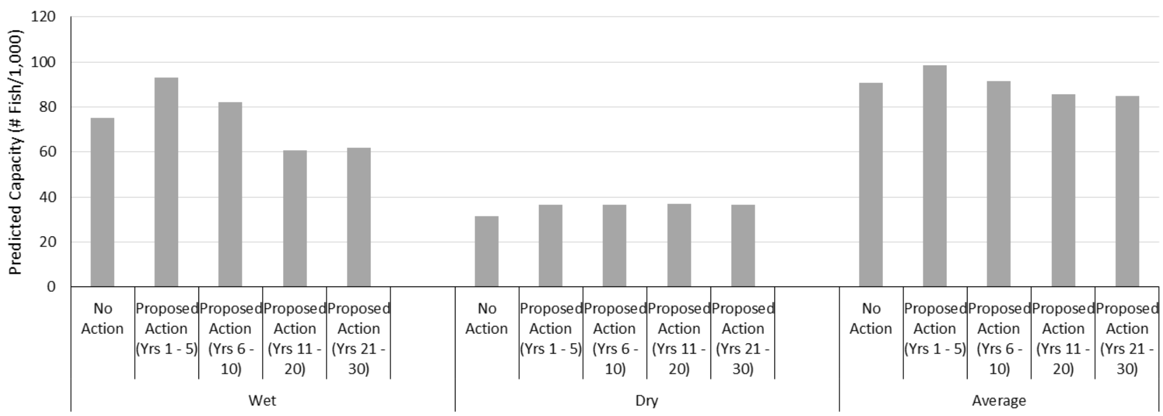
Conservation Measures CR-4, CR-5, and CR-6 in the Crooked River would benefit steelhead trout habitat. Under Conservation Measure CR-4, funds would be available to support Crooked River habitat restoration measures and would benefit steelhead trout habitat. Conservation Measure CR-5 would provide funds for screening to National Oceanic and Atmospheric Administration (NOAA) fish screen standards of Ochoco Irrigation District (ID) patron diversions, and maintenance and operation of fish screens on all Ochoco ID-controlled diversions.

Conservation Measure CR-6 would ensure minimum streamflows are maintained when the North Unit ID pumps are operating, which would have a beneficial effect on steelhead trout habitat by reducing intra-daily streamflow variations downstream of the North Unit ID pumps to Osborne Canyon.

Habitat Model Results

Results of modeling for summer juvenile rearing show no effect or a decline in capacity under the proposed action (Figure 26). Temperature effects are largely influencing these results with slightly warmer temperatures in the wet and normal water year type toward the end of the permit term, resulting in a decline in juvenile capacity across all reaches.

Figure 26. Juvenile Steelhead Summer Capacity Estimates for the Mainstem Crooked River under the No-Action Alternative and Proposed Action



Results of modeling winter juvenile rearing capacity are inconclusive. The decline in capacity under the proposed action in wet and normal water years modeled is from effects of summer water temperatures on the predicted abundance of steelhead in the winter (Figure 27). However, these results may not reflect winter conditions for juvenile rearing with the increased minimum streamflow rule. The results presented in Figure 27 represent effects of summer maximum water temperatures and winter streamflows (Mount Hood Environmental 2019). It is unclear if the winter minimum streamflow rule under the proposed action would affect summer water temperatures in the Crooked River. Figure 28 presents model results assuming a fixed summer maximum temperature (22˚C) in the no-action alternative and proposed action across the entire permit term. This analysis is included to focus effects of managing for higher streamflows during the storage season on juvenile capacity. In this analysis, steelhead winter capacity increases slightly under the proposed action in the dry water year with a slight increase in winter streamflows in that year type. Winter streamflows and juvenile capacity did not change under the proposed action in a wet and normal water year type because under the no-action alternative, streamflows exceeded the minimum rule.

Figure 27. Juvenile Steelhead Winter Capacity Estimates for the Mainstem Crooked River under the No-Action Alternative and Proposed Action

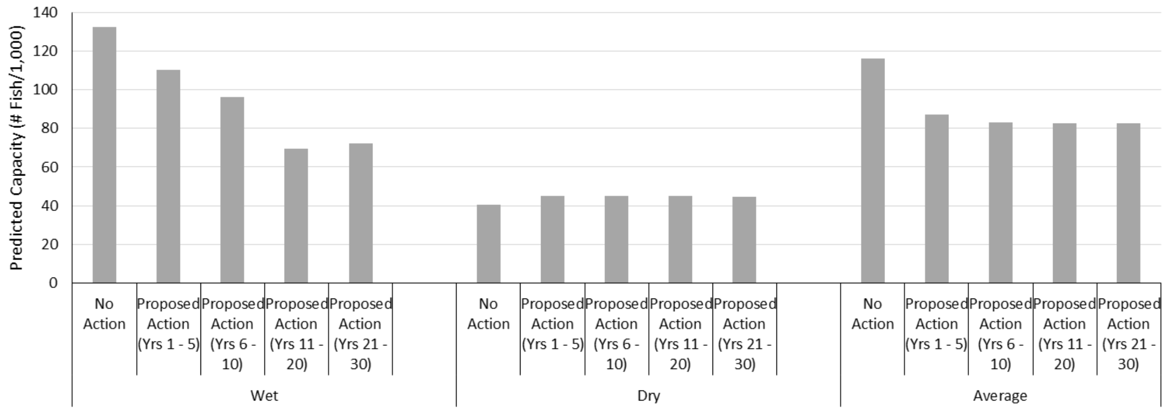
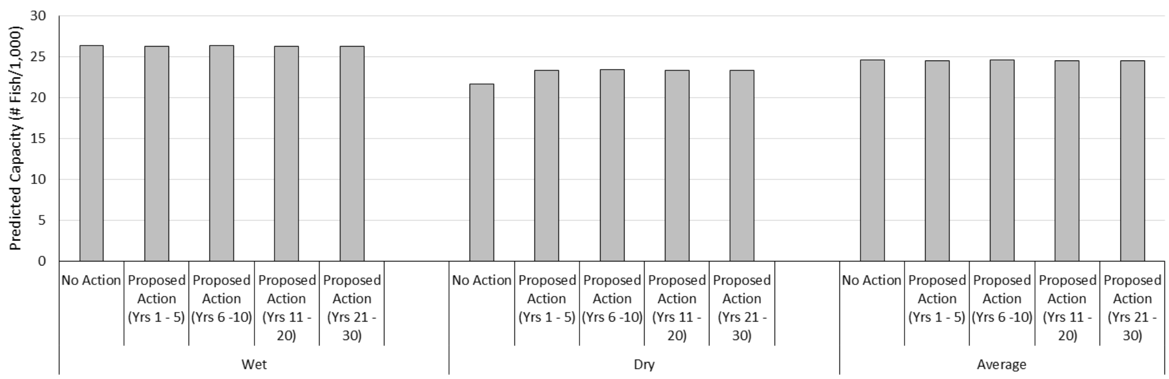


Figure 28. Juvenile Steelhead Winter Capacity Estimates for the Mainstem Crooked River with Fixed Summer Maximum Temperatures (22˚C) under the No-Action Alternative and Proposed Action



Water Temperature Results

Tables 11 and 12 summarize temperature thresholds and predicted temperatures for steelhead trout egg incubation and juvenile rearing.

Steelhead fry may emerge from the gravel into late June to early July and survival of eggs prior to emergence can be affected by rapidly warming conditions toward the end of the incubation period. Water temperatures during egg incubation are not being affected by water management under the proposed action (Table 11). The number of days in the preferred category tended to not change or actually increased over the permit term for the year types.

Analysis of temperature thresholds for juvenile steelhead rearing show an effect of the shift in timing of release of water for the NUID pumps to May on temperatures (Table 12). The number of days in the avoidance category increase in the wet water year in the reach immediately downstream of Bowman Dam. The number of days increased from 33 days under the no-action alternative to 59 days under the proposed action by the end of the permit term. In addition, there were more warm days in the normal water year toward the end of the permit term. The number of suboptimal days increased from 77 days to 109 days in the reach immediately downstream of Bowman Dam (CR-10). The number of days in the stress/disease category increased from 34 days to 48 days in reach CR - 9, downstream of the canyon reach and from 27 days to 52 days in reach CR–8, upstream of Prineville.

Effects of water management on water temperature in lower reaches (CR-7 through CR-2) tended to be more variable as temperatures were warmer under the no-action alternative and effects of water management from Bowman Dam have less of an influence on water temperatures (Berger et al. 2019). Berger et al. (2019) summarized this effect this way:

> Scenario simulations showed that the temperature impact of Bowman Dam releases were very sensitive to travel time. The longer the travel time and further the distance from the dam, the less effect dam releases had on downstream river temperatures. At longer travel times, water temperatures became more of a function of meteorological conditions instead of dam release temperatures. This was illustrated by the No Action scenario predicting cooler downstream temperatures later in the summer relative to the other scenarios for 1993 and 2005 due to higher Bowman Dam releases.

Overall there was a tendency for more days in the stress/disease and lethal categories under the proposed action.

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Table 11. Predicted Number of Days within Water Temperature Thresholds for Steelhead Trout Egg Incubation under the No-Action Alternative and Proposed Action

		Wet Water Year					Dry Water Year					Normal Water Year				
Reach	Life Stage Thresholds	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)
Steelhead Trout Egg Incubation Temperature Thresholds																
CR - 10	Preference <=11.1 C	62	62	62	62	62	53	53	53	53	53	63	63	63	75	90
	SubOptimal >11.1 C & <=15 C	32	34	32	32	32	64	63	63	63	63	59	59	59	47	32
	Stress/Disease >15 C	28	26	28	28	28	5	6	6	6	6	0	0	0	0	1
CR - 9	Preference <=11.1 C	51	57	57	57	57	49	49	49	49	49	49	48	48	62	64
	SubOptimal >11.1 C & <=15 C	36	30	29	29	29	7	4	4	4	4	70	46	59	54	53
	Stress/Disease >15 C	35	35	36	36	36	66	69	69	69	69	3	28	15	6	5
CR - 8	Preference <=11.1 C	57	57	57	57	57	50	49	49	49	49	51	51	51	60	66
	SubOptimal >11.1 C & <=15 C	30	29	30	30	30	7	7	7	7	7	57	37	49	49	44
	Stress/Disease >15 C	35	36	35	35	35	65	66	66	66	66	14	34	22	13	4
CR - 7	Preference <=11.1 C	56	57	57	57	57	53	53	53	53	53	54	54	54	54	61
	SubOptimal >11.1 C & <=15 C	35	35	34	34	34	48	46	45	45	45	50	36	46	63	56
	Stress/Disease >15 C	31	30	31	31	31	21	23	24	24	24	18	32	22	5	5
CR - 6	Preference <=11.1 C	54	54	54	54	54	54	54	54	54	54	55	55	55	55	55
	SubOptimal >11.1 C & <=15 C	26	27	26	26	26	27	27	27	27	27	29	30	30	52	52
	Stress/Disease >15 C	42	41	42	42	42	41	41	41	41	41	38	37	37	15	11
CR - 5	Preference <=11.1 C	44	44	44	44	44	46	46	46	45	45	43	40	39	38	42
	SubOptimal >11.1 C & <=15 C	28	28	28	28	28	6	6	6	7	7	12	15	16	18	14
	Stress/Disease >15 C	50	50	50	50	50	70	70	70	70	70	67	67	67	66	59
CR - 4	Preference <=11.1 C	43	46	45	45	45	38	40	40	40	40	28	28	28	28	27
	SubOptimal >11.1 C & <=15 C	26	23	24	24	24	13	11	11	11	11	21	21	21	21	22
	Stress/Disease >15 C	53	53	53	53	53	71	71	71	71	71	73	73	73	73	73
CR - 3	Preference <=11.1 C	47	48	47	47	47	50	50	50	50	50	48	48	48	48	48
	SubOptimal >11.1 C & <=15 C	24	22	23	23	23	3	3	3	3	3	6	6	6	6	6
	Stress/Disease >15 C	51	52	52	52	51	69	69	69	69	69	68	68	68	68	68
CR - 2	Preference <=11.1 C	45	46	45	45	45	47	47	47	47	48	39	39	39	38	39
	SubOptimal >11.1 C & <=15 C	25	24	25	25	25	6	6	6	6	5	15	15	15	16	15
	Stress/Disease >15 C	52	52	52	52	52	69	69	69	69	69	68	68	68	68	62

Source: Water Temperature Thresholds: R2 and Pacific Biota 2013, Water Temperatures: Berger et al. 2019.

Table 12. Predicted Number of Days within Water Temperature Thresholds for Steelhead Trout Juvenile Rearing under the No-Action Alternative and Proposed Action

		Wet Water Year					Dry Water Year					Normal Water Year				
Reach	Life Stage Thresholds	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)
Steelhead Trout Juvenile Rearing Temperature Thresholds																
CR - 10	Preference <=14.0 C	203	201	203	203	203	239	234	234	234	234	285	294	290	270	253
	SubOptimal >14 C & <=19 C	126	131	128	121	100	87	99	99	99	99	77	68	72	92	109
	Avoidance >19 C & <22 C	33	30	31	38	59	24	28	28	28	28	0	0	0	0	0
	Stress/Disease >22 C	0	0	0	0	0	12	1	1	1	1	0	0	0	0	0
CR - 9	Preference <=14.0 C	199	199	199	198	198	170	182	182	182	182	249	229	236	230	244
	SubOptimal >14 C & <=19 C	149	150	153	144	125	92	71	71	71	71	63	98	77	59	46
	Avoidance >19 C & <22 C	14	13	10	20	39	38	38	38	38	37	16	17	17	25	24
	Stress/Disease >22 C	0	0	0	0	0	62	71	71	71	72	34	18	32	48	48
CR - 8	Preference <=14.0 C	207	208	208	207	208	194	194	194	194	194	249	224	233	248	253
	SubOptimal >14 C & <=19 C	103	104	100	98	104	75	73	73	73	73	66	109	84	46	40
	Avoidance >19 C & <22 C	52	50	54	57	50	63	56	56	57	57	20	20	21	19	17
	Stress/Disease >22 C	0	0	0	0	0	30	39	39	38	38	27	9	24	49	52
CR - 7	Preference <=14.0 C	206	207	206	206	206	212	217	217	217	217	218	213	217	236	239
	SubOptimal >14 C & <=19 C	92	91	86	88	96	95	96	96	95	95	95	116	98	58	53
	Avoidance >19 C & <22 C	62	64	70	68	60	55	49	49	50	50	44	33	38	56	56
	Stress/Disease >22 C	2	0	0	0	0	0	0	0	0	0	5	0	9	12	14
CR - 6	Preference <=14.0 C	203	203	203	203	203	205	208	208	208	208	203	203	203	217	227
	SubOptimal >14 C & <=19 C	72	68	71	75	76	95	96	96	96	96	107	114	109	76	65
	Avoidance >19 C & <22 C	77	80	80	71	63	62	58	58	58	58	30	39	30	39	39
	Stress/Disease >22 C	10	11	8	13	20	0	0	0	0	0	22	6	20	30	31
CR - 5	Preference <=14.0 C	199	203	203	204	204	166	177	177	177	177	176	176	176	176	181
	SubOptimal >14 C & <=19 C	68	62	65	69	68	59	52	52	52	52	68	55	67	84	83
	Avoidance >19 C & <22 C	51	52	54	47	50	63	60	59	59	59	66	82	70	31	27
	Stress/Disease >22 C	44	45	40	42	40	74	73	74	74	74	52	49	49	71	71
CR - 4	Preference <=14.0 C	202	202	203	203	203	179	179	179	179	179	171	171	171	171	171
	SubOptimal >14 C & <=19 C	45	43	43	42	41	19	19	19	19	19	40	40	40	52	65
	Avoidance >19 C & <22 C	50	53	52	52	43	48	55	55	55	55	51	43	51	56	49
	Stress/Disease >22 C	65	64	64	65	75	116	109	109	109	109	100	108	100	83	77
CR - 3	Preference <=14.0 C	208	207	208	208	208	197	197	197	197	197	191	191	191	191	195
	SubOptimal >14 C & <=19 C	60	57	59	59	60	35	33	33	33	33	58	57	57	70	75
	Avoidance >19 C & <22 C	43	48	44	39	34	55	52	52	52	52	45	31	42	33	24
	Stress/Disease >22 C	51	50	51	56	60	75	80	80	80	80	68	83	72	68	68
CR - 2	Preference <=14.0 C	215	216	215	215	216	196	196	196	196	196	195	195	195	196	197
	SubOptimal >14 C & <=19 C	61	59	65	67	60	61	65	65	65	65	66	63	65	82	87
	Avoidance >19 C & <22 C	51	52	50	55	70	63	55	55	55	55	54	40	48	23	17
	Stress/Disease >22 C	35	35	32	25	16	42	46	46	46	46	47	64	54	61	61

Source: Water Temperature Thresholds: R2 and Pacific Biota 2013, Water Temperatures: Berger et al. 2019.

Summary

Steelhead trout would be exposed to a range of water management effects under the proposed action, including differences in streamflow across the year affecting the amount of habitat available and effects of water management on water temperatures during critical life stages (Conservation Measures CR-1 and WR-1).

Habitat model results suggest an adverse effect on summer rearing and inconclusive effects on winter rearing, although higher streamflows are predicted to increase habitat capacity independent of summer water temperatures.

Decreased streamflows downstream of the North Unit ID pumps to Osborne Canyon (Reaches CR-2 through 1.3; RM 28 to 8) from May through September would have an adverse effect on steelhead trout habitat in a little over half of the years over the permit term due to increased North Unit ID reliance on the Crooked River to compensate for decreased Upper Deschutes water supply under Conservation Measure WR-1.

Analysis of water temperature thresholds for juvenile steelhead trout rearing habitat suggest an adverse effect of water management on water temperatures and juvenile habitat in all water years in years 21 through 30 of the permit term.

BIO-7: Affect Steelhead Trout Migratory Life Stages

The proposed action would have no effect on steelhead trout migratory life stages in Whychus, Ochoco, and McKay Creeks because streamflows would be unchanged in these creeks over the permit term. Likewise, the proposed action would have no effect on steelhead trout migratory life stages in the Lower Deschutes because the increase in winter streamflows over the permit term would be minor.

Middle Deschutes

The proposed action would have no effect on steelhead trout migratory life stages during the irrigation period because streamflows in this reach during this period would be unchanged over the permit term.

Small to moderate increases in winter streamflows, under the proposed action, would have no effect on steelhead trout migratory life stages in the portion of the reach accessible to the species over the permit term.

Crooked River

Analysis of effects of the proposed action on steelhead trout migratory life stages is based predicted streamflows and water temperature predictions (Berger et al. 2019) and thresholds for steelhead trout migratory life stages (R2 and Biota Pacific 2013).

The analysis considered the effects of water management on adult migration and temperature thresholds (Table 13), smolt migration and temperature thresholds (Table 14), and any evidence that streamflows may impair adult or juvenile migration.

There was no evidence that the proposed action streamflows were affecting water temperatures during steelhead trout migratory life stages across the permit term compared to the no-action alternative for all three water year types (Tables 15 and 16). In general, it appears there were more days that water temperatures were in the preferred category for migratory life stages under the proposed action, possibly suggesting a beneficial effect.

Overall, there would be no effect on migratory life stages of steelhead trout in this reach.

BIO-8: Affect Spring Chinook Salmon Habitat

The proposed action would have no effect on spring Chinook salmon habitat in Whychus, and Ochoco Creeks because streamflows would be unchanged in this creek over the permit term. Differences in reservoir volume and elevations in Lake Billy Chinook and Lake Simtustus would be minor under the proposed action and would have no effect on spring Chinook salmon habitat. Likewise, the proposed action would have no effect on spring Chinook salmon habitat in the Lower Deschutes because the increase in winter streamflows over the permit term would be minor.

The proposed action would have no effect on spring Chinook salmon habitat in Whychus Creek, the Lower Deschutes River, Lake Billy Chinook, or Lake Simtustus because changes in streamflows and reservoir volumes and elevations would either not change or changes would be minor over the permit term compared to the no-action alternative. The proposed action would have small beneficial effects on spring Chinook salmon habitat in Ochoco Creek, from slightly higher seasonal minimum and maximum median streamflows under Conservation Measure CR-2. Effects in the remaining reaches relevant to the species are described.

Middle Deschutes

The proposed action would have no effect on spring Chinook salmon habitat during the irrigation period because streamflows in the Middle Deschutes would be unchanged over the permit term. Small to moderate increases in winter streamflows, under the proposed action, would have no effect on spring Chinook salmon habitat in the portion of the reach accessible to the species over the permit term.

Crooked River

Conservation Measures CR-4, CR-5, and CR-6 in the Crooked River would benefit spring Chinook salmon habitat. Under Conservation Measure CR-4, funds would be available to support Crooked River habitat restoration measures and would benefit spring Chinook salmon habitat. Conservation Measure CR-5 would provide funds for screening to National Oceanic and Atmospheric Administration (NOAA) fish screen standards of Ochoco Irrigation District (ID) patron diversions, and maintenance and operation of fish screens on all Ochoco ID-controlled diversions.

Conservation Measure CR-6 would ensure minimum streamflows are maintained when the North Unit ID pumps are operating, which would have a beneficial effect on spring Chinook salmon habitat by reducing intra-daily streamflow variations downstream of the North Unit ID pumps to Osborne Canyon.

Habitat Model Results

Results of modeling available summer habitat for Chinook juvenile rearing indicate no trend toward adverse or beneficial effects. Effects of streamflows on available habitat do not suggest any particular trend between the no-action alternative and the proposed action (Figure 29).

Table 13. Predicted Number of Days within Water Temperature Thresholds for Steelhead Trout Adult Migrants under the No-Action Alternative and Proposed Action

		Wet Water Year					Dry Water Year					Normal Water Year				
Reach	Life Stage Thresholds	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)
Steelhead Trout Adult Migration Temperature Thresholds																
CR - 10	Preference <=12.8 C	147	147	148	148	148	162	159	159	159	159	155	156	156	156	154
	SubOptimal >12.8 C & <=14 C	9	9	8	8	8	5	4	4	4	4	23	23	23	23	18
	Avoidance >14.4 C & <21 C	23	23	23	23	23	12	16	16	16	16	1	0	0	0	7
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 9	Preference <=12.8 C	147	151	150	150	150	141	160	160	160	160	155	156	156	156	155
	SubOptimal >12.8 C & <=14 C	13	9	10	10	10	12	2	2	2	2	5	6	6	6	5
	Avoidance >14.4 C & <21 C	19	19	19	19	19	21	11	11	11	11	19	17	17	17	19
	Delay >21 C & <=23.9 C	0	0	0	0	0	2	3	3	3	3	0	0	0	0	0
CR - 8	Preference <=12.8 C	152	152	152	152	152	168	170	170	170	170	164	167	166	166	163
	SubOptimal >12.8 C & <=14 C	14	14	14	14	14	5	3	3	3	3	14	11	12	12	15
	Avoidance >14.4 C & <21 C	13	13	13	13	13	6	6	6	6	6	1	1	1	1	1
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 7	Preference <=12.8 C	151	151	151	151	151	144	159	159	159	159	155	155	155	155	154
	SubOptimal >12.8 C & <=14 C	12	12	12	12	12	14	4	4	4	4	5	7	7	7	7
	Avoidance >14.4 C & <21 C	16	16	16	16	16	21	16	16	16	16	19	17	17	17	18
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 6	Preference <=12.8 C	150	151	151	151	151	148	158	158	158	158	154	154	154	154	153
	SubOptimal >12.8 C & <=14 C	12	11	11	11	11	11	5	5	5	5	5	5	5	5	5
	Avoidance >14.4 C & <21 C	17	17	17	17	17	20	16	16	16	16	20	20	20	20	21
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 5	Preference <=12.8 C	151	151	151	151	152	138	147	147	148	148	150	150	150	151	150
	SubOptimal >12.8 C & <=14 C	14	14	15	15	14	12	12	12	11	11	5	5	5	4	5
	Avoidance >14.4 C & <21 C	14	14	13	13	13	29	20	20	20	20	24	24	24	24	24
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 4	Preference <=12.8 C	160	158	159	159	159	152	156	156	156	156	154	154	154	154	154
	SubOptimal >12.8 C & <=14 C	7	9	7	7	8	8	5	5	4	4	2	2	2	2	2
	Avoidance >14.4 C & <21 C	12	12	13	13	12	19	18	18	19	19	23	23	23	23	23
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 3	Preference <=12.8 C	166	165	165	165	165	173	169	169	169	169	160	159	159	160	162
	SubOptimal >12.8 C & <=14 C	5	5	6	6	6	2	6	6	6	6	12	13	13	12	15
	Avoidance >14.4 C & <21 C	8	9	8	8	8	4	4	4	4	4	7	7	7	7	2
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 2	Preference <=12.8 C	166	166	166	166	166	173	173	173	173	173	162	162	162	162	162
	SubOptimal >12.8 C & <=14 C	6	6	6	6	6	2	2	2	2	2	17	17	17	17	17
	Avoidance >14.4 C & <21 C	7	7	7	7	7	4	4	4	4	4	0	0	0	0	0
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

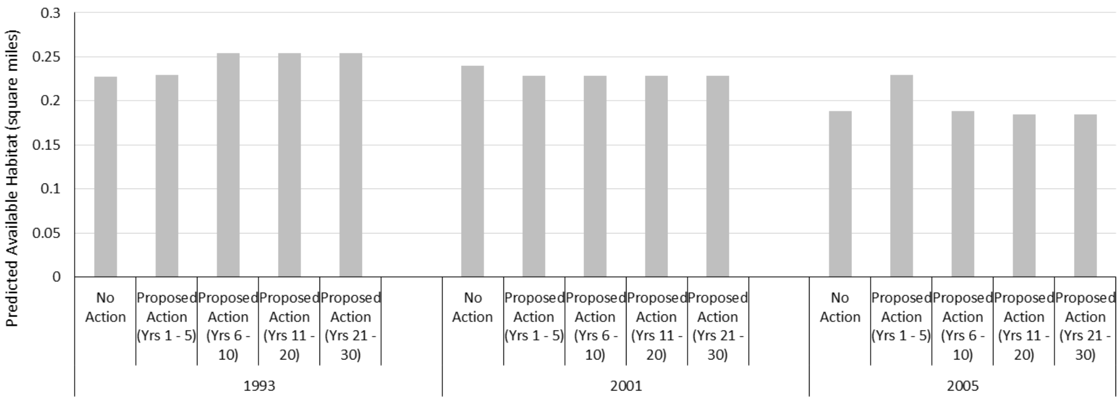
Source: R2 and Pacific Biota 2013.

Table 14. Predicted Number of Days within Water Temperature Thresholds for Steelhead Trout Smolt Migrants under the No-Action Alternative and Proposed Action

		Wet Water Year					Dry Water Year					Normal Water Year				
Reach	Life Stage Thresholds	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)
Steelhead Trout Smolt Migration Temperature Thresholds																
CR - 10	Preference <=13.6 C	46	45	46	45	46	67	67	67	67	67	89	78	89	88	87
	Delay > 13.6 C	45	46	45	46	45	24	24	24	24	24	2	13	2	3	4
CR - 9	Preference <=13.6 C	42	42	42	42	42	21	21	21	21	21	67	38	50	66	81
	Delay > 13.6 C	49	49	49	49	49	70	70	70	70	70	24	53	41	25	10
CR - 8	Preference <=13.6 C	41	41	41	41	41	22	21	21	21	21	51	35	45	60	71
	Delay > 13.6 C	50	50	50	50	50	69	70	70	70	70	40	56	46	31	20
CR - 7	Preference <=13.6 C	42	42	42	42	42	51	49	49	49	48	55	52	53	74	80
	Delay > 13.6 C	49	49	49	49	49	40	42	42	42	43	36	39	38	17	11
CR - 6	Preference <=13.6 C	41	41	41	41	41	39	39	39	39	39	40	40	40	50	69
	Delay > 13.6 C	50	50	50	50	50	52	52	52	52	52	51	51	51	41	22
CR - 5	Preference <=13.6 C	38	38	37	37	37	20	20	20	20	20	22	22	21	21	23
	Delay > 13.6 C	53	53	54	54	54	71	71	71	71	71	69	69	70	70	68
CR - 4	Preference <=13.6 C	36	36	36	36	36	18	18	18	18	18	16	16	16	16	16
	Delay > 13.6 C	55	55	55	55	55	73	73	73	73	73	75	75	75	75	75
CR - 3	Preference <=13.6 C	37	37	37	37	37	22	21	21	21	21	22	22	22	22	21
	Delay > 13.6 C	54	54	54	54	54	69	70	70	70	70	69	69	69	69	70
CR - 2	Preference <=13.6 C	37	37	37	37	37	21	21	21	21	21	21	21	22	21	23
	Delay > 13.6 C	54	54	54	54	54	70	70	70	70	70	70	70	69	70	68

Source: R2 and Pacific Biota 2013.

Figure 29. Estimate of Juvenile Chinook Summer Habitat Availability for the Mainstem Crooked River under the No-Action Alternative and Proposed Action



Water Temperature Results

The results of spring Chinook juvenile rearing temperature thresholds are shown in Table 15.

Analysis of temperature thresholds for spring Chinook salmon juveniles suggest an effect of water management operations on water temperatures under the modeled streamflows for the proposed action. The number of days in the stress/disease category in the wet water year in the reach immediately downstream of Bowman Dam increased from 28 days under the no-action alternative to 58 days under the proposed action by the end of the permit term. There were more warm days in the normal water year toward the end of the permit term. The number of sub-optimal days increased from 41 days to 62 days in the reach immediately downstream of Bowman Dam (CR-10). The number of days in the optimal category decreased from 47 days to 26 days in reach CR - 9, downstream of the canyon reach and from 53 days to 31 days in reach CR–8, upstream of Prineville. Effects of water management on water temperature in lower reaches (CR-7 through CR-2) tended to be more variable as temperatures were warmer under the no-action alternative and effects of water management from Bowman Dam have less of an influence on water temperatures (Berger et al. 2019). Overall there was a tendency for more days in the stress/disease and lethal categories under the proposed action.

Water temperatures thresholds were not available for adult spring Chinook holding through the summer in the Crooked River. However, the additional number of warm days under the proposed action toward the end of the permit term indicate a worsening of habitat conditions for spring Chinook adults holding through the summer. The number of days in each category for juvenile Chinook report in Table 15 indicate conditions would be more stressful for spring Chinook adults in the upper Crooked River reaches where temperatures are fairly cool through the summer under the no-action alternative.

Modeled water temperatures from Bowman Dam to Smith Rock in August and September during spring Chinook salmon spawning are higher than the preference threshold of 14.0°C under the no-action alternative and the proposed action. Daily maximum water temperatures do not drop below the avoidance threshold of 16.0°C until mid-September. The proposed action would not affect water temperatures and habitat for spring Chinook salmon spawning.

Modeled water temperatures from Bowman Dam to Smith Rock exceed the preference threshold of 12.8°C for spring Chinook salmon egg incubation under the no-action alternative. Water temperatures cool rapidly in late September and early October. The proposed action would not affect water temperatures and habitat for spring Chinook salmon egg incubation.

Summary

In the Crooked River, Conservation Measures CR-4, CR-5, and CR-6 would result in beneficial effects on spring Chinook salmon habitat. However, water management under the proposed action (Conservation Measure WR-1) would result in adverse effects on habitat quantity and quality during juvenile Chinook salmon summer rearing and adult holding in dry and normal water years in years 21 through 30, and to a lesser extent in years 11 through 20, of the permit term depending on annual water management practices. Water supply modeling assumes early irrigation season diversions from the Crooked River could increase as water supply availability on the Deschutes River declines related to Conservation Measure WR-1. The frequency of this outcome would depend on specific, annual water supply management decisions and water supply availability that are not captured fully by modeling results. This effect on Chinook salmon habitat is considered to be adverse in the Crooked River because the potential exists for early season irrigation diversions to affect Chinook habitat in dry and normal water years in years 11 through 30 of the permit term.

Habitat model results show no trend toward better or worsening amount of available habitat. Streamflows in late summer and early fall during spawning and from fall to spring during egg incubation tended to not change in most years indicating no effect on these life stages.

Table 15. Predicted Number of Days within Water Temperature Thresholds for Juvenile Spring Chinook June through September under the No-Action Alternative and Proposed Action

		Wet Water Year					Dry Water Year					Normal Water Year				
Reach	**Life Stage Thresholds**	**No Action**	**Proposed Action (Yrs 1–5)**	**Proposed Action (Yrs 6–10)**	**Proposed Action (Yrs 11–20)**	**Proposed Action (Yrs 21–30)**	**No Action**	**Proposed Action (Yrs 1–5)**	**Proposed Action (Yrs 6–10)**	**Proposed Action (Yrs 11–20)**	**Proposed Action (Yrs 21–30)**	**No Action**	**Proposed Action (Yrs 1–5)**	**Proposed Action (Yrs 6–10)**	**Proposed Action (Yrs 11–20)**	**Proposed Action (Yrs 21–30)**
Chinook Juvenile Rearing Temperature Thresholds																
CR - 10	Preference <=15.6 C	9	9	9	9	9	46	46	45	45	45	81	102	89	72	60
	Sub-optimal (>15.6 & <=19.1)	85	95	84	82	55	43	50	51	51	51	41	20	33	50	62
	Stress/Disease >19.1 & <=22 C	28	18	29	31	58	21	25	25	25	25	0	0	0	0	0
	Lethal >22.0 C	0	0	0	0	0	12	1	1	1	1	0	0	0	0	0
CR - 9	Preference <=15.6 C	9	9	9	9	9	9	4	4	4	4	47	43	44	26	26
	Sub-optimal (>15.6 & <=19.1)	103	103	110	98	76	28	26	27	27	27	26	45	30	25	26
	Stress/Disease >19.1 & <=22 C	10	10	3	15	37	28	26	25	25	24	15	16	16	23	22
	Lethal >22.0 C	0	0	0	0	0	57	66	66	66	67	34	18	32	48	48
CR - 8	Preference <=15.6 C	9	8	9	9	9	4	1	1	1	1	53	39	49	33	31
	Sub-optimal (>15.6 & <=19.1)	63	67	59	58	67	37	39	39	39	39	23	55	30	23	23
	Stress/Disease >19.1 & <=22 C	50	47	54	55	46	51	43	43	44	44	19	19	19	17	16
	Lethal >22.0 C	0	0	0	0	0	30	39	39	38	38	27	9	24	49	52
CR - 7	Preference <=15.6 C	10	9	9	9	9	15	15	15	15	15	31	9	24	26	26
	Sub-optimal (>15.6 & <=19.1)	55	56	50	54	58	58	60	59	59	59	42	80	51	28	28
	Stress/Disease >19.1 & <=22 C	55	57	63	59	55	49	47	48	48	48	44	33	38	56	54
	Lethal >22.0 C	2	0	0	0	0	0	0	0	0	0	5	0	9	12	14
CR - 6	Preference <=15.6 C	7	7	7	6	6	7	7	6	6	5	4	0	3	20	20
	Sub-optimal (>15.6 & <=19.1)	30	29	31	34	37	57	57	58	59	60	66	78	69	33	32
	Stress/Disease >19.1 & <=22 C	75	75	76	69	59	58	58	58	57	57	30	38	30	39	39
	Lethal >22.0 C	10	11	8	13	20	0	0	0	0	0	22	6	20	30	31
CR - 5	Preference <=15.6 C	0	0	0	0	0	0	0	0	0	0	0	0	0	9	6
	Sub-optimal (>15.6 & <=19.1)	30	29	35	37	36	6	10	10	10	10	16	4	15	19	21
	Stress/Disease >19.1 & <=22 C	48	48	47	43	46	50	47	46	46	46	54	69	58	23	24
	Lethal >22.0 C	44	45	40	42	40	66	65	66	66	66	52	49	49	71	71
CR - 4	Preference <=15.6 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sub-optimal (>15.6 & <=19.1)	25	25	25	24	23	0	0	0	0	0	5	6	4	16	13
	Stress/Disease >19.1 & <=22 C	32	33	33	33	24	25	32	32	32	32	26	17	27	29	32
	Lethal >22.0 C	65	64	64	65	75	97	90	90	90	90	91	99	91	77	77
CR - 3	Preference <=15.6 C	7	7	7	7	7	4	4	4	4	4	5	2	2	4	4
	Sub-optimal (>15.6 & <=19.1)	22	22	22	22	22	11	14	14	14	13	18	21	21	32	29
	Stress/Disease >19.1 & <=22 C	42	43	42	37	33	42	35	35	35	36	34	20	31	18	21
	Lethal >22.0 C	51	50	51	56	60	65	69	69	69	69	65	79	68	68	68
CR - 2	Preference <=15.6 C	13	13	13	13	13	3	4	4	4	4	9	10	10	12	12
	Sub-optimal (>15.6 & <=19.1)	34	35	36	39	33	32	35	35	35	35	21	16	19	32	32
	Stress/Disease >19.1 & <=22 C	40	39	41	45	60	50	42	42	42	42	46	34	41	17	17
	Lethal >22.0 C	35	35	32	25	16	37	41	41	41	41	46	62	52	61	61

Source: R2 and Pacific Biota 2013

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BIO-9: Affect Spring Chinook Salmon Migratory Life Stages

The proposed action would have no effect on spring Chinook salmon habitat in Whychus Creek because streamflows would be unchanged in this creek over the permit term. Likewise, the proposed action would have no effect on spring Chinook salmon migratory life stages in the Lower Deschutes because the increase in winter streamflows over the permit term would be minor.

Middle Deschutes

The proposed action would have no effect on spring Chinook salmon migratory life stages during the irrigation period because streamflows in the Middle Deschutes would be unchanged over the permit term.

The proposed action would have no effect on spring Chinook salmon migratory life stages during the irrigation period because streamflows in the Middle Deschutes would be unchanged over the permit term. Small to moderate increases in winter streamflows would have no effect on spring Chinook salmon migratory life stages in the portion of the reach accessible to the species over the permit term because they are outside of the migratory period for adult spring Chinook and smolts.

Crooked River

Water Temperature

The results of water temperature modeling during spring migration of adults and temperature thresholds are listed in Table 16. Water temperature thresholds and results for smolt migration are listed in Table 17.

Water temperatures were evaluated for migrating adult spring Chinook using thresholds reported in R2 and Biota Pacific (2013) and an assumed spring migration timing (see previous section for discussion of adult holding effects). The proposed action would result in fewer warm days during the adult spring migration because of the earlier release of water at Bowman Dam for the NUID pump diversion. The number of avoidance, delay and lethal days tended to decrease over the permit term (Table 16).

However, radio tracking data collected in 2013 of migrating adult spring Chinook salmon identified one adult entering the Crooked River in mid-June that was later recovered at the mouth of Ochoco Creek in late August, suggesting adults may move upstream in the Crooked River in July and August (Hill et al. 2014). Furthermore, radio tracking of adults in other locations upstream of the Pelton-Round Butte Complex indicate movement of adults in July and August (Lickwar pers. comm. [b]). These results suggest that spring Chinook salmon may attempt to migrate upstream later in the year and that migration habitat could be affected by elevated river temperatures during those months. Because of this potential effect on migration habitat during July and August, the effect of water temperature on adult spring Chinook salmon migration habitat would be potentially adverse because the potential for migration effects exist but are not conclusive based on the available data.

Average depth of riffles in the Crooked River suggest low streamflows may impede adult migration under the no action alternative (Chapter 8, Section 8.3.3, of the Draft Deschutes Basin HCP). Water supply modeling assumes early irrigation season diversions from the Crooked River could increase as water supply availability on the Deschutes River declines. The frequency of this outcome would depend on specific, annual water supply management decisions and water supply availability that are not captured fully by modeling results. This effect on Chinook salmon adult migration habitat may be beneficial by increasing riffle depths in May and June with higher streamflows between Bowman Dam and the North Unit ID diversion at RM 28. However, adult migration may be adversely affected downstream of the North Unit ID diversion to approximately Osborne Canyon (RM 8) because of lower streamflows when early season irrigation diversions occur and riffle depths are reduced compared to the no-action alternative. Water temperatures did not differ during the spring smolt migration (Table 17).

Summary

The proposed action would have no effect on migrating spring Chinook salmon adults attempting to move upstream in the spring or outmigrating smolts because of water temperature effects on these life stages would be minor. However, because of the potential effect on adult migration habitat during July and August, the effect of water temperature on adult spring Chinook salmon migration habitat would be potentially adverse because the potential for migration effects exist but are not conclusive based on the available data. Average riffle depths are shallow and would impede upstream adult migration. The shift in irrigation releases at Bowman Dam to May and June in the last 10 years of the permit term would be beneficial to migrating adult salmon. However, reduced streamflows in July and August would adversely affect adult migration. Effects of reduced streamflows below the North Unit ID diversion at RM 28 may adversely affect migration habitat to approximately RM 8 at Osborne Canyon.

Table 16. Predicted Number of Days within Water Temperature Thresholds for Migrating Adult Spring Chinook March through June under the No-Action Alternative and Proposed Action

		Wet Water Year					Dry Water Year					Normal Water Year				
Reach	Life Stage Thresholds	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)	No Action	Proposed Action (Yrs 1–5)	Proposed Action (Yrs 6–10)	Proposed Action (Yrs 11–20)	Proposed Action (Yrs 21–30)
Chinook Adult Spring Migration Temperature Thresholds																
CR - 10	Preference <= 19.0 C	122	122	122	122	122	122	122	122	122	122	122	122	122	122	122
	Avoidance >19.4 C & <= 21 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Delay >21.0 C & <= 25.0 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lethal >25.0 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 9	Preference <= 19.0 C	121	122	121	121	122	99	92	92	92	92	122	122	122	121	121
	Avoidance >19.4 C & <= 21 C	1	0	1	1	0	13	18	18	18	18	0	0	0	1	1
	Delay >21.0 C & <= 25.0 C	0	0	0	0	0	10	12	12	12	12	0	0	0	0	0
	Lethal >25.0 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 8	Preference <= 19.0 C	106	106	106	106	120	96	93	93	93	93	122	122	122	121	121
	Avoidance >19.4 C & <= 21 C	14	14	14	14	2	17	18	18	19	19	0	0	0	1	1
	Delay >21.0 C & <= 25.0 C	2	2	2	2	0	9	11	11	10	10	0	0	0	0	0
	Lethal >25.0 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 7	Preference <= 19.0 C	108	109	108	107	122	122	122	122	122	122	122	122	122	122	122
	Avoidance >19.4 C & <= 21 C	14	13	14	15	0	0	0	0	0	0	0	0	0	0	0
	Delay >21.0 C & <= 25.0 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lethal >25.0 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 6	Preference <= 19.0 C	107	107	107	107	108	122	122	122	122	122	122	121	122	121	120
	Avoidance >19.4 C & <= 21 C	5	5	5	5	14	0	0	0	0	0	0	1	0	1	2
	Delay >21.0 C & <= 25.0 C	10	10	10	10	0	0	0	0	0	0	0	0	0	0	0
	Lethal >25.0 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 5	Preference <= 19.0 C	104	103	104	104	104	75	75	75	75	75	96	83	95	112	116
	Avoidance >19.4 C & <= 21 C	2	3	2	2	15	20	20	19	19	19	24	25	24	6	2
	Delay >21.0 C & <= 25.0 C	16	16	16	16	3	27	27	28	28	28	2	14	3	4	4
	Lethal >25.0 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 4	Preference <= 19.0 C	84	85	84	84	84	53	53	53	53	53	59	59	59	71	84
	Avoidance >19.4 C & <= 21 C	19	18	19	19	19	11	11	11	11	11	21	17	23	29	26
	Delay >21.0 C & <= 25.0 C	5	5	5	5	19	38	38	38	38	38	41	33	39	19	9
	Lethal >25.0 C	14	14	14	14	0	20	20	20	20	20	1	13	1	3	3
CR - 3	Preference <= 19.0 C	102	98	101	101	102	69	66	66	66	66	78	78	78	91	99
	Avoidance >19.4 C & <= 21 C	4	7	5	5	3	11	11	11	11	11	17	14	15	16	13
	Delay >21.0 C & <= 25.0 C	13	12	11	11	17	41	44	44	44	44	27	26	29	14	9
	Lethal >25.0 C	3	5	5	5	0	1	1	1	1	1	0	4	0	1	1
CR - 2	Preference <= 19.0 C	95	94	95	95	95	80	80	80	80	80	89	86	88	106	112
	Avoidance >19.4 C & <= 21 C	11	12	11	11	13	22	22	22	22	22	28	21	29	10	6
	Delay >21.0 C & <= 25.0 C	16	16	16	16	14	20	20	20	20	20	5	15	5	6	4
	Lethal >25.0 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: R2 and Pacific Biota 2013

Table 17. Predicted Number of Days within Water Temperature Thresholds for Migrating Smolt Spring Chinook under the No-Action Alternative and Proposed Action

		Wet Water Year					Dry Water Year					Normal Water Year				
Reach	**Life Stage Thresholds**	**No Action**	**Proposed Action (Yrs 1–5)**	**Proposed Action (Yrs 6–10)**	**Proposed Action (Yrs 11–20)**	**Proposed Action (Yrs 21–30)**	**No Action**	**Proposed Action (Yrs 1–5)**	**Proposed Action (Yrs 6–10)**	**Proposed Action (Yrs 11–20)**	**Proposed Action (Yrs 21–30)**	**No Action**	**Proposed Action (Yrs 1–5)**	**Proposed Action (Yrs 6–10)**	**Proposed Action (Yrs 11–20)**	**Proposed Action (Yrs 21–30)**
Chinook Smolt Migration Temperature Thresholds																
CR - 10	Preference <=20 C	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
	Delay > 20 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 9	Preference <=20 C	120	120	120	120	120	120	117	117	117	117	120	120	120	120	120
	Delay > 20 C	0	0	0	0	0	0	3	3	3	3	0	0	0	0	0
CR - 8	Preference <=20 C	120	120	120	120	120	114	112	112	112	112	120	120	120	120	120
	Delay > 20 C	0	0	0	0	0	6	8	8	8	8	0	0	0	0	0
CR - 7	Preference <=20 C	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
	Delay > 20 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 6	Preference <=20 C	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
	Delay > 20 C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CR - 5	Preference <=20 C	120	120	120	120	120	108	108	108	108	108	114	113	113	119	120
	Delay > 20 C	0	0	0	0	0	12	12	12	12	12	6	7	7	1	0
CR - 4	Preference <=20 C	115	115	116	116	116	86	86	86	86	85	94	93	95	96	112
	Delay > 20 C	5	5	4	4	4	34	34	34	34	35	26	27	25	24	8
CR - 3	Preference <=20 C	120	120	120	120	120	104	102	102	102	102	113	112	112	113	120
	Delay > 20 C	0	0	0	0	0	16	18	18	18	18	7	8	8	7	0
CR - 2	Preference <=20 C	120	120	120	120	120	109	109	108	108	108	113	113	113	116	120
	Delay > 20 C	0	0	0	0	0	11	11	12	12	12	7	7	7	4	0

BIO-10: Affect Sockeye Salmon Habitat

The proposed action would have no effect on sockeye salmon habitat in Whychus Creek because streamflows would be unchanged in this creek over the permit term. Differences in reservoir volume and elevations in Lake Billy Chinook and Lake Simtustus would be minor under the proposed action and would have no effect on sockeye salmon habitat. Likewise, the proposed action would have no effect on sockeye salmon habitat in the Lower Deschutes because the increase in winter streamflows over the permit term would be minor.

Middle Deschutes

The proposed action would have no effect on sockeye salmon habitat during the irrigation period because streamflows in the Middle Deschutes would be unchanged over the permit term.

Relatively small increases in winter streamflows, under the proposed action, would have no effect on sockeye salmon habitat in the portion of the reach accessible to the species over the permit term.

Crooked River

Adult sockeye salmon may enter the Crooked River in the fall to spawn in the lower section of the river, downstream of Opal Springs hydroelectric project. Eggs would remain in the gravel through the winter. Newly emerged fry would migrate to Lake Billy Chinook in the spring for juvenile rearing. The limited use by sockeye suggests any effects of water management on sockeye salmon habitat would be limited to availability of spawning and egg incubation habitat in the lower river, downstream of Opal Springs hydroelectric project.

Under the proposed action, modeled streamflows in the Crooked River at the Opal node in the lower river (Reaches CR-1.2 and CR-1.1; RMs 4–0) are relatively unchanged compared to the no-action alternative for the entire permit term. The changes in flow from upstream water management are too small in the context of the high volume groundwater inflow upstream of the Opal node to result in effects on the species in this reach. Therefore, there would be no effect on habitat for sockeye salmon in the portion of the Crooked River used by sockeye salmon for spawning.

BIO-11: Affect Sockeye Salmon Migratory Life Stages

The proposed action would have no effect on sockeye salmon migratory life stages in Whychus Creek because streamflows would be unchanged in this creek over the permit term. Likewise, the proposed action would have no effect on sockeye salmon migratory life stages in the Lower Deschutes because the increase in winter streamflows over the permit term would be minor.

Middle Deschutes

The proposed action would have no effect on sockeye salmon migratory life stages during the irrigation period because streamflows in the Middle Deschutes would be unchanged over the permit term.

Relatively small increases in winter streamflows, under the proposed action, would have no effect on sockeye salmon migratory life stages in the portion of the reach accessible to the species over the permit term.

Crooked River

Adult sockeye salmon may enter the Crooked River in the fall to spawn in the lower section of the river, downstream of the Opal Springs hydroelectric project. The limited use by sockeye salmon suggests any effects of water management on sockeye salmon migration habitat would be limited to the lower river, downstream of the Opal Springs hydroelectric project. Under the proposed action, RiverWare modeled streamflows in the Crooked River at the Opal node in the lower river are unchanged or change slightly (less than 2%) compared to the no-action alternative for the entire permit term. The changes in flow are too small to result in migration effects on sockeye salmon when considered in context with the high volume of groundwater inflow upstream of the Opal node. Therefore, there would be no effect on adult or juvenile migration life stages for this species in the portion of the Crooked River likely used by sockeye salmon for spawning and egg incubation.

BIO-12: Affect Redband Trout Habitat

The proposed action would have no effect on redband trout habitat in Whychus and Tumalo Creeks and the Lower Deschutes because streamflows would be unchanged over the permit term. Likewise, differences in reservoir volume and elevations in Lake Billy Chinook, Lake Simtustus, and Prineville Reservoir would be minor under the proposed action and would have no effect on redband trout habitat. The proposed action would have small beneficial effects on steelhead trout habitat in Ochoco Creek, from slightly higher seasonal minimum and maximum median streamflows under Conservation Measure CR-2, and in McKay Creek, from higher minimum streamflows during the active irrigation season under Conservation Measure CR-3.

Ramping rates (change in streamflow over a period of hours or days) would prevent the more adverse impacts on redband trout that would otherwise result from unregulated hourly or daily variation in streamflows. However, negative effects on redband trout could still occur from longer periods of variation in streamflow during less mobile life stages. These effects could occur during streamflow ramp up at the beginning of the irrigation season in response to increased irrigation demand, as well as during ramp down at the end of the irrigation season and when reservoir storage may be at critically low levels and regulation of reservoir release is necessary under Conservation Measure WR-1.

Effects in the remaining reaches relevant to the species are described below.

Crescent Lake Reservoir

Under the proposed action, reservoir elevations would not change during most of the year. Slightly higher reservoir elevations in the spring may provide a minor improvement in access to spawning tributaries during this period. However, the increase in reservoir elevation in the spring would be minor and would likely have no discernable effect on redband trout connectivity to tributary spawning habitat. Therefore, the proposed action would have no effect on redband trout habitat in Crescent Lake Reservoir.

Crescent Creek

Under the proposed action, streamflows would be lower in the fall and early spring and may adversely affect winter habitat. Streamflows would be slightly higher during the summer, which may affect emergent bank vegetation and corresponding habitat structure important to juvenile redband trout. However, the differences would be minor and would likely have no discernable effect on stream margin vegetation related to redband trout habitat. Streamflows would be more variable during the summer, but likely to not enough to suggest an adverse effect when compared to variability in streamflows under the no-action alternative.

Ramping rates (change in streamflow over a period of hours or days), made mandatory under the proposed action (Conservation Measure CC-2), would prevent the more adverse effects on redband trout habitat that would otherwise result from unregulated daily variation in streamflows.

Therefore, the proposed action would have no effect on redband trout habitat in Crescent Creek.

Little Deschutes River

There would be minimal changes in streamflows because inflow from Little Deschutes River and Big Marsh Creek into Crescent Creek downstream of Crescent Lake Reservoir essentially overwhelm any effects of water management from Crescent Lake Reservoir. Therefore, the proposed action would have no effect on redband trout habitat in the Little Deschutes River.

Crane Prairie Reservoir

Reservoir elevations and volume would be less variable over the year, and would be higher throughout most of the year. The rate of fill in the fall would be more gradual and may allow juvenile and subadult redband trout to adjust to rising reservoir elevations at the start of the storage season. Therefore, the proposed action would have a beneficial effect on redband trout habitat in Crane Prairie Reservoir because less variable and higher reservoir volumes indicate improved reservoir ecology for redband trout prey items and improved migratory habitat for redband trout to move to and from Crane Prairie Reservoir.

Upper Deschutes between Crane Prairie and Wickiup Reservoirs

Although streamflows in the Upper Deschutes River downstream of Crane Prairie Reservoir would be more variable at times during the year, overall water management would maintain minimum streamflows during the winter and spring, during redband trout spawning and egg incubation, and streamflows would be less variable and higher in most years. Therefore, the proposed action would have a beneficial effect on redband trout habitat in the Upper Deschutes River between Crane Prairie and Wickiup Reservoirs.

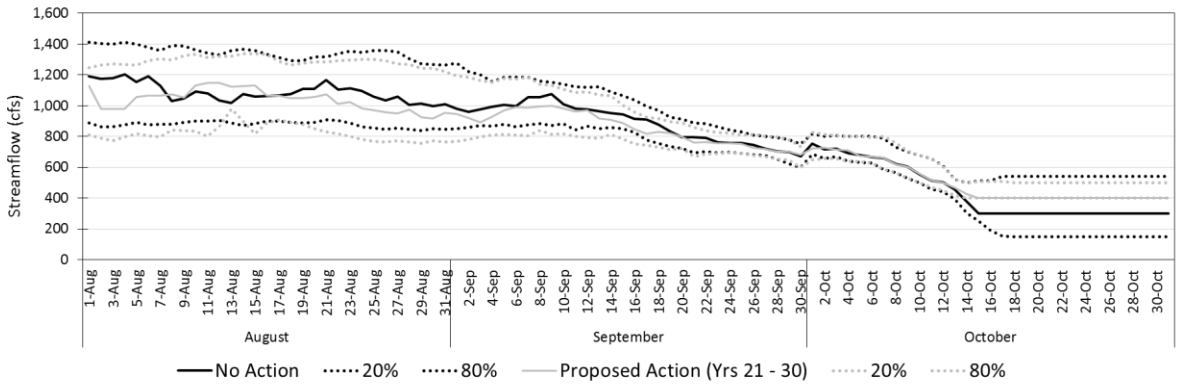
Wickiup Reservoir

The extreme variability in reservoir volume and elevation over the year and greater variability in years 21 to 30 of the permit term would adversely affect reservoir rearing habitat for juvenile and subadult redband trout, may adversely affect redband trout access to spawning tributaries in the spring, and would adversely affect the lake food web (Murphy et al. 2019). Furthermore, the extreme drawdown would result in the greater competition with and predation by other nonnative trout species and entrainment of juvenile redband trout into the unscreened reservoir outlet resulting in the displacement of redband trout to the Deschutes River. Therefore, the proposed action would have an adverse effect on redband trout habitat in Wickiup Reservoir.

Upper Deschutes between Wickiup Reservoir and City of Bend

There would be several beneficial effects of the proposed action. Higher winter streamflows over the permit term would benefit redband trout habitat (Starcevich and Bailey 2015). Reduced summer streamflows would be expected to result in emergent vegetation recruitment into the river channel, thereby improving habitat complexity for redband trout (River Design Group and HDR 2017). The proposed action would also decrease the fall transition in streamflows at the end of the irrigation season, further benefiting redband trout by reducing the risk of stranding of trout in side channels (Starcevich and Bailey 2015). The range of streamflows in the fall indicate a decreased reduction in streamflows during the transition at the end of the irrigation season (Figure 30).

Figure 30. Streamflow Ramping in the Upper Deschutes Downstream of Wickiup Reservoir (WICO node) during End of Irrigation Season under the No-Action Alternative and Proposed Action (Years 21–30)



However, the proposed action would also result in greater within-year variation in spring and summer streamflows in years when storage is unable to meet irrigation demand. In approximately 30% of the analysis years at the end of the permit term streamflows modeled in RiverWare increase at the start of irrigation season (May) to over 1,000 cfs and then decline over several days to approximately 500 to 700 cfs (differs by year) when Wickiup Reservoir storage can no longer meet irrigation demand. This was analyzed by examining annual streamflows at the Wickiup outlet RiverWare node (WICO) and using the coefficient of variation (CV) of daily streamflow (the standard deviation of daily streamflow in the month divided by average streamflow over the month) for the no-action alternative and proposed action (Figure 31). Variation in streamflows in the spring determined by the CV was higher under the proposed action at the end of the permit term. This variation may negatively affect redband spawning, egg incubation, and juvenile rearing survival, by dewatering in locations where adult redband trout are attempting to spawn. Within-year variation is greatest in May and August under the proposed action. Variation in daily streamflows are approximately the same as under the no-action alternative in other months.

In addition to the possible dewatering of eggs while in the gravel, the within-year variation in streamflows during the spring and summer would have a negative effect on survival of newly emerged fry and rearing juveniles. This adverse effect would be less severe downstream of Benham Falls because of additional inflow from the Little Deschutes and elsewhere, offsetting the effects of irrigation demand and storage shortages on daily streamflow.

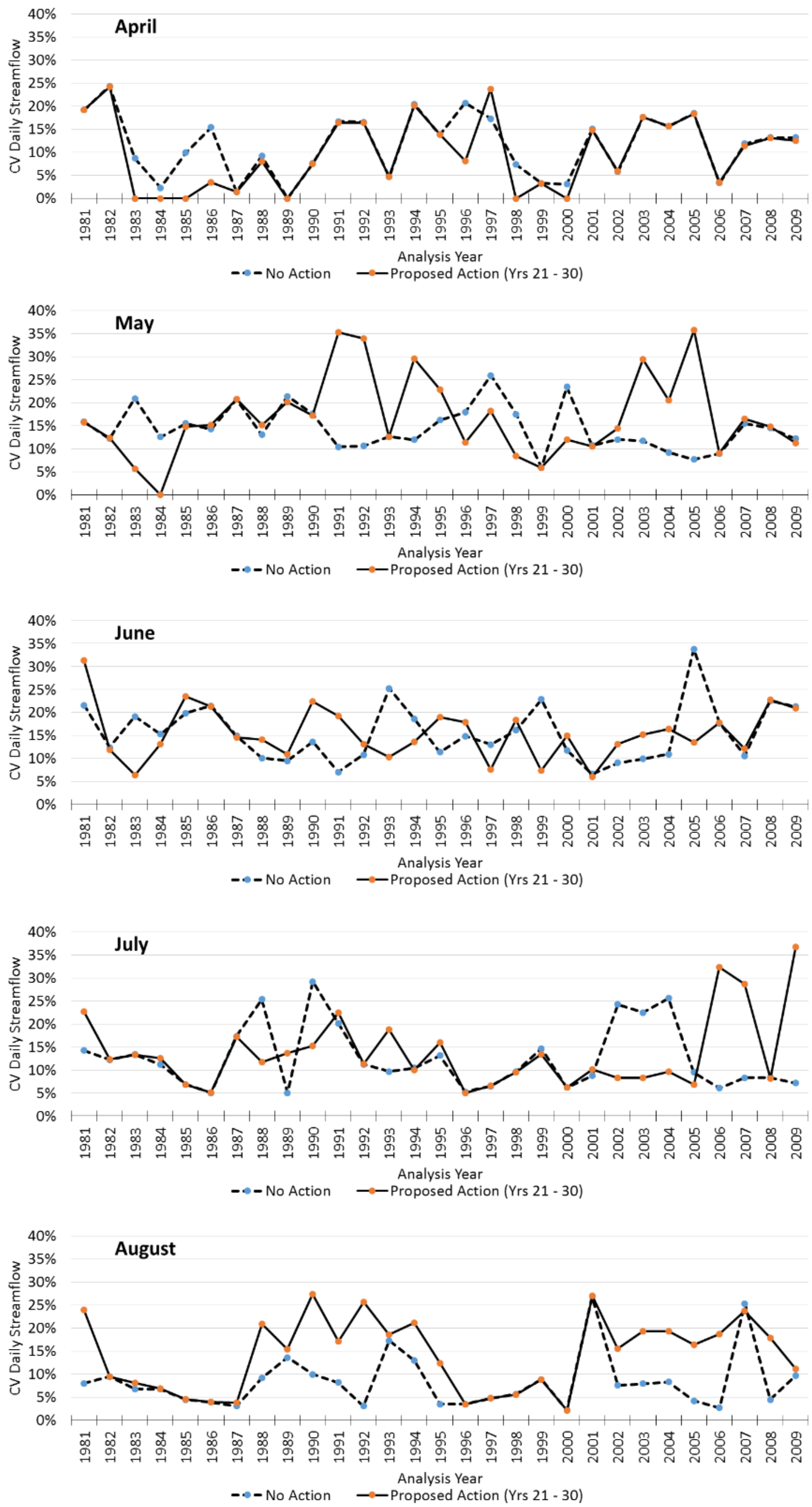
An additional adverse effect on redband trout habitat in the Upper Deschutes River would be the displacement of nonnative brown trout and nonnative brown bullhead catfish (*Ictalurus nebulosus*) into the Upper Deschutes River following extreme drawdown of Wickiup Reservoir during the irrigation season. Brown trout compete with native redband trout in the Upper Deschutes River (Starcevich and Bailey 2015). Brown bullhead catfish will eat a variety of aquatic invertebrates, freshwater mussels, frogs, snails, and insects. They will also eat other fish, fish eggs, and plants.

In summary, several components of the proposed action would be beneficial to redband trout habitat:

- Increased winter streamflows would provide more habitat for redband trout
- Lower summer streamflows would improve riparian vegetation over the permit term

However, these benefits would be substantially offset by an increase in variability in streamflows in critical months in years when Wickiup Reservoir storage is low and streamflows increase at the start of the irrigation season and then sharply decline when redband trout are spawning or eggs are in the gravel. Overall, based on this variability the proposed action would have an adverse effect on redband trout habitat in the Upper Deschutes River between Wickiup Reservoir and the city of Bend.

Figure 31. Change in Daily Streamflows in the Upper Deschutes Downstream of Wickiup Reservoir (WICO node) during Redband Trout Spawning, Egg Incubation, and Juvenile Rearing (April–August) under the No-Action Alternative and Proposed Action (Years 21–30)



Middle Deschutes

Increased median streamflows by 20% in the Middle Deschutes River from October to March (Conservation Measure DR-1 and WR-1) in the portion immediately downstream of Bend would have a beneficial effect on the quantity and connectivity of redband trout habitat over the permit term. This beneficial effect would be in the portion of the river upstream of significant groundwater influences. Higher winter streamflows would increase wetted channel area and add more depth to pool habitat used by redband trout.

There are concerns specific to the rapid down ramping of streamflows in April below the diversions in the city of Bend and the negative effect on survival of resident redband trout in that reach (Hodgson pers. comm.). Down ramping at the start of the irrigation season is not predicted to change under the proposed action based on RiverWare model results at the DEBO node. The ramp down of streamflows follows a typical pattern starting in early April and ending by the second week of April. Any adverse effect of down ramping during this period on redband trout habitat would be the same under the proposed action.

Overall, the proposed action would have a beneficial effect on redband trout habitat in the Middle Deschutes River between the city of Bend and Lake Billy Chinook.

Lake Billy Chinook

The proposed action would have no effect on redband trout habitat in Lake Billy Chinook because the minor changes to inflow to the reservoir would not change redband trout habitat over the permit term.

Prineville Reservoir

The proposed action would have no effect on redband trout habitat in Prineville Reservoir because the minor changes to reservoir elevation and volume would not change redband habitat over the permit term.

Crooked River

In the Crooked River, abundant populations of redband trout exist in the CR-10 reach immediately downstream of Bowman Dam due to a consistent supply of cool water from Bowman Dam and in the lower Crooked River reaches CR-1.2 and 1.1 upstream of Lake Billy Chinook due to a consistent input of cool groundwater.

Conservation Measures CR-4, CR-5, and CR-6 would benefit redband trout habitat as described for steelhead trout (Impact BIO-6).

Redband trout would be exposed to a range of streamflow and related water temperature effects under the proposed action similar to effects evaluated for juvenile steelhead (Conservation Measure WR-1). These effects include differences in streamflow across the year, which would affect the amount of habitat available, and water management for irrigation delivery, which would affect water temperatures during critical life stages.

There would be a beneficial effect of higher minimum winter streamflows under the proposed action (Conservation Measure CR-1), consistent with study findings by Porter and Hodgson (2016). They concluded low streamflows during the winter were a factor negatively effecting redband trout habitat in the Crooked River. The habitat model developed for juvenile steelhead rearing for the

Deschutes Basin HCP analysis supports their findings. Higher winter streamflows would increase habitat capacity for juvenile steelhead. The same conclusion is applicable to juvenile redband trout.

However, under the proposed action, during the irrigation season, streamflows and redband trout habitat in the Crooked River downstream of the North Unit ID pumps to Osborne Canyon (Reaches CR-2 through 1.3; RM 28 to 8) would be adversely affected from May through September in a little over half of the years over the permit term due to increased North Unit ID reliance on the Crooked River.

Also, there would be an adverse effect on redband trout habitat because of an increase in number of days of warm water temperatures due to changes in timing of release of water from Prineville Reservoir in all water year types in years 21 through 30 of the permit term as discussed for steelhead trout (Impact BIO-6). The Crooked River downstream of the canyon reach (Reach CR-9; RM 57 to 48) and in the reach just upstream of the city of Prineville (Reach CR-8) would experience more warming with changes in streamflow adversely affecting redband trout movement and use of other habitats in the Crooked River. Effects in the reach immediately downstream of Bowman Dam (Reach CR-10) would be lesser, but there would still be some effect. Therefore, the proposed action would have an adverse effect on redband trout habitat in the Crooked River in the canyon reach downstream of Bowman Dam (Reach CR-10) and a more severe adverse effect in reaches downstream of the canyon reach (Reaches CR-8 and CR-9) during the irrigation season.

Overall, the proposed action would have an adverse effect on redband trout habitat in the Crooked River for the same reason discussed for steelhead trout.

BIO-13: Affect Nonnative Resident Trout Habitat

The proposed action would have no effect on nonnative trout habitat in Whychus, Ochoco, and McKay Creeks because streamflows would be unchanged in these creeks over the permit term. Differences in reservoir volume and elevations in Crescent Lake Reservoir, Crane Prairie Reservoir, Prineville Reservoir, Ochoco Reservoir, Lake Billy Chinook, and Lake Simtustus under the proposed action would be minor and would have no effect on nonnative trout habitat. Differences in streamflows in Crescent Creek, Little Deschutes River, and Lower Deschutes River under the proposed action would be minor and would have no effect on nonnative trout habitat.

Upper Deschutes River between Crane Prairie and Wickiup Reservoirs

Although streamflows in the Upper Deschutes River downstream of Crane Prairie Reservoir would be more variable at times during the year, overall water management would maintain minimum streamflows during the winter for juvenile and subadult rearing, and streamflows would be less variable and higher in most years. Therefore, the proposed action would have a beneficial effect on nonnative resident trout habitat in the upper Deschutes River between Crane Prairie and Wickiup Reservoirs.

Wickiup Reservoir

The extreme variation in reservoir elevation and volume under the proposed action would have an adverse effect on nonnative trout in the reservoir. In addition, trout would be entrained in the dam outlet and swept downstream during extreme drawdown of the reservoir. Therefore, the proposed action would have an adverse effect on nonnative resident trout habitat in Wickiup Reservoir.

Upper Deschutes River Wickiup Reservoir and Bend

Increased winter flows would provide additional habitat for nonnative brook and brown trout. Both species are fall spawners and spawning and egg incubation would occur during times of the year when streamflow variation is less under the proposed action. Therefore, the proposed action would have a beneficial effect on nonnative resident trout habitat in the Upper Deschutes River between Wickiup Reservoir and Bend.

Middle Deschutes

The proposed action would have a beneficial effect on nonnative resident trout habitat in the Middle Deschutes River between Bend and Lake Billy Chinook because increased winter streamflows would provide additional habitat for nonnative brook and brown trout.

Crooked River

The proposed action would have an adverse effect on nonnative resident trout habitat in the Crooked River because of effects of streamflows on summer temperatures discussed previously for salmon, steelhead, and redband trout. Increased periods of warm temperatures discussed for Chinook, steelhead and redband trout would also adversely affect habitat for nonnative trout.

BIO-14: Affect Summer/Fall Chinook Salmon Habitat

Summer/fall Chinook salmon distribution is limited to the Lower Deschutes, downstream of the Pelton-Round Butte Complex.

The proposed action would have no effect on summer/fall Chinook salmon habitat in the Lower Deschutes because the increase in winter streamflows over the permit term would be minor.

BIO-15: Affect Kokanee Salmon Habitat and Migratory Life Stages

The proposed action would have no effect on kokanee salmon habitat and migratory life stages in Crescent Lake Reservoir or Whychus Creek because lake conditions and streamflows, respectively, would not change over the permit term. Differences in reservoir volume and elevations in Lake Billy Chinook and Lake Simtustus would be minor under the proposed action and would have no effect on kokanee salmon habitat.

Crane Prairie Reservoir

Higher reservoir elevations and volumes in fall and winter months indicate improved conditions in the reservoir for kokanee salmon and possibly better access to tributary and, if present, lake beach spawning habitats in the fall. The greater variability in reservoir elevation and volume across the analysis period suggests negative effects in some years. However, the lower reservoir elevations in spring and summer would not be enough to suggest an impact on lake habitat used by rearing kokanee. Therefore, the proposed action would have no effect overall on kokanee salmon habitat and migratory life stages in Crane Prairie Reservoir because of the counter-seasonal differences of improved and possibly less suitable conditions over the year.

Wickiup Reservoir

The predicted extreme variation in reservoir elevation and volume over the permit term would adversely affect kokanee habitat in the reservoir. Effects would be less extreme in years 1–5 of the permit term. Near the end of the permit term (years 21–30), extremely low reservoir elevations in low water years would have an adverse effect on kokanee habitat in the reservoir.

The extreme variation in reservoir volume over the year likely would cause additional effects on the population by entrainment at the dam outlet and downstream displacement of kokanee salmon into the Deschutes River.

Therefore, the proposed action would have an adverse effect overall on kokanee salmon habitat and migratory life stages in Wickiup Reservoir because of extremely low reservoir elevations and volumes in most years and extreme seasonal differences.

BIO-16: Affect Native Non-Trout and Non-Game Fish Habitat

The proposed action would have no effect on habitat for native non-trout and non-game species—including as mountain whitefish (*Prosopium williamsoni*), bridgelip sucker (*Catostomus columbianus*), largescale sucker *(C. macrocheilus*), chiselmouth (*Acrocheilus alutaceus*), and northern pikeminnow (*Ptychocheilus oregonensis*)—in Whychus Creek, the Lower Deschutes River, Lake Billy Chinook, or Lake Simtustus because changes in streamflows and reservoir volumes and elevations would either not change or changes would be minor over the permit term compared to the no-action alternative.

The proposed action would have small beneficial effects on species present in Ochoco and McKay Creeks from increased flows.

Water management in Wickiup Reservoir would likely have adverse effects on habitat for these species (except for Pacific lamprey, which is not present in the reservoir) due to the extreme variation in reservoir elevation and volume.

On the Upper Deschutes River downstream of Wickiup Reservoir, increased fall and winter flows would provide additional habitat for native non-game species present in this reach. Mountain whitefish are fall spawners and spawning and egg incubation would occur during times of the year when streamflow variation is less variable under the proposed action resulting in a beneficial effect for this species when combined with increased winter streamflows under the proposed action. Other native non-game species spawn in spring and summer and are broadcast spawners; i.e., do not build a nest. These species would benefit from higher winter streamflows under the proposed action, but may be adversely affected by greater variability in streamflows in the spring and summer under the proposed action. Overall, effects in this reach on native non-trout and non-game species habitats would be not adverse because of the beneficial effect during winter to all species and uncertain conclusion of adverse effect during spring and summer on a subset of species.

On the Middle Deschutes River the proposed action would have a beneficial effect on native non-trout and non-game species habitat because increased winter flows would provide additional habitat for these species.

In the Crooked River, water management could have adverse effects on habitat of cold water preference cyprinid species because of effects of water management on water temperature discussed for other species. Several native species are adapted to the cooler temperatures typical in most areas in the study area. The effect of water management resulting in more warm days under the proposed action toward the end of the permit term would adversely affect these species.

BIO-17: Affect Freshwater Mollusk Habitat

There would be no effect on freshwater mollusk habitat in Whychus, Ochoco, and McKay Creeks under the proposed action because streamflows would not change over the permit term. Likewise, there would be no effect on freshwater mollusk habitat in the Lower Deschutes under the proposed action because increases in winter streamflows at the Madras gauge would be minor. Effects in the remaining reaches where species occur or have the potential to occur are described below.

Crescent Lake Reservoir

Crater Lake Tightcoil and Evening Field Slug. Overall, there would be no adverse effect on Crater Lake tightcoil and evening field slug habitat in the Crescent Lake Reservoir under the proposed action because reservoir elevations, while lower between August and October than under the no-action alternative, would be generally higher the rest of the year.

Crescent Creek

Crater Lake Tightcoil. Increased summer streamflows would provide additional moist habitat for this species. Flow differences during winter months would have little no effect on this species because tightcoil often aestivate under the ground during the winter. Overall, there would be a beneficial effect on Crater Lake tightcoil habitat in Crescent Creek under the proposed action.

Evening Field Slug. Unlike snails, slugs generally remain active during cooler months as long as temperatures are slightly above freezing. Therefore, while the reduced fall streamflows under the proposed action could lessen habitat for the field slug in the fall, increased summer streamflows would provide additional moist habitat and be beneficial for the species. Overall, there would be no adverse effect on evening field slug in Crescent Creek under the proposed action.

Western Pearlshell Mussels. Reductions in streamflows during fall and spring could interfere with juvenile development and adult maturation resulting in an adverse effect; however, increased summer streamflows could be beneficial for maturing western pearlshell mussels and for their glochidia traveling on host fish.

Extreme water level reductions at the end of September and beginning of October could cause stranding of newly settled juveniles, which need to be inundated to survive and do not have a good mechanism for avoiding rapid reductions in water level. In addition, streamflows in October and November would be lower in some years than under the no-action alternative (<25 cfs versus 30 cfs, respectively). This could cause additional mussel stranding or reduced water quality. Streamflows would be as low as approximately 20 cfs in some years in late April through May, a critical period for adult pearlshell maturation. In June, increased streamflows could provide additional habitat and better streamflow conditions during the time period of larval pearlshell attachment and maturation on host fish.

Overall effects would not be adverse, comprising both adverse and beneficial effects across seasons.

Little Deschutes River

Crater Lake Tightcoil and Evening Field Slug. There would be no adverse effect on Crater Lake tightcoil and evening field slug habitat in the Little Deschutes River under the proposed action because changes in streamflows would be minimal across an annual cycle, resulting in no additional or improved habitat (perennially moist areas) for the species.

Western Pearlshell Mussels. There would be a beneficial effect on western pearlshell mussel habitat in the Little Deschutes River under the proposed action because May and June, the critical period of reproduction and juvenile establishment for the species, are the months that experience the most significant median streamflow increases.

Upper Deschutes

Crater Lake Tightcoil. In the far Upper Deschutes (CRAO gauge), streamflow would change variably throughout the year but not in a way that would cause less inundation on average. Similarly, lower in the Upper Deschutes (WICO and BENO gauges), average median streamflows generally increase from October through March and decrease from May through September. Though streamflows decrease on average in the summer months, overall the streamflow levels are still relatively high and are higher than fall and winter streamflows. Overall, fall and winter streamflows would provide more inundation for the tightcoil.

There would be no adverse effect on Crater Lake tightcoil habitat on the Upper Deschutes under the proposed action because though there would be summer streamflow decreases overall, with additional summer streamflow decreases over the course of the permit term, these decreases would not significantly alter habitat for the species.

Evening Field Slug. Increased base streamflow during fall and winter months in most of the Upper Deschutes would provide additional habitat for the evening field slug during this time, and while summer months experience significantly lowered flows, the flow levels are still relatively high. There would be no adverse effect on evening field slug habitat in the Upper Deschutes under the proposed action because though there would be summer streamflow decreases overall, with additional summer streamflow decreases over the course of the permit term, these decreases would not significantly alter habitat for the species.

Western Pearlshell Mussels. Flows would decrease (WICO and BENO gauges) in May and June, the critical period of reproduction and juvenile establishment, flows would still be high and not significantly affect establishment success. Further upstream at the CRAO node, flows increase on average in May and decrease only slightly in June on average. Therefore, there would be no adverse effect on Western pearlshell mussel habitat in the Upper Deschutes under the proposed action.

Crane Prairie Reservoir

Crater Lake Tightcoil. There would be no adverse effect on Crater Lake tightcoil in Crane Prairie Reservoir under the proposed action because changes in reservoir elevations would be small and not affect habitat used by this species.

Evening Field Slug. There would be no adverse effect on evening field slug in Crane Prairie Reservoir under the proposed action because differences in reservoir elevation and volume are minor.

Wickiup Reservoir

Crater Lake Tightcoil. Riparian conditions in Wickiup Reservoir are poor and suggest that Crater Lake tightcoil is not present; however, increased variation in reservoir elevations would have an adverse effect on the species if present.

Evening Field Slug. There would be an adverse effect on evening field slug in Wickiup Reservoir under the proposed action. Riparian conditions in Wickiup Reservoir are mostly poor and suggest that Crater Lake tightcoil is not present or located in a few isolated locations. Increased variation in reservoir elevations would adversely affect the species if present.

Middle Deschutes

Crater Lake Tightcoil and Evening Field Slug. There would be a beneficial effect on Crater Lake tightcoil habitat in the Middle Deschutes under the proposed action because there would be significant increases in streamflows October through March and no other significant flow changes during other times of the year.

Western Pearlshell Mussels. Overall, May and June, the critical period for reproduction and juvenile establishment, would experience the largest average decreases in median flows among months in the reaches immediately downstream of the DEBO gauge. Therefore, there would be an adverse effect on Western pearlshell mussel habitat in the Middle Deschutes downstream of the DEBO gauge under the proposed action.

Western Ridged Mussels. There would be potential beneficial effects from higher streamflows during some times of the year; however, average streamflows would decline during the first part of the reproductive period for this species.

Western ridged mussels are present in this reach, up to Big Falls. The most critical time period for population success is during reproduction and juvenile settlement, from June through August. While flows would decrease on average in June, by July and August when mussels would be settling, the changes would be very minimal on average, and increased winter flows would be beneficial for host fish.

Overall, there would be no adverse effect on western ridges mussel habitat in the Middle Deschutes under the proposed action.

Crooked River

Crater Lake Tightcoil. In the Upper and Middle Crooked River, decreased flows in some summer months in some years could cause drying of potential habitat for Crater Lake tightcoil. In the reach downstream of the NUID pumps, there would be even more of a decrease in median monthly flow in summer months, which could negatively affect tightcoil habitat. Additionally, while increased median monthly flows in winter months could provide increased moist habitat for tightcoil, any severe or sudden increases in flows in winter months could inundate overwintering tightcoil.

There would be an adverse effect on Crater Lake tightcoil habitat in the Crooked River under the proposed action because of an increased frequency of lowered flows in summer months.

Evening Field Slug. There would be an adverse effect on evening field slug habitat in the Crooked River under the proposed action because of an increased frequency of decreased median monthly flows in summer months through the majority of the Crooked River, which could cause drying of potential habitat for this species.

Floater Species Mussels. There would be an adverse effect on floater species mussel habitat in the Crooked River under the proposed action because of more frequent decreased median monthly flows during May through August, the critical period of reproduction and juvenile establishment for this species.

Western Pearlshell Mussels. There would be no adverse effect on western pearlshell mussel habitat in the Crooked River because flows would change variably through May and June, the critical period of reproduction and juvenile establishment, with some flows and years experiencing significant increase in flows.

Western Ridged Mussels. There would be an adverse effect on western ridged mussel habitat in the Crooked River under the proposed action because there would be a higher frequency of years with decreasing median monthly flows during June through August, the critical period of reproduction and juvenile establishment for this species.

Alternative 3: Enhanced Variable Streamflows

Modeled changes in streamflows, reservoir volumes and elevations, and water quality conditions under Alternative 3 compared to the no-action alternative are described below in the *Modeled Environmental Conditions* section followed by descriptions of how these changes would affect individual species in the *Species Impacts* section.

Modeled Environmental Conditions

This section describes important changes in reservoir storage and elevation, seasonal river and creek streamflows, and relevant water quality information in the study area by geographic area and subarea under Alternative 3. Effects are evaluated based on changes in modeled results for Alternative 3 compared to the no-action alternative.

Changes in streamflows and reservoir elevations and variability would be the same type as described for the proposed action for all reaches except for the Crooked River and the Upper and Middle Deschutes River.

Upper Deschutes

Under Alternative 3, as under the proposed action, summer flows would diminish and winter flows would increase compared to the no-action alternative. Alternative 3 would alter the timing of those changes, such that winter minimum flow targets would be achieved earlier in the permit term and would end at a higher level compared to the proposed action. Although Alternative 3 targets a higher minimum flow (500 cfs) in above-normal and wet years, the model used the same assumption for release of flows in excess of the minimum for the proposed action in above-normal and wet years.[4] Therefore, modeled flow values presented for the proposed action and Alternative 3 at these flows (400 cfs and 400–500 cfs, respectively) are the same.

Accordingly, modeled environmental conditions under Alternative 3 are the same type as described for the proposed action in all reaches except the Crooked River, which is described below.

Crooked River

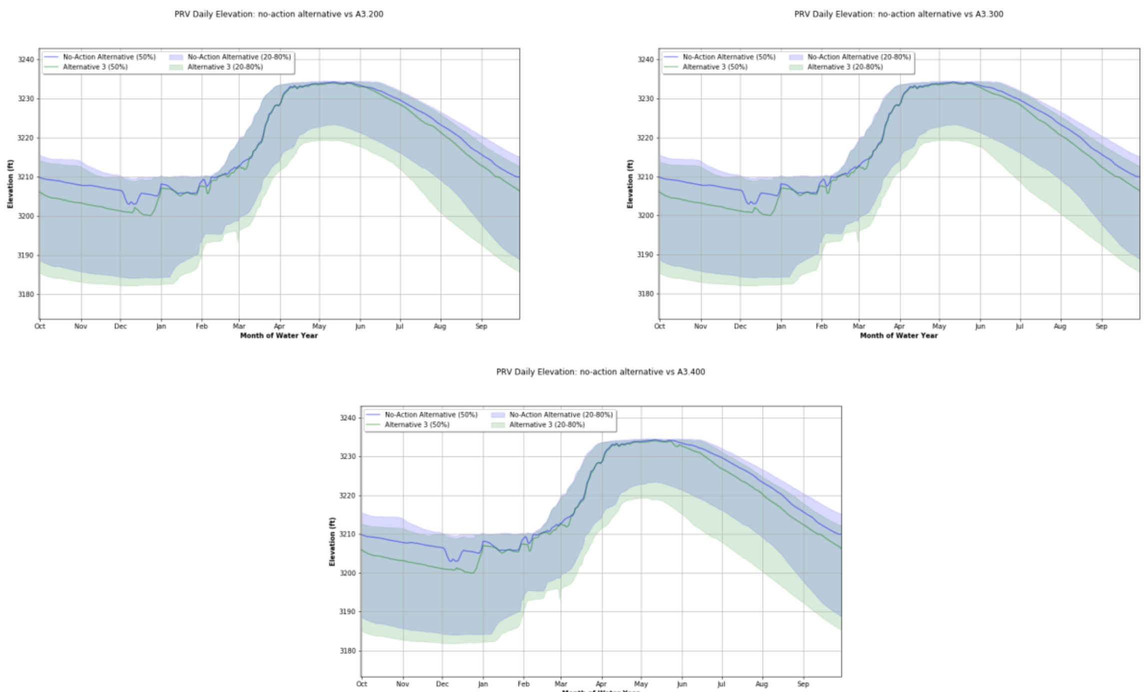
Prineville Reservoir

Model predictions comparing Prineville Reservoir elevations under the no-action alternative and Alternative 3 are shown in Figure 32.

[4] Although the proposed action does not include the commitment to target the higher flow, typical operations practice is to release more water during above-normal and wet years. The RiverWare model required an assumption for how flows in excess of the minimum would be managed. The same equation for managing flows was applied to the proposed action and Alternative 3 to maintain comparative model outputs.

- Median elevations are lower from July to January under Alternative 3. Differences in elevation are greatest in October and November.
- Median elevations are unchanged from February to June.
- Elevations do not differ over the permit term.
- There is a tendency toward more variation from year to year in the low and high range of elevations.

Figure 32. Modeled Elevations for Prineville Reservoir (PRV) under the No-Action Alternative and Alternative 3



Crooked River

Modeled environmental conditions in the Crooked River are described below based on median monthly streamflows and modeled water temperatures.

Median Monthly Streamflow

The following is a summary of differences in streamflow at Prineville Outlet (PRVO), Highway 126 (CAPO), streamflow below the North Unit Irrigation District pumps (NUID), and streamflow at Opal (OPAL).

Observations of monthly median streamflow at PRVO across all RiverWare model years:

- October through March, average increases of approximately 100% in median monthly streamflow in about 20% of the years, a majority years no change in winter flows.
- April- no change in median streamflows.
- May and June - small increase in years 1 through 5 in June, in years 6 through 10 an average increase of 9% in May and 28% in June in about one-third of years

- July through September- median streamflows decrease in about 30% of the years by an average of 36% in July, 43% in August, and 53% in September in years 11 through 30.

Observations of monthly median streamflow at CAPO across all RiverWare model years:

- October through March—average increases of approximately 200% in median monthly streamflows in about 20% of years.
- April—no change in median streamflows
- May and June—large increase years 1 through 5 in June, and years 6 through 30 an average increase of almost 350% in May and 260% in June in nearly half of all years
- July through September- median streamflows decrease in a majority of years by years 11 through 30 of the permit term by an average of 60%

Observations monthly median streamflow below the NUID pumps across all RiverWare model years:

- October through March—in most years there was no change in monthly median streamflows, in about 10% of years there was an average increase in median streamflows of 50% and about 10% of years an average decrease in median streamflows of approximately 20% on average
- April—no change in median streamflows
- May through September—average decrease across all months of 25% in about 40% of the years.

There were no discernable differences in streamflow at the OPAL node

Water Temperature Modeling

The annual hydrograph for the 3 years is shown in Figure 33 for the CAPO node. Differences between the no-action and Alternative 3 are influencing habitat availability and water temperatures. Shifts in streamflow timing are most pronounced under the normal water year.

The shift in timing of water released from Prineville Reservoir has consequences to water temperatures in the Crooked River (Berger et al. 2019). The 7-day average of the daily maximum water temperature was used to evaluate habitat suitability for species in the Crooked River.

An example of the shift in predicted water temperatures at the CAPO node is shown in Figure 34. Under Alternative 3 water temperatures are cooler in early summer and warm rapidly when streamflows are lower in July. The consequence of the shift in streamflow timing is a more protracted period of warm temperatures. Maximum water temperatures were not affected by the shift in timing. The 7-day daily average is approximately the same between the no-action alternative and Alternative 3.

Figure 33. Annual Hydrograph for Crooked River (CAPO node) for Wet, Dry, and Normal Water Years under the No-Action Alternative and Alternative 3 and Years 1 through 5 (top), 6 through 10 (middle) and 11 through 30 (bottom)

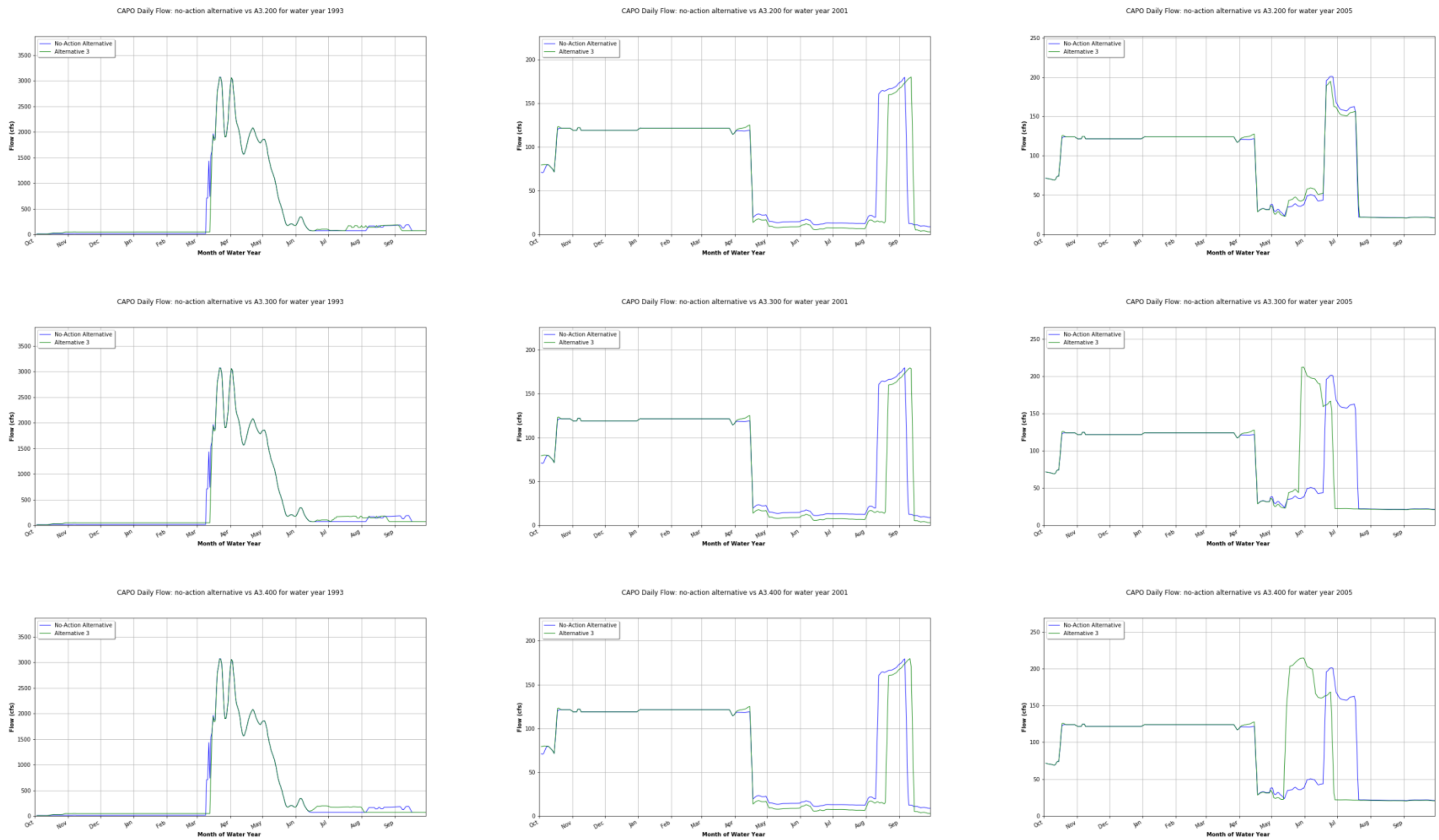
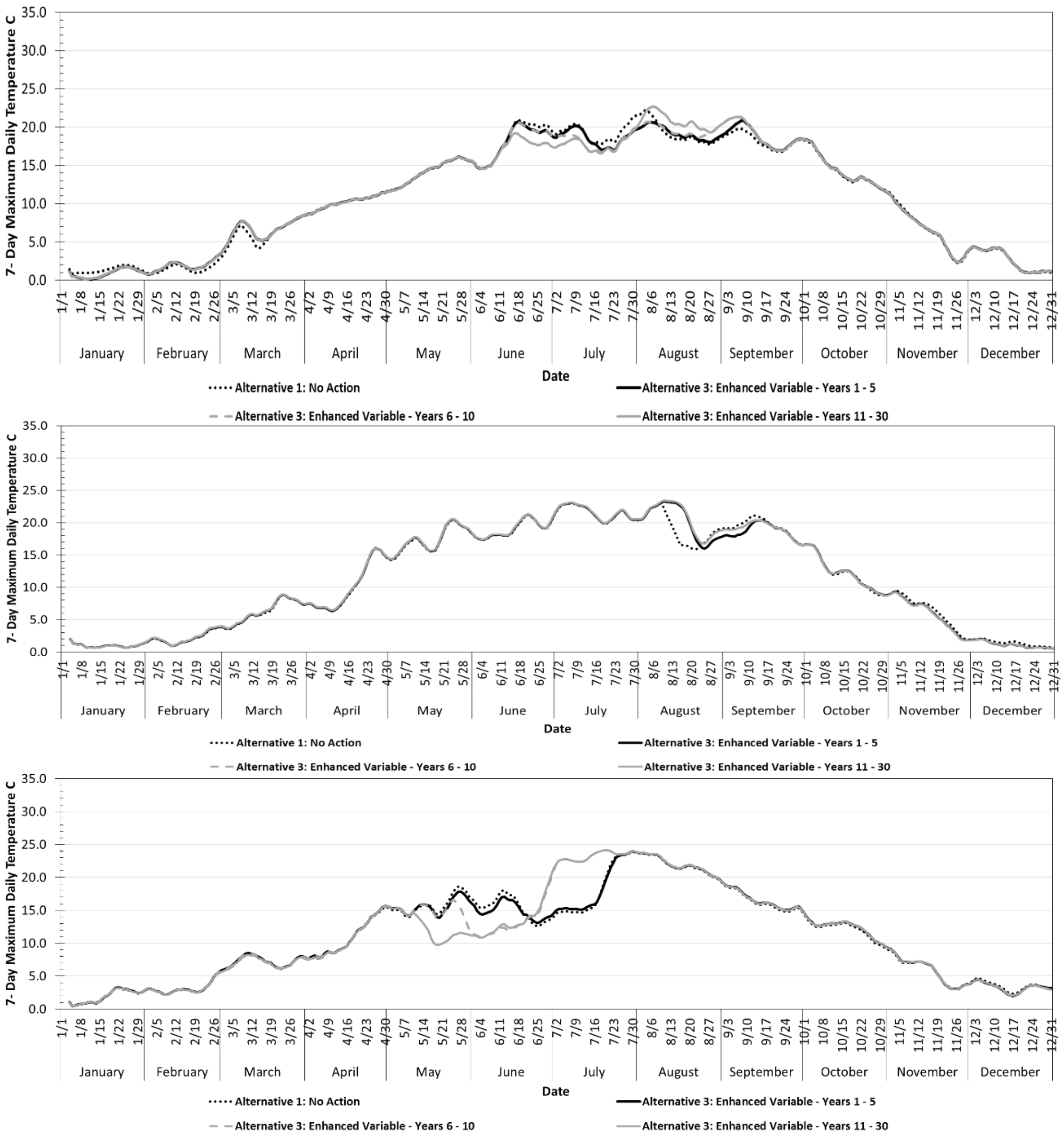


Figure 34. Annual Water Temperature Predictions for the Crooked River (CAPO node) for a Wet (top), Dry (middle) and Normal (bottom) Water Year under the No-Action Alternative and Alternative 3



Modeled RiverWare streamflows at the CAPO node indicate the normal year water temperature scenario is not that unusual across the analysis period. Across the RiverWare analysis period the shift toward higher streamflows in May and June and lower streamflows in July and August under the Alternative 3 occurs in about 30% of the time in years 21 through 30 of the permit term (Table 18 and Figure 35).

The predicted 7DADM results were compared to species preferences, sublethal, and lethal temperature thresholds summarized from a literature review (R2 and Pacific Biota 2013). This analysis is discussed in the species effects sections by alternative.

Figure 35. May through August Difference in Median Monthly Streamflow for the Crooked River (CAPO node) for the No-Action Alternative and Alternative 3 (Years 11–30)

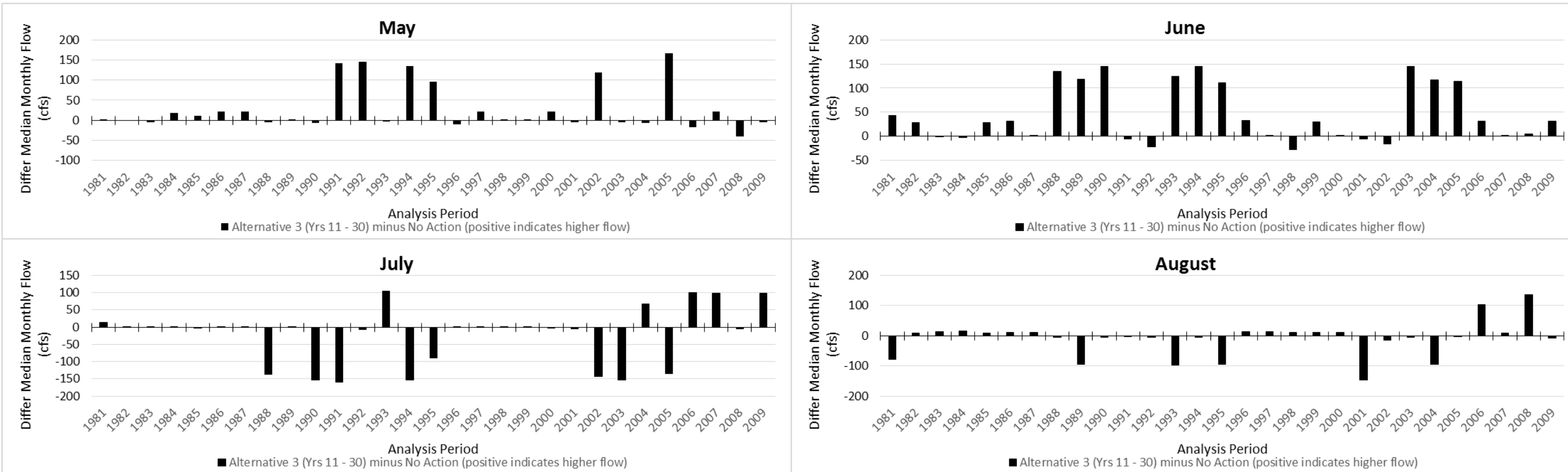


Table 18. Summary Monthly Median Flows for the Crooked River near Highway 126 (CAPO node) under the No-Action Alternative and Alternative 3 (Years 11–30)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
Average diff. median flow (%)	20%	33%	36%	30%	31%	22%	-3%	141%	155%	-4%	10%	-8%
Range diff. in monthly median flow (%)	-20–296%	-61–440%	-44–440%	-19–342%	-19–342%	-19–342%	-32–4%	-43–1216%	-80–1060%	-96–186%	-90–608%	-100–26%
# Years no diff. in median flow	20	14	18	19	20	21	25	11	6	12	2	8
# Years increase in median flow	5	5	5	5	5	3	0	12	18	6	14	11
Range increase in monthly median flow (%)	14–296%	13–440%	13–440%	12–342%	12–342%	93–342%	NA	14–1216%	10–1060%	9–186%	6–608%	15–26%
Average increase median flow (%)	121%	232%	232%	189%	189%	230%	NA	354%	262%	120%	68%	20%
# Years decrease in median flow	4	10	6	5	4	5	4	6	5	11	13	10
Range decrease in monthly median flow (%)	-20–-6%	-61–-6%	-44–-6%	-19–-6%	-19–-6%	-19–-5%	-32–-15%	-43–-5%	-80–-15%	-96–-20%	-90–-16%	-100–-14%
Average decrease median flow (%)	-13%	-23%	-20%	-15%	-12%	-11%	-25%	-28%	-52%	-77%	-54%	-46%

Species Impacts

This section describes effects on fish and mollusks under Alternative 3 compared to the no-action alternative. Where effects are the same as for the proposed action, the description of effects under the proposed action are referenced for brevity.

Changes in streamflows and reservoir elevations and variability would be the same or nearly the same type as described for the proposed action for all of the reaches except for the Crooked River between the North Unit ID pumps and Osborne Canyon due to instream protection of uncontracted storage releases from Prineville Reservoir. In addition, because implementation of increased releases from Wickiup Reservoir would occur earlier under Alternative 3 than the proposed action (Table 3.1-1), related effects would occur earlier as well, as noted in the effects discussion.

BIO-4: Affect Bull Trout Habitat

Effects on bull trout habitat under Alternative 3 would be the same type as described for the proposed action in the Middle and Lower Deschutes River, Lake Billy Chinook and Lake Simtustus, and Whychus, Ochoco and McKay Creeks. Effects on bull trout habitat in the Crooked River are described below.

In addition, effects in the Middle Deschutes River and Crooked River would occur earlier in the permit term and, therefore, be of longer duration under Alternative 3 than the proposed action

Crooked River

Adverse effects in the Crooked River reach between the North Unit ID pumps and Osborne Canyon related to early season irrigation diversions in dry and normal water year types at full implementation would be of slightly lesser magnitude due to instream protection of uncontracted releases under this alternative (Conservation Measure CR-1).

Water Temperature Results

Streamflows under Alternative 3 would be expected to affect bull trout habitat should their distribution expand up to Bowman Dam upon the completion of a fish passage structure at Opal Springs Diversion Dam.

Table 19 and 20 summarize temperature thresholds predicted temperatures for bull trout spawning and egg incubation, respectively. Results support conclusions that current water temperatures and temperatures under Alternative 3 do not support bull trout spawning in the Crooked River.

Table 21 summarizes temperature thresholds and predicted temperatures for juvenile and subadult rearing. At the end of the permit term under Alternative 3 water temperatures for the dry and normal water years are predicted to exceed the stress/disease threshold by an additional 23 and 19 days, respectively in the reach immediately downstream of Bowman Dam (CR-10). Seventy days above the preference threshold would occur in under water management in the normal water year at the end of the permit term compared to 49 days under the no-action alternative in CR-10. In CR-9, 114 days would occur above the preference threshold in the normal year under Alternative 3 compared to 96 days under the no-action alternative. In CR-8, 96 days would occur above the preference threshold in the normal year under the Alternative 3 compared to 90 days under the no-action alternative, but more days exceeding the preference threshold would exceed the lethal threshold under Alternative 3.

Effects of water management on water temperature in lower reaches (CR-7 through CR-2) tended to be more variable as temperatures were warmer under the no-action alternative and effects of water management from Bowman Dam have less of an influence on water temperatures (Berger et al. 2019). Overall there was a tendency for more days in the stress/disease and lethal categories under Alternative 3.

Water management and associated water temperatures in the wet water year shows no effect on bull trout juvenile and subadult habitat over the permit term. However, water management in dry and normal water years indicate a potential for adverse effects on bull trout that may attempt to rear through the summer, such as in the reach downstream of Bowman Dam (CR - 10).

Table 19. Predicted Number of Days within Water Temperature Water Temperature Thresholds for Spawning Bull Trout under the No-Action Alternative and Alternative 3

		Wet Water Year				Dry Water Year				Normal Water Year			
Reach	Life Stage Thresholds	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)
Bull Trout Spawning Temperature Thresholds													
CR - 10	Preference <=9.0 C	0	0	0	0	2	0	0	0	0	0	0	0
	Suboptimal >9 C & <=11 C	0	0	0	0	9	3	3	3	0	0	0	0
	Avoidance > 11.0 C	92	92	92	92	81	89	89	89	92	92	92	92
CR - 9	Preference <=9.0 C	0	0	0	0	0	0	0	0	0	0	0	0
	Suboptimal >9 C & <=11 C	0	0	0	0	0	6	6	6	1	1	1	1
	Avoidance > 11.0 C	92	92	92	92	92	86	86	86	91	91	91	91
CR - 8	Preference <=9.0 C	0	0	0	0	3	6	6	6	1	0	0	0
	Suboptimal >9 C & <=11 C	0	0	0	0	7	6	6	6	7	8	8	8
	Avoidance > 11.0 C	92	92	92	92	82	80	80	80	84	84	84	84
CR - 7	Preference <=9.0 C	0	0	0	0	0	0	0	0	0	0	0	0
	Suboptimal >9 C & <=11 C	0	0	0	0	0	2	3	3	0	0	0	0
	Avoidance > 11.0 C	92	92	92	92	92	90	89	89	92	92	92	92
CR - 6	Preference <=9.0 C	0	0	0	0	0	0	0	0	0	0	0	0
	Suboptimal >9 C & <=11 C	0	0	0	0	0	0	0	0	0	0	0	0
	Avoidance > 11.0 C	92	92	92	92	92	92	92	92	92	92	92	92
CR - 5	Preference <=9.0 C	0	0	0	0	0	0	0	0	0	0	0	0
	Suboptimal >9 C & <=11 C	0	0	0	0	0	0	0	0	0	0	0	0
	Avoidance > 11.0 C	92	92	92	92	92	92	92	92	92	92	92	92
CR - 4	Preference <=9.0 C	0	0	0	0	0	0	0	0	0	0	0	0
	Suboptimal >9 C & <=11 C	0	0	0	0	0	0	0	0	1	1	1	1
	Avoidance > 11.0 C	92	92	92	92	92	92	92	92	91	91	91	91
CR - 3	Preference <=9.0 C	0	0	0	0	0	0	0	0	0	0	0	0
	Suboptimal >9 C & <=11 C	7	5	5	7	11	10	10	10	6	6	6	6
	Avoidance > 11.0 C	85	87	87	85	81	82	82	82	86	86	86	86
CR - 2	Preference <=9.0 C	0	0	0	0	3	3	3	3	0	0	0	0
	Suboptimal >9 C & <=11 C	5	5	6	7	11	11	11	11	6	6	6	6
	Avoidance > 11.0 C	87	87	86	85	78	78	78	78	86	86	86	86

Table 20. Predicted Number of Days within Water Temperature Water Temperature Thresholds for Bull Trout Egg Incubation under the No-Action Alternative and Alternative 3

		Wet Water Year				Dry Water Year				Normal Water Year			
Reach	Life Stage Thresholds	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)
Bull Trout Egg Incubation Temperature Thresholds													
CR - 10	Preference <=6.0 C	104	106	106	106	110	105	106	106	82	91	91	84
	Stress/Disease >6 C	136	134	134	134	130	135	134	134	158	149	149	156
CR - 9	Preference <=6.0 C	99	107	106	107	96	106	106	106	97	95	95	97
	Stress /Disease >6 C	141	133	134	133	144	134	134	134	143	145	145	143
CR - 8	Preference <=6.0 C	109	110	109	109	107	109	110	110	99	98	98	99
	Stress /Disease >6 C	131	130	131	131	133	131	130	130	141	142	142	141
CR - 7	Preference <=6.0 C	108	108	108	108	88	111	110	111	108	107	107	108
	Stress /Disease >6 C	132	132	132	132	152	129	130	129	132	133	133	132
CR - 6	Preference <=6.0 C	109	107	107	107	87	107	106	107	105	104	104	105
	Stress /Disease >6 C	131	133	133	133	153	133	134	133	135	136	136	135
CR - 5	Preference <=6.0 C	102	98	98	98	68	80	78	78	84	85	86	86
	Stress /Disease >6 C	138	142	142	142	172	160	162	162	156	155	154	154
CR - 4	Preference <=6.0 C	107	103	103	103	94	95	95	95	94	94	94	94
	Stress /Disease >6 C	133	137	137	137	146	145	145	145	146	146	146	146
CR - 3	Preference <=6.0 C	118	112	113	113	108	108	108	108	101	101	101	101
	Stress /Disease >6 C	122	128	127	127	132	132	132	132	139	139	139	139
CR - 2	Preference <=6.0 C	118	112	113	114	108	107	107	107	99	99	100	100
	Stress /Disease >6 C	122	128	127	126	132	133	133	133	141	141	140	140

Table 21. Predicted Number of Days within Water Temperature Water Temperature Thresholds for Juvenile and Subadult Bull Trout under the No-Action Alternative and Alternative 3

		Wet Water Year				Dry Water Year				Normal Water Year			
Reach	Life Stage Thresholds	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)
Bull Trout Juvenile and Subadult Rearing Temperature Thresholds													
CR - 10	Preference <=15.0 C	223	222	222	223	259	258	255	256	313	311	293	292
	Avoidance >15 C and <= 16 C	13	14	14	13	43	33	24	23	13	16	24	15
	Stress/Disease >16 C & <=23 C	126	126	126	126	60	71	83	83	36	35	45	55
	Lethal >23.0 C	0	0	0	0	0	0	0	0	0	0	0	0
CR - 9	Preference <=15.0 C	220	219	219	219	181	187	185	185	266	270	249	248
	Avoidance >15 C and <= 16 C	17	18	18	18	24	13	11	11	5	3	2	3
	Stress/Disease >16 C & <=23 C	125	125	125	125	111	104	107	107	73	59	71	77
	Lethal >23.0 C	0	0	0	0	46	58	59	59	18	30	40	34
CR - 8	Preference <=15.0 C	225	225	225	225	199	198	198	198	272	270	261	266
	Avoidance >15 C and <= 16 C	16	16	16	16	17	8	5	5	25	24	14	8
	Stress/Disease >16 C & <=23 C	121	121	121	121	129	130	131	131	47	49	55	55
	Lethal >23.0 C	0	0	0	0	17	26	28	28	18	19	32	33
CR - 7	Preference <=15.0 C	224	224	224	225	231	234	234	234	236	238	247	249
	Avoidance >15 C and <= 16 C	16	14	14	13	21	17	17	16	33	31	13	8
	Stress/Disease >16 C & <=23 C	122	124	124	124	110	111	111	112	93	93	102	105
	Lethal >23.0 C	0	0	0	0	0	0	0	0	0	0	0	0
CR - 6	Preference <=15.0 C	213	213	213	213	215	221	221	221	214	214	237	242
	Avoidance >15 C and <= 16 C	13	12	12	12	23	17	17	17	33	32	22	17
	Stress/Disease >16 C & <=23 C	132	137	137	127	124	124	124	124	113	113	94	91
	Lethal >23.0 C	4	0	0	10	0	0	0	0	2	3	9	12
CR - 5	Preference <=15.0 C	207	208	208	208	175	181	181	181	180	180	180	188
	Avoidance >15 C and <= 16 C	12	11	12	12	7	3	3	3	5	5	18	22
	Stress/Disease >16 C & <=23 C	114	130	130	120	132	122	122	122	127	128	95	83
	Lethal >23.0 C	29	13	12	22	48	56	56	56	50	49	69	69
CR - 4	Preference <=15.0 C	208	207	207	207	181	182	182	182	176	175	175	175
	Avoidance >15 C and <= 16 C	4	4	4	4	7	7	7	7	4	5	5	8
	Stress/Disease >16 C & <=23 C	102	101	95	95	80	81	80	80	100	104	107	106
	Lethal >23.0 C	48	50	56	56	94	92	93	93	82	78	75	73
CR - 3	Preference <=15.0 C	217	216	216	217	200	199	199	200	201	202	202	202
	Avoidance >15 C and <= 16 C	6	8	8	7	9	8	8	7	11	7	9	12
	Stress/Disease >16 C & <=23 C	97	96	98	99	95	91	91	91	90	92	86	83
	Lethal >23.0 C	42	42	40	39	58	64	64	64	60	61	65	65
CR - 2	Preference <=15.0 C	223	223	223	223	198	198	198	198	207	209	209	215
	Avoidance >15 C and <= 16 C	7	8	8	8	9	9	9	9	9	6	6	15
	Stress/Disease >16 C & <=23 C	113	125	124	123	131	128	128	128	106	106	91	76
	Lethal >23.0 C	19	6	7	8	24	27	27	27	40	41	56	56

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Water management in the normal water year represents about 30% of the years over the analysis period. There would be no adverse effect when considering the normal water year and frequency of occurrence.

BIO-5: Affect Bull Trout Migratory Life Stages

Effects on bull trout migratory life stages under Alternative 3 would be the same type as described for the proposed action in the Middle and Lower Deschutes River, Lake Billy Chinook and Lake Simtustus, and Whychus, Ochoco and McKay Creeks. Effects in the Crooked River are described below.

Crooked River

RiverWare modeled streamflows and predicted water temperatures in the Crooked River do not suggest an effect on migratory life stages. Migration windows for entering and moving upstream in the fall and for subadults to leave the Crooked River in the spring before temperatures exceed preference thresholds are not impacted.

There would be no effect on migratory life stages of this species.

BIO-6: Affect Steelhead Trout Habitat

Effects on steelhead trout habitat under Alternative 3 compared to the no-action alternative would be the same type as described for the proposed action for all reaches, except in the Crooked River reach between the North Unit ID pumps and Osborne Canyon. In addition, effects in the Middle Deschutes River and Crooked River would occur earlier in the permit term and, therefore, be of longer duration under Alternative 3 than the proposed action.

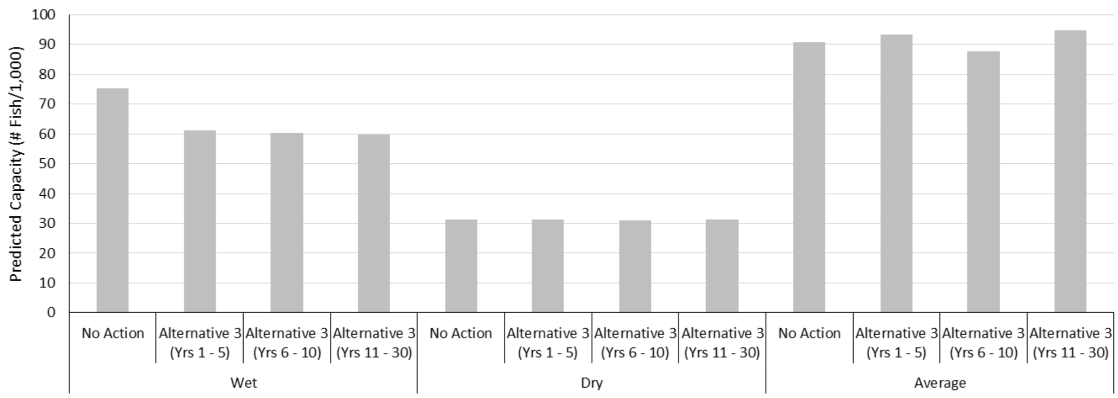
Crooked River

Adverse effects in the Crooked River reach between the North Unit ID pumps and Osborne Canyon related to early season irrigation diversions in dry and normal water year types at full implementation would be of slightly lesser magnitude due to instream protection of uncontracted releases under this alternative (Conservation Measure CR-1).

Habitat Model Results

Results of modeling for summer juvenile rearing show no effect or a decline in capacity under the alternative 3 (Figure 36). Temperature effects are largely influencing these results.

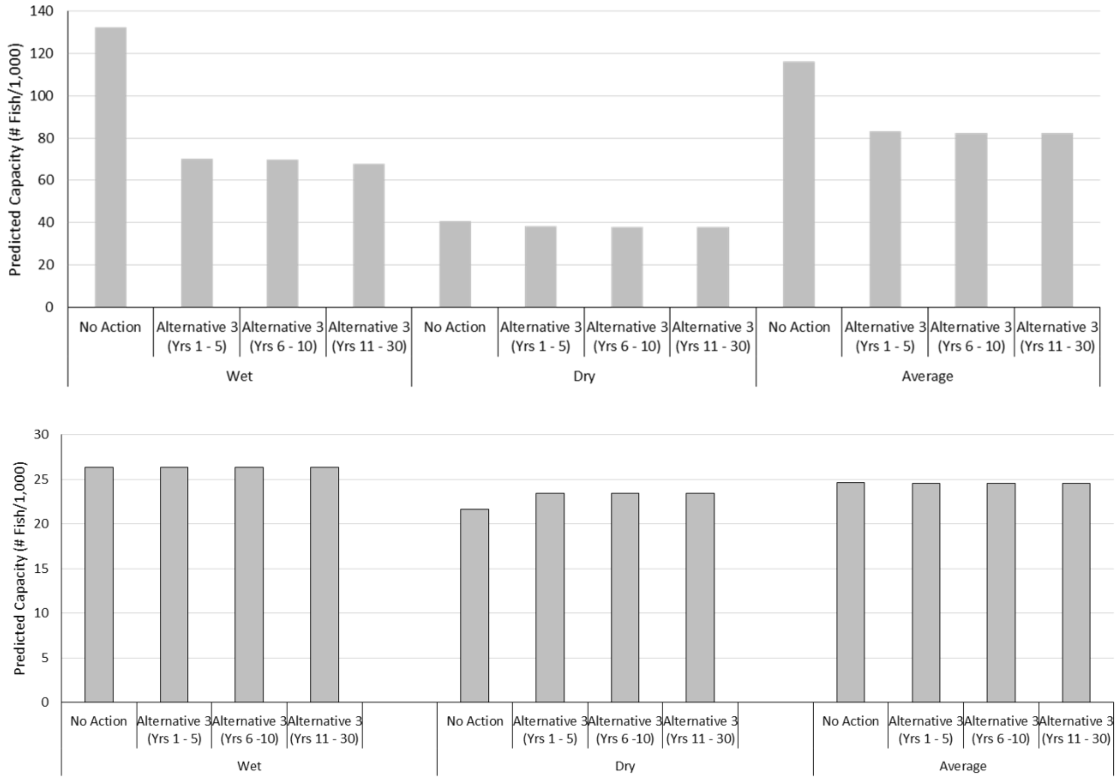
Figure 36. Juvenile Steelhead Summer Capacity Estimates for the Mainstem Crooked River under the No-Action Alternative and Alternative 3



Results of modeling winter juvenile rearing capacity are inconclusive. The decline in capacity under Alternative 3 in wet and normal years modeled is from effects of summer water temperatures on the predicted abundance of steelhead in the winter (Figure 37). However, these results may not reflect winter conditions for juvenile rearing with the increased minimum streamflow rule (Conservation Measure CR-1). The results presented in Figure 37 represent effects of summer maximum water temperatures and winter streamflows (Mount Hood Environmental 2019). It is unclear if the winter minimum streamflow rule under Alternative 3 would affect summer water temperatures in the Crooked River. Figure 37 also presents model results assuming a fixed summer maximum temperature (22°C) in the no action and Alternative 3 across the entire permit term. This analysis is included to focus effects of managing for higher streamflows during the storage season on juvenile capacity. In this analysis steelhead winter capacity increases slightly under the proposed action in the dry year type with a slight increase in winter flows. Winter flows did not change under Alternative 3 in a wet and normal water year type because under the no action streamflows exceeded the minimum rule.

It is likely the minimum winter streamflow rule (Conservation Measure CR-1) and summer water temperatures are independent and increased winter streamflows under Alternative 3 would be expected to improve winter habitat conditions for juvenile steelhead.

Figure 37. Juvenile Steelhead Winter Capacity Estimates for the Mainstem Crooked River with Predicted Summer Temperatures (top) and with Fixed Summer Maximum Temperatures (22˚C, bottom) under the No-Action Alternative and Alternative 3



Water Temperature Results

Tables 22 and 23 summarize temperature thresholds and predicted temperatures for steelhead trout egg incubation and juvenile rearing.

Water temperatures during egg incubation would not be affected by water management under Alternative 3 (Table 22). The number of days in the preferred category tended to not change or actually increased over the permit term for the year types.

Analysis of temperature thresholds for juvenile steelhead rearing show an effect of the shift in timing of release of water for the NUID pumps to May on temperatures (Table 23). The number of days in the avoidance category in the wet water year in the reach immediately downstream of Bowman Dam increased from 33 days under the no-action alternative to 61 days under Alternative 3 by the end of the permit term. In addition, there were more warm days in the normal water year toward the end of the permit term. The number of suboptimal days increased from 77 days to 109 days in the reach immediately downstream of Bowman Dam (CR-10). The number of days in the stress/disease category increased in reaches CR-9 and CR-8. Effects of water management on water temperature in lower reaches (CR-7 through CR-2) tended to be more variable as temperatures were warmer under the no-action alternative and effects of water management from Bowman Dam have less of an influence on water temperatures (Berger et al. 2019). Overall there was a tendency for more days in the stress/disease and lethal categories under the proposed action.

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Table 22. Predicted Number of Days within Water Temperature Water Temperature Thresholds for Egg Incubation Steelhead Trout under the No-Action Alternative and Alternative 3

		Wet Water Year				Dry Water Year				Normal Water Year			
Reach	Life Stage Thresholds	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)
Steelhead Trout Egg Incubation Temperature Thresholds													
CR - 10	Preference <=11.1 C	62	62	62	62	53	53	52	52	63	63	73	90
	SubOptimal >11.1 C & <=15 C	32	32	32	32	64	63	63	63	59	59	49	31
	Stress/Disease >15 C	28	28	28	28	5	6	7	7	0	0	0	1
CR - 9	Preference <=11.1 C	51	57	57	57	49	49	49	49	49	48	58	64
	SubOptimal >11.1 C & <=15 C	36	29	29	29	7	4	4	4	70	74	60	53
	Stress/Disease >15 C	35	36	36	36	66	69	69	69	3	0	4	5
CR - 8	Preference <=11.1 C	57	57	57	57	50	49	49	49	51	50	57	66
	SubOptimal >11.1 C & <=15 C	30	30	30	30	7	7	7	7	57	56	56	52
	Stress/Disease >15 C	35	35	35	35	65	66	66	66	14	16	9	4
CR - 7	Preference <=11.1 C	56	57	57	57	53	53	53	53	54	54	54	61
	SubOptimal >11.1 C & <=15 C	35	34	34	34	48	45	45	45	50	52	61	56
	Stress/Disease >15 C	31	31	31	31	21	24	24	24	18	16	7	5
CR - 6	Preference <=11.1 C	54	54	54	54	54	54	54	54	55	55	55	55
	SubOptimal >11.1 C & <=15 C	26	26	26	26	27	27	27	27	29	29	52	56
	Stress/Disease >15 C	42	42	42	42	41	41	41	41	38	38	15	11
CR - 5	Preference <=11.1 C	44	44	44	44	46	46	45	45	43	42	42	44
	SubOptimal >11.1 C & <=15 C	28	28	28	28	6	6	7	7	12	13	13	19
	Stress/Disease >15 C	50	50	50	50	70	70	70	70	67	67	67	59
CR - 4	Preference <=11.1 C	43	45	45	45	38	40	40	40	28	28	28	27
	SubOptimal >11.1 C & <=15 C	26	24	24	24	13	11	11	11	21	21	21	22
	Stress/Disease >15 C	53	53	53	53	71	71	71	71	73	73	73	73
CR - 3	Preference <=11.1 C	47	47	47	47	50	50	50	50	48	48	48	48
	SubOptimal >11.1 C & <=15 C	24	23	23	24	3	3	3	3	6	6	6	6
	Stress/Disease >15 C	51	52	52	51	69	69	69	69	68	68	68	68
CR - 2	Preference <=11.1 C	45	45	45	45	47	47	47	47	39	39	39	39
	SubOptimal >11.1 C & <=15 C	25	25	25	25	6	6	6	6	15	15	15	21
	Stress/Disease >15 C	52	52	52	52	69	69	69	69	68	68	68	62

Table 23. Predicted Number of Days within Water Temperature Water Temperature Thresholds for Juvenile Steelhead Trout under the No-Action Alternative and Alternative 3

		Wet Water Year				Dry Water Year				Normal Water Year			
Reach	Life Stage Thresholds	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)
Steelhead Trout Juvenile Rearing Temperature Thresholds													
CR - 10	Preference <=14.0 C	203	203	203	203	239	234	231	233	285	279	260	253
	SubOptimal >14 C & <=19 C	126	127	115	98	87	99	96	94	77	83	102	109
	Avoidance >19 C & <22 C	33	32	44	61	24	28	33	33	0	0	0	0
	Stress/Disease >22 C	0	0	0	0	12	1	2	2	0	0	0	0
CR - 9	Preference <=14.0 C	199	198	198	199	170	182	183	183	249	245	233	244
	SubOptimal >14 C & <=19 C	149	151	145	121	92	71	64	65	63	60	50	46
	Avoidance >19 C & <22 C	14	13	19	42	38	37	38	37	16	19	25	21
	Stress/Disease >22 C	0	0	0	0	62	72	77	77	34	38	54	51
CR - 8	Preference <=14.0 C	207	207	207	208	194	194	194	194	249	227	242	250
	SubOptimal >14 C & <=19 C	103	98	98	105	75	73	69	69	66	87	51	42
	Avoidance >19 C & <22 C	52	57	57	45	63	56	60	61	20	17	16	17
	Stress/Disease >22 C	0	0	0	4	30	39	39	38	27	31	53	53
CR - 7	Preference <=14.0 C	206	206	206	206	212	217	217	216	218	213	233	239
	SubOptimal >14 C & <=19 C	92	95	93	100	95	96	83	84	95	100	60	53
	Avoidance >19 C & <22 C	62	61	63	48	55	49	62	62	44	38	57	56
	Stress/Disease >22 C	2	0	0	8	0	0	0	0	5	11	12	14
CR - 6	Preference <=14.0 C	203	203	203	203	205	208	208	207	203	202	212	227
	SubOptimal >14 C & <=19 C	72	70	75	76	95	97	84	84	107	108	81	65
	Avoidance >19 C & <22 C	77	80	70	62	62	57	68	69	30	30	39	39
	Stress/Disease >22 C	10	9	14	21	0	0	2	2	22	22	30	31
CR - 5	Preference <=14.0 C	199	203	204	204	166	177	178	178	176	176	176	181
	SubOptimal >14 C & <=19 C	68	66	70	70	59	52	46	46	68	68	85	83
	Avoidance >19 C & <22 C	51	51	46	47	63	57	62	62	66	67	30	27
	Stress/Disease >22 C	44	42	42	41	74	76	76	76	52	51	71	71
CR - 4	Preference <=14.0 C	202	202	203	203	179	179	179	179	171	171	171	171
	SubOptimal >14 C & <=19 C	45	43	42	41	19	19	19	19	40	41	53	65
	Avoidance >19 C & <22 C	50	51	48	43	48	51	49	49	51	55	57	49
	Stress/Disease >22 C	65	66	69	75	116	113	115	115	100	95	81	77
CR - 3	Preference <=14.0 C	208	208	208	208	197	197	197	197	191	191	191	195
	SubOptimal >14 C & <=19 C	60	59	61	60	35	33	32	32	58	58	80	73
	Avoidance >19 C & <22 C	43	42	38	35	55	52	53	53	45	45	22	26
	Stress/Disease >22 C	51	53	55	59	75	80	80	80	68	68	69	68
CR - 2	Preference <=14.0 C	215	215	216	216	196	196	196	196	195	195	196	197
	SubOptimal >14 C & <=19 C	61	66	62	61	61	65	65	65	66	66	82	87
	Avoidance >19 C & <22 C	51	55	59	70	63	55	55	55	54	47	24	17
	Stress/Disease >22 C	35	26	25	15	42	46	46	46	47	54	60	61

Habitat model results suggest an adverse effect on summer rearing and inconclusive effects on winter rearing, although higher streamflows are predicted to increase habitat capacity independent of summer water temperatures. However, overall there would be an adverse effect because of substantially longer periods of warmer water in the Crooked River under the proposed action.

BIO-7: Affect Steelhead Trout Migratory Life Stages

Effects on steelhead migratory life stages under Alternative 3 would be the same type as described for the proposed action in the Middle and Lower Deschutes River, Lake Billy Chinook and Lake Simtustus, and Whychus, Ochoco and McKay Creeks. Effects in the Crooked River are described below.

Crooked River

Effects on steelhead migratory life stages under Alternative 3 would be the same type as described for the proposed action. There would be no effect on steelhead trout migratory life stages in the Crooked River under Alternative 3 because streamflows would not affect water temperatures across the permit term compared to the no-action alternative (Tables 24 and 25).

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Table 24. Predicted Number of Days within Water Temperature Thresholds for Adult Migrant Steelhead Trout under the No-Action Alternative and Alternative 3

		Wet Water Year				Dry Water Year				Normal Water Year			
Reach	Life Stage Thresholds	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)
Steelhead Trout Adult Migration Temperature Thresholds													
CR - 10	Preference <=12.8 C	147	148	148	148	162	159	159	159	155	154	154	154
	SubOptimal >12.8 C & <=14 C	9	8	8	8	5	4	4	4	23	23	23	18
	Avoidance >14.4 C & <21 C	23	23	23	23	12	16	16	16	1	2	2	7
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0	0	0	0
CR - 9	Preference <=12.8 C	147	150	150	150	141	160	160	160	155	155	155	155
	SubOptimal >12.8 C & <=14 C	13	10	10	10	12	2	2	2	5	6	6	5
	Avoidance >14.4 C & <21 C	19	19	19	19	21	11	11	11	19	18	18	19
	Delay >21 C & <=23.9 C	0	0	0	0	2	3	3	3	0	0	0	0
CR - 8	Preference <=12.8 C	152	152	152	152	168	170	170	170	164	163	163	163
	SubOptimal >12.8 C & <=14 C	14	14	14	14	5	3	3	3	14	15	15	15
	Avoidance >14.4 C & <21 C	13	13	13	13	6	6	6	6	1	1	1	1
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0	0	0	0
CR - 7	Preference <=12.8 C	151	151	151	151	144	159	159	159	155	154	154	154
	SubOptimal >12.8 C & <=14 C	12	12	12	12	14	4	5	5	5	7	7	7
	Avoidance >14.4 C & <21 C	16	16	16	16	21	16	15	15	19	18	18	18
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0	0	0	0
CR - 6	Preference <=12.8 C	150	151	151	151	148	158	158	158	154	153	153	153
	SubOptimal >12.8 C & <=14 C	12	11	11	11	11	5	5	5	5	4	5	5
	Avoidance >14.4 C & <21 C	17	17	17	17	20	16	16	16	20	22	21	21
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0	0	0	0
CR - 5	Preference <=12.8 C	151	152	152	152	138	147	148	148	150	149	150	150
	SubOptimal >12.8 C & <=14 C	14	14	14	14	12	12	11	11	5	6	5	5
	Avoidance >14.4 C & <21 C	14	13	13	13	29	20	20	20	24	24	24	24
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0	0	0	0
CR - 4	Preference <=12.8 C	160	159	159	159	152	156	156	156	154	153	153	153
	SubOptimal >12.8 C & <=14 C	7	7	7	8	8	5	4	4	2	3	3	3
	Avoidance >14.4 C & <21 C	12	13	13	12	19	18	19	19	23	23	23	23
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0	0	0	0
CR - 3	Preference <=12.8 C	166	165	165	165	173	169	169	169	160	159	159	162
	SubOptimal >12.8 C & <=14 C	5	6	6	6	2	6	6	6	12	13	13	15
	Avoidance >14.4 C & <21 C	8	8	8	8	4	4	4	4	7	7	7	2
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0	0	0	0
CR - 2	Preference <=12.8 C	166	166	166	166	173	173	173	173	162	162	162	162
	SubOptimal >12.8 C & <=14 C	6	6	6	6	2	2	2	2	17	17	17	17
	Avoidance >14.4 C & <21 C	7	7	7	7	4	4	4	4	0	0	0	0
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0	0	0	0

Table 25. Predicted Number of Days within Water Temperature Thresholds for Steelhead Trout Smolts under the No-Action Alternative and Alternative 3

		Wet Water Year				Dry Water Year				Normal Water Year			
Reach	Life Stage Thresholds	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)
Steelhead Trout Smolt Migration Temperature Thresholds													
CR - 10	Preference <=13.6 C	46	45	46	46	67	67	63	63	89	90	87	87
	Delay > 13.6 C	45	46	45	45	24	24	28	28	2	1	4	4
CR - 9	Preference <=13.6 C	42	42	42	42	21	21	21	21	67	57	66	78
	Delay > 13.6 C	49	49	49	49	70	70	70	70	24	34	25	13
CR - 8	Preference <=13.6 C	41	41	41	41	22	21	21	21	51	42	60	70
	Delay > 13.6 C	50	50	50	50	69	70	70	70	40	49	31	21
CR - 7	Preference <=13.6 C	42	42	42	42	51	49	49	48	55	51	73	80
	Delay > 13.6 C	49	49	49	49	40	42	42	43	36	40	18	11
CR - 6	Preference <=13.6 C	41	41	41	41	39	39	39	38	40	40	50	69
	Delay > 13.6 C	50	50	50	50	52	52	52	53	51	51	41	22
CR - 5	Preference <=13.6 C	38	37	37	37	20	20	20	20	22	21	21	23
	Delay > 13.6 C	53	54	54	54	71	71	71	71	69	70	70	68
CR - 4	Preference <=13.6 C	36	36	36	36	18	18	18	18	16	16	16	16
	Delay > 13.6 C	55	55	55	55	73	73	73	73	75	75	75	75
CR - 3	Preference <=13.6 C	37	37	37	37	22	21	21	21	22	22	22	21
	Delay > 13.6 C	54	54	54	54	69	70	70	70	69	69	69	70
CR - 2	Preference <=13.6 C	37	37	37	37	21	21	21	21	21	21	21	23
	Delay > 13.6 C	54	54	54	54	70	70	70	70	70	70	70	68

BIO-8: Affect Spring Chinook Salmon Habitat

Effects on spring Chinook salmon habitat under Alternative 3 would be the same type as described for the proposed action in the Middle and Lower Deschutes River, Lake Billy Chinook and Lake Simtustus, and Whychus, and Ochoco Creeks. Effects in the Crooked River are described below.

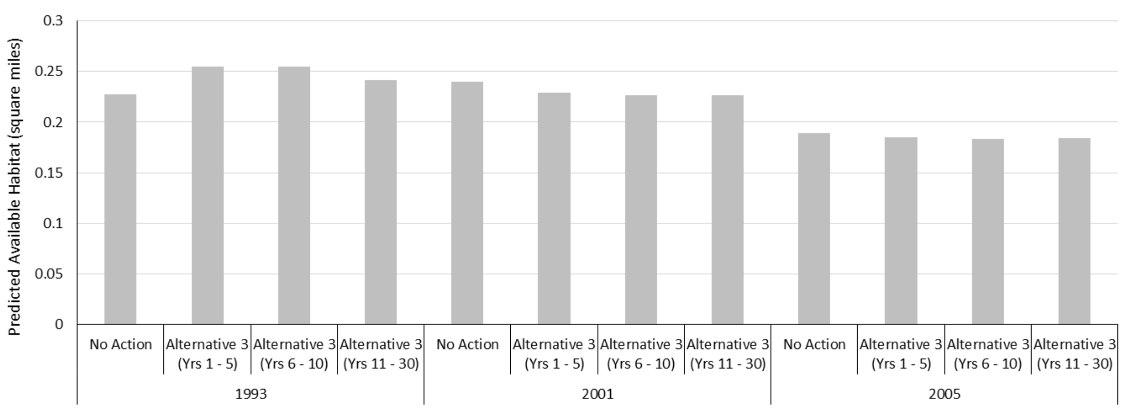
Crooked River

In the Crooked River reach between the North Unit ID pumps and Osborne Canyon adverse effects would be of slightly lesser magnitude than described for the proposed action due to instream protection of uncontracted releases under this alternative (Conservation Measure CR-1).

Habitat Model Results

Results of modeling available summer habitat for Chinook juvenile rearing are inconclusive. Effects of streamflows on available habitat are not suggesting any particular trend between the no-action alternative and Alternative 3 (Figure 38).

Figure 38. Estimate of Juvenile Chinook Summer Habitat Availability for the Mainstem Crooked River under the No-Action Alternative and Alternative 3



Water Temperature Results

The results of spring Chinook juvenile rearing temperature thresholds are listed in Table 26.

Similar to the proposed action, analysis of temperature thresholds for juvenile Chinook rearing indicate an effect of timing of release of water from Bowman Dam on water temperatures.

The number of days in the stress/disease category in the wet water year in the reach immediately downstream of Bowman Dam increased from 28 days under the no-action alternative to 61 days under Alternative 4 by the end of the permit term. There were more warm days in the normal water year toward the end of the permit term. The number of stress/disease days increased from 41 days to 67 days in the reach immediately downstream of Bowman Dam (CR-10). The number of days in the optimal category decreased from 47 days to 24 days in reach CR - 9, downstream of the canyon reach and from 53 days to 25 days in reach CR–8, upstream of Prineville. In CR-9 the number of days in the lethal category increased from 34 days to 68 days and in CR-8 the number of days in the lethal category increased from 27 days to 57 days.

Effects of water management on water temperature in lower reaches (CR-7 through CR-2) tended to be more variable as temperatures were warmer under the no-action alternative and effects of water management from Bowman Dam have less of an influence on water temperatures (Berger et al. 2019). Overall there was a tendency for more days in the stress/disease and lethal categories under the proposed action.

Water temperatures thresholds were not explicitly evaluated for adult spring Chinook holding through the summer in the Crooked River. However, similar to the proposed action, the additional number of warm days toward the end of the permit term indicate a worsening of habitat conditions for spring Chinook adults holding through the summer.

Habitat model results are inconclusive, results suggest no trend toward better or worsening amount of available habitat. However, these results do not reflect variation in summer streamflows and cumulative effects of summer water temperatures. Similar to the proposed action, there would be an adverse effect toward the end of the permit term based on the wet, dry, and normal year type water temperature simulations. The adverse effect would occur earlier in the permit term and last longer under Alternative 3.

Table 26. Predicted Number of Days within Water Temperature Thresholds for Juvenile Spring Chinook (June–September) under the No-Action Alternative and Alternative 3

		Wet Water Year				Dry Water Year				Normal Water Year			
Reach	Life Stage Thresholds	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)
Chinook Juvenile Rearing Temperature Thresholds													
CR - 10	Preference <=15.6 C	9	9	9	9	46	45	34	36	81	81	65	60
	Sub-optimal (>15.6 & <=19.1)	85	83	76	54	43	51	56	54	41	41	57	62
	Stress/Disease >19.1 & <=22 C	28	30	37	59	21	25	30	30	0	0	0	0
	Lethal >22.0 C	0	0	0	0	12	1	2	2	0	0	0	0
CR - 9	Preference <=15.6 C	9	9	9	9	9	4	0	0	47	48	26	26
	Sub-optimal (>15.6 & <=19.1)	103	103	97	73	28	27	26	26	26	20	21	25
	Stress/Disease >19.1 & <=22 C	10	10	16	40	28	24	24	24	15	16	21	20
	Lethal >22.0 C	0	0	0	0	57	67	72	72	34	38	54	51
CR - 8	Preference <=15.6 C	9	9	9	9	4	1	0	0	53	50	29	30
	Sub-optimal (>15.6 & <=19.1)	63	59	59	67	37	39	37	36	23	25	25	24
	Stress/Disease >19.1 & <=22 C	50	54	54	42	51	43	46	48	19	16	15	15
	Lethal >22.0 C	0	0	0	4	30	39	39	38	27	31	53	53
CR - 7	Preference <=15.6 C	10	9	9	9	15	15	15	15	31	24	26	26
	Sub-optimal (>15.6 & <=19.1)	55	59	59	61	58	59	48	48	42	49	28	28
	Stress/Disease >19.1 & <=22 C	55	54	54	44	49	48	59	59	44	38	56	54
	Lethal >22.0 C	2	0	0	8	0	0	0	0	5	11	12	14
CR - 6	Preference <=15.6 C	7	7	6	6	7	6	5	5	4	1	20	20
	Sub-optimal (>15.6 & <=19.1)	30	29	35	37	57	59	51	51	66	70	33	32
	Stress/Disease >19.1 & <=22 C	75	77	67	58	58	57	64	64	30	29	39	39
	Lethal >22.0 C	10	9	14	21	0	0	2	2	22	22	30	31
CR - 5	Preference <=15.6 C	0	0	0	0	0	0	0	0	0	0	8	6
	Sub-optimal (>15.6 & <=19.1)	30	32	37	37	6	10	6	6	16	15	20	21
	Stress/Disease >19.1 & <=22 C	48	48	43	44	50	44	48	48	54	56	23	24
	Lethal >22.0 C	44	42	42	41	66	68	68	68	52	51	71	71
CR - 4	Preference <=15.6 C	0	0	0	0	0	0	0	0	0	0	0	0
	Sub-optimal (>15.6 & <=19.1)	25	24	24	23	0	0	0	0	5	4	16	13
	Stress/Disease >19.1 & <=22 C	32	32	29	24	25	28	26	26	26	31	29	32
	Lethal >22.0 C	65	66	69	75	97	94	96	96	91	87	77	77
CR - 3	Preference <=15.6 C	7	7	7	7	4	4	4	4	5	2	2	4
	Sub-optimal (>15.6 & <=19.1)	22	22	24	22	11	14	12	12	18	21	41	29
	Stress/Disease >19.1 & <=22 C	42	40	36	34	42	35	37	37	34	32	10	21
	Lethal >22.0 C	51	53	55	59	65	69	69	69	65	67	69	68
CR - 2	Preference <=15.6 C	13	13	13	13	3	4	4	4	9	10	10	12
	Sub-optimal (>15.6 & <=19.1)	34	36	33	34	32	35	35	35	21	21	34	32
	Stress/Disease >19.1 & <=22 C	40	47	51	60	50	42	42	42	46	38	18	17
	Lethal >22.0 C	35	26	25	15	37	41	41	41	46	53	60	61

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BIO-9: Affect Spring Chinook Salmon Migratory Life Stages

Effects on spring Chinook salmon migratory life stages under Alternative 3 would be the same type as described for the proposed action in the Middle and Lower Deschutes River, Lake Billy Chinook and Lake Simtustus, and Whychus, and Ochoco Creeks. Effects in the Crooked River are described below.

Crooked River

Effects in the Crooked River would occur earlier in the permit term and, therefore, have a longer duration under Alternative 3 than under the proposed action.

Water Temperature

The results of adult migration temperature thresholds are listed in Table 27. Smolt migration thresholds are listed in Table 28.

Similar to the proposed action, Alternative 3 would have no effect on migrating spring Chinook salmon adults attempting to move upstream in the spring or downstream migrating smolts because of water temperature effects on these life stages would be minor. However, the effect of water temperature on adult spring Chinook salmon migration habitat in July and August would be potentially adverse because the potential for migration effects exist but are not conclusive based on the available data.

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Table 27. Predicted Number of Days within Water Temperature Thresholds for Migrating Adult Spring Chinook (March–June) under the No-Action Alternative and Alternative 3

		Wet Water Year				Dry Water Year				Normal Water Year			
Reach	Life Stage Thresholds	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)
Chinook Adult Spring Migration Temperature Thresholds													
CR - 10	Preference <= 19.0 C	122	122	122	122	122	122	122	122	122	122	122	122
	Avoidance >19.4 C & <= 21 C	0	0	0	0	0	0	0	0	0	0	0	0
	Delay >21.0 C & <= 25.0 C	0	0	0	0	0	0	0	0	0	0	0	0
	Lethal >25.0 C	0	0	0	0	0	0	0	0	0	0	0	0
CR - 9	Preference <= 19.0 C	121	122	122	122	99	92	90	91	122	122	121	121
	Avoidance >19.4 C & <= 21 C	1	0	0	0	13	18	20	19	0	0	1	1
	Delay >21.0 C & <= 25.0 C	0	0	0	0	10	12	12	12	0	0	0	0
	Lethal >25.0 C	0	0	0	0	0	0	0	0	0	0	0	0
CR - 8	Preference <= 19.0 C	106	106	106	120	96	93	93	93	122	122	121	120
	Avoidance >19.4 C & <= 21 C	14	16	16	2	17	18	17	18	0	0	1	2
	Delay >21.0 C & <= 25.0 C	2	0	0	0	9	11	12	11	0	0	0	0
	Lethal >25.0 C	0	0	0	0	0	0	0	0	0	0	0	0
CR - 7	Preference <= 19.0 C	108	117	116	122	122	122	122	122	122	122	122	122
	Avoidance >19.4 C & <= 21 C	14	5	6	0	0	0	0	0	0	0	0	0
	Delay >21.0 C & <= 25.0 C	0	0	0	0	0	0	0	0	0	0	0	0
	Lethal >25.0 C	0	0	0	0	0	0	0	0	0	0	0	0
CR - 6	Preference <= 19.0 C	107	107	107	108	122	122	122	122	122	122	121	120
	Avoidance >19.4 C & <= 21 C	5	15	15	14	0	0	0	0	0	0	1	2
	Delay >21.0 C & <= 25.0 C	10	0	0	0	0	0	0	0	0	0	0	0
	Lethal >25.0 C	0	0	0	0	0	0	0	0	0	0	0	0
CR - 5	Preference <= 19.0 C	104	104	104	104	75	75	75	75	96	96	113	116
	Avoidance >19.4 C & <= 21 C	2	2	2	15	20	19	19	19	24	25	5	2
	Delay >21.0 C & <= 25.0 C	16	16	16	3	27	28	28	28	2	1	4	4
	Lethal >25.0 C	0	0	0	0	0	0	0	0	0	0	0	0
CR - 4	Preference <= 19.0 C	84	84	84	84	53	53	53	53	59	60	72	84
	Avoidance >19.4 C & <= 21 C	19	19	19	19	11	11	11	11	21	23	29	26
	Delay >21.0 C & <= 25.0 C	5	7	7	19	38	38	38	38	41	39	18	9
	Lethal >25.0 C	14	12	12	0	20	20	20	20	1	0	3	3
CR - 3	Preference <= 19.0 C	102	101	101	102	69	66	66	66	78	79	101	97
	Avoidance >19.4 C & <= 21 C	4	5	5	3	11	11	11	11	17	21	11	15
	Delay >21.0 C & <= 25.0 C	13	14	14	17	41	44	44	44	27	22	9	8
	Lethal >25.0 C	3	2	2	0	1	1	1	1	0	0	1	2
CR - 2	Preference <= 19.0 C	95	95	95	95	80	80	80	80	89	89	106	112
	Avoidance >19.4 C & <= 21 C	11	11	11	13	22	22	22	22	28	28	12	6
	Delay >21.0 C & <= 25.0 C	16	16	16	14	20	20	20	20	5	5	4	4
	Lethal >25.0 C	0	0	0	0	0	0	0	0	0	0	0	0

Table 28. Predicted Number of Days within Water Temperature Thresholds for Migrating Smolt Spring Chinook under the No-Action Alternative and Alternative 3

		Wet Water Year				Dry Water Year				Normal Water Year			
Reach	Life Stage Thresholds	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)	No Action	Alternative 3 (Yrs 1–5)	Alternative 3 (Yrs 6–10)	Alternative 3 (Yrs 11–30)
Chinook Smolt Migration Temperature Thresholds													
CR - 10	Preference <=20 C	120	120	120	120	120	120	120	120	120	120	120	120
	Delay > 20 C	0	0	0	0	0	0	0	0	0	0	0	0
CR - 9	Preference <=20 C	120	120	120	120	120	117	116	116	120	120	120	120
	Delay > 20 C	0	0	0	0	0	3	4	4	0	0	0	0
CR - 8	Preference <=20 C	120	120	120	120	114	112	112	112	120	120	120	120
	Delay > 20 C	0	0	0	0	6	8	8	8	0	0	0	0
CR - 7	Preference <=20 C	120	120	120	120	120	120	120	120	120	120	120	120
	Delay > 20 C	0	0	0	0	0	0	0	0	0	0	0	0
CR - 6	Preference <=20 C	120	120	120	120	120	120	120	120	120	120	120	120
	Delay > 20 C	0	0	0	0	0	0	0	0	0	0	0	0
CR - 5	Preference <=20 C	120	120	120	120	108	108	108	108	114	114	120	120
	Delay > 20 C	0	0	0	0	12	12	12	12	6	6	0	0
CR - 4	Preference <=20 C	115	116	116	116	86	86	85	85	94	94	96	111
	Delay > 20 C	5	4	4	4	34	34	35	35	26	26	24	9
CR - 3	Preference <=20 C	120	120	120	120	104	102	102	102	113	113	116	120
	Delay > 20 C	0	0	0	0	16	18	18	18	7	7	4	0
CR - 2	Preference <=20 C	120	120	120	120	109	108	108	108	113	113	116	120
	Delay > 20 C	0	0	0	0	11	12	12	12	7	7	4	0

BIO-10: Affect Sockeye Salmon Habitat

Effects on sockeye salmon habitat under Alternative 3 would be the same type as described for the proposed action in the Middle and Lower Deschutes River, Lake Billy Chinook and Lake Simtustus, and Whychus Creek. Effects in the Crooked River are described below.

Crooked River

Adult sockeye may enter the Crooked River in the fall to spawn in the lower section of the river. Eggs would remain in the gravel through the winter. Newly emerged fry would migration to Lake Billy Chinook in the spring for juvenile rearing. The limited use by sockeye suggests any effects of streamflows on sockeye habitat would be limited to availability of spawning areas and egg incubation habitat in the lower river downstream of Osborne Canyon.

Under Alternative 3 predicted streamflows in the Crooked River at the Opal gauge are unchanged or change slightly compared to the no-action alternative for the entire permit term. Groundwater inflow upstream of the Opal gauge mostly negates any impact of water management observed in reaches higher in the Crooked River.

There would be no adverse effect on habitat for this species in the portion of the Crooked River likely used by sockeye for spawning.

BIO-11: Affect Sockeye Salmon Migratory Life Stages

Effects on sockeye salmon migratory life stages under Alternative 3 would be the same type as described for the proposed action in the Middle and Lower Deschutes River, Lake Billy Chinook and Lake Simtustus, and Whychus Creek. Effects in the Crooked River are described below.

Crooked River

Adult sockeye may enter the Crooked River in the fall to spawn in the lower section of the river. The limited use by sockeye suggests any effects of streamflows on sockeye migration would be limited to access to spawning areas in the lower river, downstream of Osborne Canyon.

Under Alternative 3 predicted streamflows in the Crooked River at the Opal gauge are mostly unchanged compared to the no-action alternative for the entire permit term. Groundwater inflow upstream of the Opal gauge negates any impact of water management observed in reaches higher in the Crooked River.

There would be no adverse effect on habitat for this species in the portion of the Crooked River likely used by sockeye for spawning.

BIO-12: Affect Redband Trout Habitat

Effects on redband trout under Alternative 3 compared to the no-action alternative would be the same type as described for the proposed action for all reaches, except in the Upper Deschutes River and the Crooked River between North Unit ID pumps and Osborne Canyon. In the Upper Deschutes River between Wickiup Reservoir and Bend, beneficial effects would be greater with implementation of habitat restoration activities funded through Conservation Measure DR-2. In the Crooked River between North Unit ID pumps and Osborne Canyon adverse effects would be of slightly lesser magnitude due to instream protection of uncontracted releases under this alternative in Conservation Measure CR-1. Effects in Wickiup Reservoir, the Upper and Middle Deschutes River, and the Crooked River would occur earlier in the permit term and therefore be of longer duration under Alternative 3 than the proposed action. Overall, effects on redband trout habitat under Alternative 3 would be adverse compared to the no-action alternative for the reasons described for the proposed action.

Crooked River

There would be a beneficial effect of higher minimum winter streamflows under Alternative 3, consistent with study findings by Porter and Hodgson (2016) and habitat modeling by Mount Hood Environmental (2019). Porter and Hodgson concluded low flows during the winter were a factor negatively effecting redband trout habitat the Crooked River. The habitat model developed Mount Hood Environmental (2019) for steelhead for the Deschutes Basin HCP analysis supports their findings. Habitat modeling showed higher winter streamflows would increase habitat capacity for juvenile steelhead. The same conclusion is applicable to juvenile redband trout.

However, under Alternative 3, there would be an overall adverse effect on redband trout habitat in the Crooked River because of an increase in the number of days of warm water temperatures due to changes in timing of release of water from Prineville Reservoir reported by Berger et al. (2019). Water temperatures in the Upper Crooked River reach (CR-10) are less affected by water management compared to downstream reaches, which experience more warming with change in streamflow. This finding suggests habitat would not change as much in this key reach as downstream. However, warming of water temperatures in downstream reaches would impact redband trout movement in the Crooked River and their ability to occupy habitats elsewhere in the Crooked River.

BIO-13: Affect Nonnative Resident Trout Habitat

Effects on nonnative resident trout under Alternative 3 compared to the no-action alternative would be the same type as described for the proposed action in all reaches, except in the Upper Deschutes River where beneficial effects would be slightly greater and the Crooked River between North Unit ID pumps and Osborne Canyon where adverse effects would be slightly less, as described above for redband trout. Effects in Wickiup Reservoir and the Upper and Middle Deschutes River and Crooked River would occur earlier in the permit term and, therefore, be of longer duration under Alternative 3 than under the proposed action. Overall, effects on nonnative resident trout habitat under Alternative 3 would be not adverse compared to the no-action alternative for the reasons described for the proposed action.

BIO-14: Affect Summer/Fall Chinook Salmon Habitat

Summer/Fall Chinook salmon distribution is limited to the Lower Deschutes, downstream of the Pelton-Round Butte Complex. Effects would be the same type as described for the proposed action.

BIO-15: Affect Kokanee Salmon Habitat and Migratory Life Stages

Effects on kokanee salmon habitat and migratory life stages under Alternative 3 compared to the no-action alternative would be the same type as described for the proposed action. Effects in Wickiup Reservoir would occur earlier in the permit term and, therefore, be of longer duration under Alternative 3 than under the proposed action. Overall, effects on kokanee salmon habitat and migratory life stages under Alternative 3 would be adverse compared to the no-action alternative for the reasons described for the proposed action.

BIO-16: Affect Native Non-Trout and Non-Game Fish Habitat

Effects on non-game native fish habitat under Alternative 3 compared to the no-action alternative would be the same type as described for the proposed action, except that implementation of habitat restoration activities funded through Conservation Measure DR-2 under Alternative 3 could offset potential adverse effects and increase beneficial effects in the Upper Deschutes River. Effects in Wickiup Reservoir, Upper and Middle Deschutes River, and Crooked River would occur earlier in the permit term and, therefore, be of longer duration under Alternative 3 than under the proposed action. Overall, effects on non-game native fish habitat under Alternative 3 would be not adverse compared to the no-action alternative for the reasons described for the proposed action.

BIO-17: Affect Freshwater Mollusk Habitat

Effects on freshwater mollusk habitat under Alternative 3 would be the same type as described for the proposed action except for in the Crooked River, which is described below.

Crooked River

Crater Lake Tightcoil and Evening Field Slug

There would be no adverse effect on Crater Lake tightcoil and evening field slug in the Crooked River under Alternative 3 because flows would increase in the fall and winter months in most years and would decrease or increase in the spring and summer months in different years, depending on reach.

Floater Species Mussels

There would be an adverse effect on floater species mussels in the Crooked River under Alternative 3 because there would be an average decrease in flows during the critical period of reproduction and juvenile establishment for this species (May through August) in the reach of the river where the mussels are primarily found. There would be an average decrease in flows in July in the reaches measured by the CAPO gauge and in May through July in reaches measured by the NUID gauge.

Western Pearlshell Mussels

There would be a beneficial effect on western pearlshell mussels in the Crooked River under Alternative 3 because flows would increase in many reaches during May and June, the critical period of reproduction and juvenile establishment for the species.

Western Ridged Mussels

There would be no adverse effect on western ridged mussels in the Crooked River under Alternative 3 because though flow would increase, on average, during the initial reproductive period in many reaches, overall, there would be small decreases in flows during the later part of their reproductive period (especially July) in many reaches.

Alternative 4: Enhanced and Accelerated Variable Streamflows

Modeled changes in streamflows, reservoir volumes and elevations, and water quality conditions under Alternative 4 compared to the no-action alternative are described below in the Modeled

Environmental Conditions section followed by descriptions of how these changes would affect individual species in the Species Impacts section.

Modeled Environmental Conditions

This section describes important changes in reservoir storage and elevation, seasonal river and creek streamflows, and relevant water quality information in the study area by geographic area and subarea under Alternative 4. Effects are evaluated based on changes in modeled results for Alternative 4 compared to the no-action alternative.

Changes in streamflows and reservoir elevations and variability would be the same or nearly the same type as described for the proposed action for all reaches except for the Upper and Middle Deschutes River, Wickiup Reservoir, Crooked River, and Prineville Reservoir, which are described below.

Upper Deschutes

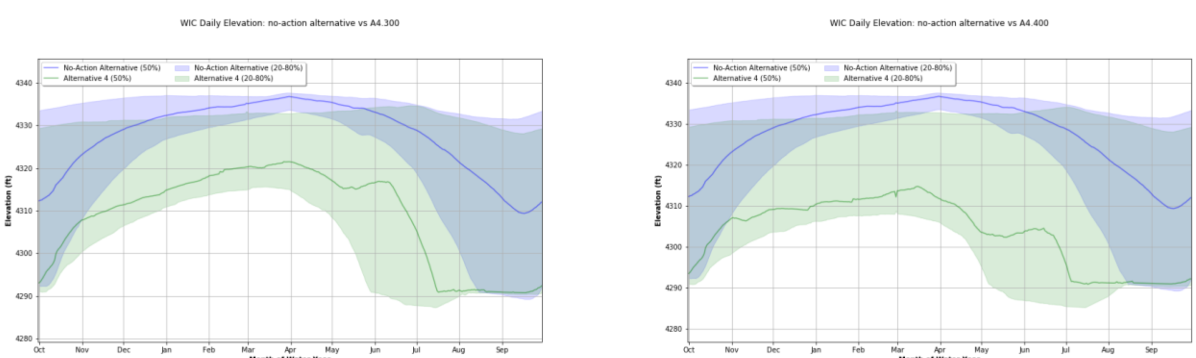
Under Alternative 4, as under the proposed action and Alternative 3, summer flows would diminish and winter flows would increase compared to the no-action alternative. Alternative 4 would alter the timing of those changes, such that winter minimum flow targets would be achieved earlier in the permit term and would end at a higher level compared to the proposed action and Alternative 3.

Accordingly, modeled environmental conditions under Alternative 4 follow the same trend over the permit term as described for the proposed action and Alternative 3. The differences described below are more extreme differences in median reservoir elevations and streamflows.

Wickiup Reservoir

Based on modeled results for Wickiup Reservoir node (WIC), illustrated in Figure 39, conditions in Wickiup Reservoir in years 1 through 5 would be the same as under the proposed action in years 16 through 20. In years 6 through 20, under Alternative 4 conditions would be similar to those describe for the proposed action in years 21 through 30, but with lower median elevations from November through mid-July.

Figure 39. Modeled Elevations for Wickiup Reservoir (WIC) under the No-Action Alternative and Alternative 4



Upper Deschutes River downstream of Wickiup Dam

Under Alternative 4, as under the proposed action and Alternative 3, summer flows would diminish and winter flows would increase compared to the no-action alternative. Alternative 4 would alter the timing of those changes, such that winter minimum flow targets would be achieved earlier in the permit term and would end at a higher level compared to the proposed action and Alternative 3.

Based on modeled results for the Wickiup Reservoir Outlet (WICO) and Benham Falls (BENO) nodes and internodes between Benham Falls and the city of Bend, streamflows in the Upper Deschutes River downstream of Wickiup Dam would be less variable over the year because regulation of streamflows would happen earlier and in more years. Variation in streamflows that would occur under the proposed action in May would be less frequent and a lower magnitude.

Middle Deschutes

Middle Deschutes River

Modeled results for the city of Bend (DEDO) node and the Culver City internode (CULOGauge.Outflow), winter streamflows would be higher.

- In years 1 through 5 of the permit term median monthly streamflows at DEBO would be higher in all analysis years during the winter storage season from October through March by on average 40% in October and 20% from November through March.
- In years 6 through 20 median monthly streamflows at DEBO during the winter storage season would be 50% higher in October and 30% higher from October through March.
- Median streamflows at DEBO during the transition period to irrigation season in April would be unchanged through the permit term in all analysis years through the permit term.
- Median monthly streamflows at DEBO from July through September at DEBO would not change in a majority of years through the permit term. Differences would be evenly split between lower or higher by 10% on average.

At the Culver City internode surface and groundwater inflows upstream of this location would reduce the effects of water management and changes in streamflow upstream of this location at DEBO. Increasing minimum winter streamflows would increase streamflows from October through March by approximately 15%, on average, by the end of the permit term.

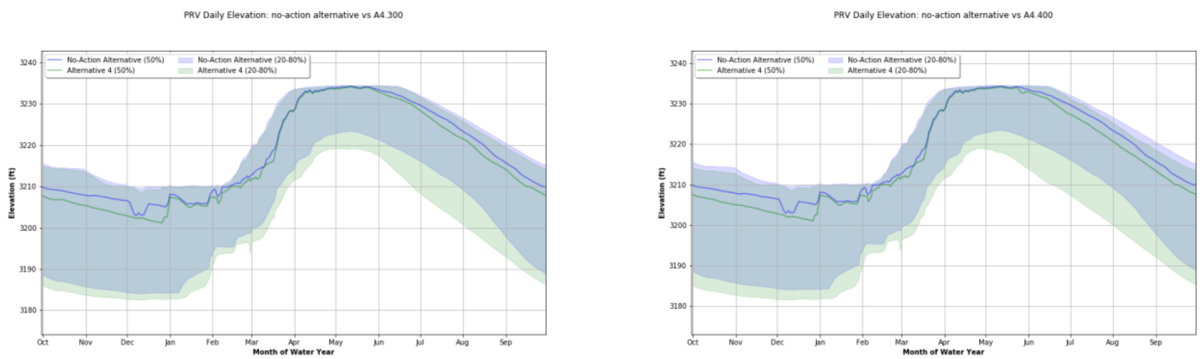
Crooked River

Prineville Reservoir

Based on modeled results for Prineville Reservoir node (PRV), illustrated in Figure 40, elevations would be similar to the proposed action. Changes are described below in comparison to the no-action alternative.

- Median elevations would be lower from July through January with differences greatest in October and November. Median elevations would be unchanged from February to June.
- Differences in median elevations would not differ over the permit term.
- Year to year variability would tend to occur in the low and high range of elevations.

Figure 40. Modeled Elevations for Prineville Reservoir (PRVO) under the No-Action Alternative and Alternative 4 (Years 1–5 [left] and Years 6–20 [right])



Crooked River

Modeled environmental conditions in the Crooked River are described below based on median monthly streamflows and modeled water temperatures.

Median Monthly Streamflow

The following is a summary of differences in streamflow at Prineville Outlet (PRVO), Highway 126 (CAPO), streamflow below the North Unit Irrigation District pumps (NUID), and streamflow at Opal (OPAL).

Observations of monthly median streamflow at PRVO across all RiverWare model years:

- In October through March, average median monthly streamflow would increase approximately 50% across all years.
- In April, median streamflow would decrease less than 2% on average across years, and in most years there would be no change.
- In May and June, median streamflow increases would be small in years 1 through 5 in June, 55% on average in May in years 6 through 20, and 31% in June in about one-third of years.
- In July through September, median streamflows would decrease in a majority of years by an average of 21% in July, 35% in August, and 18% in September.

Observations of monthly median streamflow at CAPO across all RiverWare model years:

- In October through March, median monthly streamflows would increase on average approximately 70% across all years.
- In April, median streamflows show very small decreases (less than 2% on average) across years, most years no change.
- In May and June, median streamflows show small increase in years 1 through 5 in June, years 6 through 20 an average increase of almost 400% in May and 200% in June in nearly half of all years.
- In July through September, median streamflows would decrease in a majority of years by years 6 through 20 of the permit term by an average of 50%.

Observations monthly median streamflow below the NUID pumps across all RiverWare model years:

- In October through March, median streamflows would increase on average among years and months of approximately 20% in most years.
- In April through September, median streamflows would decrease on average among years and 25% in nearly all months.

Observations monthly median streamflow in lower Crooked River (OPAL node):

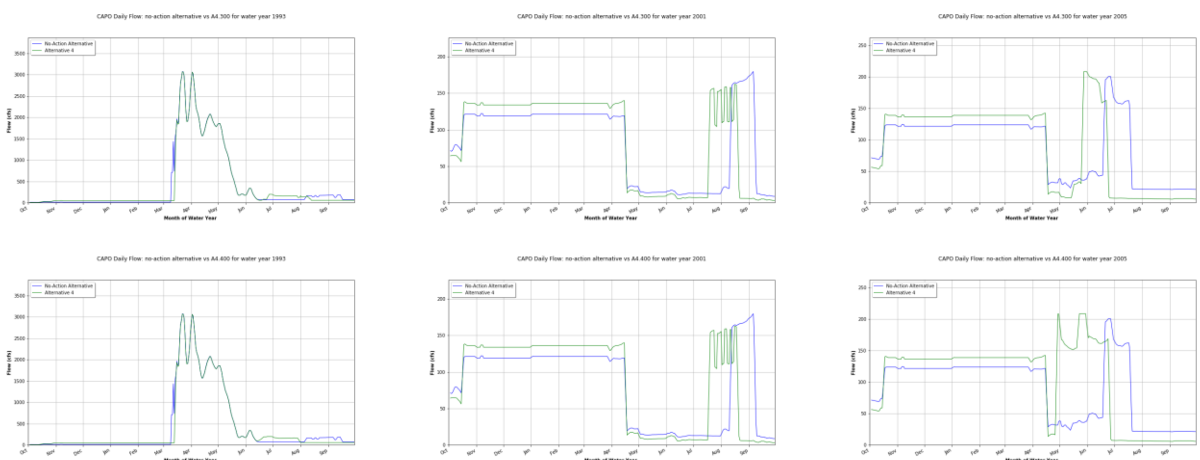
- There were no discernable differences in streamflow at the OPAL node.

The following is an overview of habitat and water temperature modeling of Crooked River streamflows.

Water Temperature Modeling

The annual hydrograph for the 3 years is shown in Figure 41 for the CAPO RiverWare node. Differences between the no-action and Alternative 4 are influencing habitat availability and water temperatures. Shifts in flow timing are most pronounced under the normal water year.

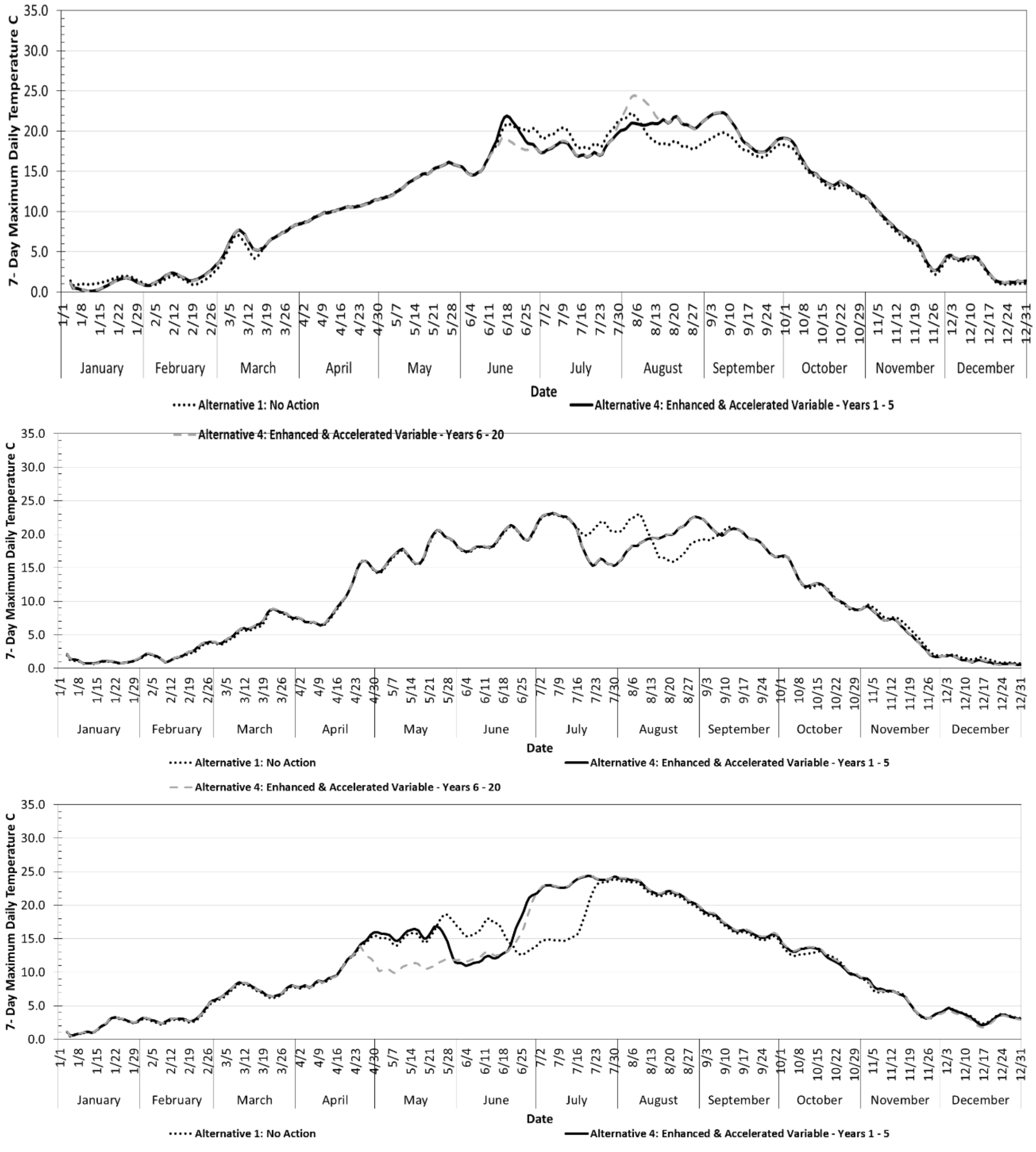
Figure 41. Annual Hydrograph for the Crooked River near Highway 126 (CAPO node) for Wet, Dry, and Normal Water Years under the No-Action Alternative and Alternative 4 (Years 1–5 and 6–20)



The shift in timing of water released from Prineville Reservoir has consequences to water temperatures in the Crooked River (Berger et al. 2019). The 7-day average of the daily maximum water temperature was used to evaluate habitat suitability for species in the Crooked River.

An example of the shift in predicted water temperatures at the CAPO node is shown in Figure 42. Under Alternative 4 water temperatures are cooler in May and early summer and warm rapidly when streamflows are lower in July. Maximum water temperatures were not affected by the shift in timing. The maximum 7-day daily average for the summer is approximately the same between the no-action alternative and Alternative 4.

Figure 42. Annual Water Temperature Predictions for the Crooked River near Highway 126 (CAPO node) for a Wet (top), Dry (middle), and Normal (bottom) Year under the No-Action Alternative and Alternative 4 (Years 1–5 and 6–20)



Modeled RiverWare streamflows at the CAPO node indicate the normal year water temperature scenario is not that unusual across the analysis period. Across the RiverWare analysis period the shift toward higher streamflows in May and June and lower streamflows in July and August under the proposed action occurs in about 30% of the time in years 21 through 30 of the permit term (Figure 43 and Table 29).

Figure 43. May through August Difference in Median Monthly Streamflow for the Crooked River near Highway 126 (CAPO node) for the No-Action Alternative and Alternative 4 (Years 6–20)

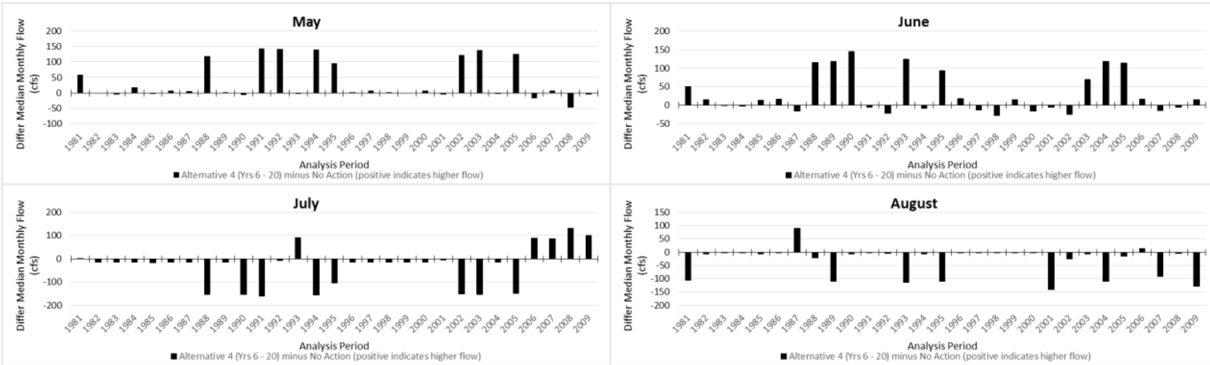


Table 29. Summary Monthly Median Flows for the Crooked River near Highway 126 (CAPO node) under the No-Action Alternative and Alternative 4 (Years 6–20)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
Average diff. median flow (%)	30%	43%	42%	34%	39%	25%	-1%	182%	91%	2%	-33%	-31%
Range diff. in monthly median flow (%)	-10%–296%	-40–440%	-27–440%	-14–342%	-10–342%	-13–342%	-38–64%	-43–1222%	-80–1059%	-96–634%	-87–125%	-100–1%
# Years no diff. in median flow	0	5	7	10	6	13	18	12	2	1	6	9
# Years increase in median flow	26	19	17	13	21	10	6	14	16	5	2	0
Range increase in monthly median flow (%)	7–296%	6–440%	7–440%	12–342%	7–342%	7–342%	5–64%	9–1222%	18–1059%	118–634%	19–125%	NA
Average increase median flow (%)	35%	69%	77%	80%	55%	77%	17%	386%	191%	241%	72%	NA
# Years decrease in median flow	3	5	5	6	2	6	5	3	11	23	21	20
Range decrease in monthly median flow (%)	-10–-7%	-40–-7%	-27–-7%	-14–-7%	-10–-8%	-13–-5%	-38–-10%	-43–-21%	-80–-12%	-96–-21%	-87–-5%	-100–-5%
Average decrease median flow (%)	-9%	-21%	-16%	-11%	-9%	-9%	-26%	-37%	-41%	-53%	-54%	-48%

The predicted 7DADM results were compared to species preferences, sublethal, and lethal temperature thresholds summarized from a literature review (R2 and Pacific Biota 2013). This analysis is discussed in the species effects sections by alternative.

Species Impacts

This section describes effects on fish and mollusks under Alternative 4 compared to the no-action alternative. Where effects are the same as for the proposed action, the description of effects under the proposed action are referenced for brevity.

Changes in streamflows and reservoir elevations and variability would be the same or nearly the same type as described for the proposed action for all of the reaches except for Wickiup Reservoir, the Crooked River, and the Upper and Middle Deschutes River.

Under Alternative 4, as under the proposed action and Alternative 3, summer streamflows would diminish and winter streamflows would increase compared to the no-action alternative in the Upper Deschutes River between Wickiup Reservoir and Bend. Alternative 4 would alter the timing of those changes, such that winter minimum streamflow targets would be achieved earlier in the permit term and would end at a higher level compared to the proposed action and Alternative 3.

Under Alternative 4, seasonal differences in Wickiup Reservoir elevation and volume would be more extreme compared to the proposed action and Alternative 3, which would affect water use on Crooked River. Higher minimum releases on the Crooked River during storage season would result in decreases in irrigation season flows even in the reaches downstream of North Unit pump with instream protection of uncontracted storage releases from Prineville Reservoir.

In addition, because implementation of increased releases from Wickiup Reservoir would occur earlier under Alternative 4 than the proposed action or Alternative 3, related effects would occur earlier as well, as noted in the effects discussion. Due to the shorter (20-year) permit term, the duration of full implementation would be 15 years (between the proposed action and Alternative 3).

BIO-4: Affect Bull Trout Habitat

Changes in streamflows and variability would be the same or nearly the same type as described for the proposed action for all reaches except for the Middle Deschutes River and Crooked River, which are described below.

Middle Deschutes

Increased storage season streamflows and associated beneficial effects on bull trout habitat in the Middle Deschutes River would be the same type as described for the proposed action but of greater magnitude at full implementation. The flow increases in the Middle Deschutes are due to increased releases from Wickiup Reservoir in above-normal and wet years under this alternative (Conservation Measure WR-1).

The increase in winter streamflows for foraging subadult and adult bull trout would have a beneficial effect over the permit term in the portion of the reach accessible to the species.

Crooked River

In the Crooked River minimum winter streamflows would increase to 80 cfs under Conservation Measure CR-1. However, adverse irrigation season effects in reaches of the Crooked River described below would also occur and would be of slightly greater magnitude due to further increased storage season releases from Prineville Reservoir to meet the 80 cfs minimum storage season flows under Conservation Measure CR-1. Furthermore, these effects would increase, though only slightly, in the reach between the North Unit ID pumps and Osborne Canyon, despite instream protection of uncontracted storage releases in this reach (Conservation Measure CR-6). This is due to further increased reliance of North Unit ID pumps on the Crooked River to compensate for further decreased Upper Deschutes water supply under Conservation Measure WR-1.

Water Temperature Results

Streamflows under Alternative 4 would be expected to affect bull trout habitat should their distribution expand up to Bowman Dam upon the completion of a fish passage structure at Opal Springs Diversion Dam.

Tables 30 and 31 summarize temperature thresholds predicted temperatures for bull trout spawning and egg incubation, respectively. Results support conclusions that current water temperatures and temperatures under Alternative 4 do not support bull trout spawning in the Crooked River.

Table 32 summarizes temperature thresholds and predicted temperatures for juvenile and subadult rearing. These temperatures support the potential use of the Crooked River by foraging bull trout during the winter in all reaches and in the summer in the reach downstream of Bowman Dam (CR-10; RM 70-57) and in the reach from Osborne Canyon to Lake Billy Chinook (CR 1.2 and 1.1; RM 8-0) (Torgerson et al. 2007).

Under the no-action alternative water temperatures during the summer portion exceed the preference threshold for over 1 month in the normal water year and longer in the wet and dry water years. However, temperature heterogeneity created by inflow of cooler subsurface flow in this reach may allow bull trout to avoid the warmest temperatures during this period.

At the end of the permit term under Alternative 4 water temperatures in CR-10 for the normal water year are predicted to exceed the stress/disease threshold by an additional 25 days (Table 32). Predicted water temperatures for the dry water year are predicted to exceed the lethal threshold by an additional 16 days. Seventy-seven days above the preference threshold would occur under water management in the normal water year at the end of the permit term compared to 49 days under the no-action alternative.

Table 30. Predicted Number of Days within Water Temperature Thresholds for Spawning Bull Trout under the No-Action Alternative and Alternative 4

		Wet Water Year			Dry Water Year			Normal Water Year		
Reach	Life Stage Thresholds	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)
Bull Trout Spawning Temperature Thresholds										
CR - 10	Preference <=9.0 C	0	0	0	2	0	0	0	0	0
	Suboptimal >9 C & <=11 C	0	0	0	9	4	3	0	0	0
	Avoidance > 11.0 C	92	92	92	81	88	89	92	92	92
CR - 9	Preference <=9.0 C	0	0	0	0	0	0	0	0	0
	Suboptimal >9 C & <=11 C	0	0	0	0	6	6	1	1	0
	Avoidance > 11.0 C	92	92	92	92	86	86	91	91	92
CR - 8	Preference <=9.0 C	0	0	0	3	6	6	1	0	0
	Suboptimal >9 C & <=11 C	0	0	0	7	6	6	7	7	6
	Avoidance > 11.0 C	92	92	92	82	80	80	84	85	86
CR - 7	Preference <=9.0 C	0	0	0	0	0	0	0	0	0
	Suboptimal >9 C & <=11 C	0	0	0	0	3	3	0	1	1
	Avoidance > 11.0 C	92	92	92	92	89	89	92	91	91
CR - 6	Preference <=9.0 C	0	0	0	0	0	0	0	0	0
	Suboptimal >9 C & <=11 C	0	0	0	0	0	0	0	0	0
	Avoidance > 11.0 C	92	92	92	92	92	92	92	92	92
CR - 5	Preference <=9.0 C	0	0	0	0	0	0	0	0	0
	Suboptimal >9 C & <=11 C	0	0	0	0	0	0	0	0	0
	Avoidance > 11.0 C	92	92	92	92	92	92	92	92	92
CR - 4	Preference <=9.0 C	0	0	0	0	0	0	0	0	0
	Suboptimal >9 C & <=11 C	0	0	0	0	0	0	1	1	1
	Avoidance > 11.0 C	92	92	92	92	92	92	91	91	91
CR - 3	Preference <=9.0 C	0	0	0	0	0	0	0	0	0
	Suboptimal >9 C & <=11 C	7	4	4	11	11	11	6	6	6
	Avoidance > 11.0 C	85	88	88	81	81	81	86	86	86
CR - 2	Preference <=9.0 C	0	0	0	3	3	3	0	0	0
	Suboptimal >9 C & <=11 C	5	4	4	11	11	11	6	6	6
	Avoidance > 11.0 C	87	88	88	78	78	78	86	86	86

Table 31. Predicted Number of Days within Water Temperature Thresholds for Egg Incubation Bull Trout under the No-Action Alternative and Alternative 4

		Wet Water Year			Dry Water Year			Normal Water Year		
Reach	Life Stage Thresholds	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)
Bull Trout Egg Incubation Temperature Thresholds										
CR - 10	Preference <=6.0 C	104	106	106	110	106	106	82	88	87
	Stress /Disease >6 C	136	134	134	130	134	134	158	152	153
CR - 9	Preference <=6.0 C	99	107	107	96	112	112	97	97	97
	Stress /Disease >6 C	141	133	133	144	128	128	143	143	143
CR - 8	Preference <=6.0 C	109	109	109	107	110	110	99	97	97
	Stress /Disease >6 C	131	131	131	133	130	130	141	143	143
CR - 7	Preference <=6.0 C	108	108	108	88	110	110	108	105	105
	Stress /Disease >6 C	132	132	132	152	130	130	132	135	135
CR - 6	Preference <=6.0 C	109	107	107	87	109	109	105	106	106
	Stress /Disease >6 C	131	133	133	153	131	131	135	134	134
CR - 5	Preference <=6.0 C	102	98	98	68	86	86	84	86	86
	Stress /Disease >6 C	138	142	142	172	154	154	156	154	154
CR - 4	Preference <=6.0 C	107	103	103	94	95	95	94	94	94
	Stress /Disease >6 C	133	137	137	146	145	145	146	146	146
CR - 3	Preference <=6.0 C	118	112	112	108	108	108	101	100	99
	Stress /Disease >6 C	122	128	128	132	132	132	139	140	141
CR - 2	Preference <=6.0 C	118	112	111	108	108	108	99	100	101
	Stress /Disease >6 C	122	128	129	132	132	132	141	140	139

Table 32. Predicted Number of Days within Water Temperature Thresholds for Juvenile and Subadult Bull Trout under the No-Action Alternative and Alternative 4

		Wet Water Year			Dry Water Year			Normal Water Year		
Reach	Life Stage Thresholds	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)
Bull Trout Juvenile and Subadult Rearing Temperature Thresholds										
CR - 10	Preference <=15.0 C	223	221	221	259	270	270	313	290	285
	Avoidance >15 C and <= 16 C	13	16	16	43	16	16	13	18	16
	Stress/Disease >16 C & <=23 C	126	125	125	60	60	60	36	54	61
	Lethal >23.0 C	0	0	0	0	16	16	0	0	0
CR - 9	Preference <=15.0 C	220	219	219	181	197	197	266	224	247
	Avoidance >15 C and <= 16 C	17	18	18	24	13	13	5	11	3
	Stress/Disease >16 C & <=23 C	125	125	125	111	91	92	73	67	51
	Lethal >23.0 C	0	0	0	46	61	60	18	60	61
CR - 8	Preference <=15.0 C	225	226	226	199	201	201	272	238	263
	Avoidance >15 C and <= 16 C	16	16	16	17	14	14	25	16	4
	Stress/Disease >16 C & <=23 C	121	120	120	129	126	126	47	63	50
	Lethal >23.0 C	0	0	0	17	21	21	18	45	45
CR - 7	Preference <=15.0 C	224	224	224	231	236	236	236	245	246
	Avoidance >15 C and <= 16 C	16	13	14	21	23	22	33	9	10
	Stress/Disease >16 C & <=23 C	122	125	115	110	103	104	93	108	106
	Lethal >23.0 C	0	0	9	0	0	0	0	0	0
CR - 6	Preference <=15.0 C	213	213	213	215	221	221	214	242	242
	Avoidance >15 C and <= 16 C	13	12	12	23	17	17	33	15	15
	Stress/Disease >16 C & <=23 C	132	137	124	124	124	124	113	92	91
	Lethal >23.0 C	4	0	13	0	0	0	2	13	14
CR - 5	Preference <=15.0 C	207	204	204	175	181	181	180	179	204
	Avoidance >15 C and <= 16 C	12	10	10	7	3	3	5	18	24
	Stress/Disease >16 C & <=23 C	114	112	104	132	142	142	127	93	64
	Lethal >23.0 C	29	36	44	48	36	36	50	72	70
CR - 4	Preference <=15.0 C	208	203	204	181	183	183	176	177	179
	Avoidance >15 C and <= 16 C	4	4	3	7	6	6	4	4	11
	Stress/Disease >16 C & <=23 C	102	91	89	80	71	70	100	102	98
	Lethal >23.0 C	48	64	66	94	102	103	82	79	74
CR - 3	Preference <=15.0 C	217	212	212	200	200	201	201	206	208
	Avoidance >15 C and <= 16 C	6	9	9	9	7	6	11	7	13
	Stress/Disease >16 C & <=23 C	97	95	91	95	102	102	90	82	76
	Lethal >23.0 C	42	46	50	58	53	53	60	67	65
CR - 2	Preference <=15.0 C	223	221	221	198	198	198	207	207	223
	Avoidance >15 C and <= 16 C	7	7	7	9	9	9	9	13	19
	Stress/Disease >16 C & <=23 C	113	123	125	131	138	138	106	82	62
	Lethal >23.0 C	19	11	9	24	17	17	40	60	58

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Water management and associated water temperatures in the wet water year shows no effect on bull trout juvenile and subadult habitat over the permit term. However, water management in dry and normal water years indicate a potential for adverse effect on bull trout that may attempt to rear through the summer, such as in the reach downstream of Bowman Dam (CR - 10). The number of "preference" days declines from 313 under the no action to 285 under Alternative 4 by the end of the permit term and the number of "stress/disease" days increases from 36 days to 61 days. In addition, bull trout that do not emigrate from the approximately 50 miles of the Crooked River encompassed by reaches CR-9 to CR-2 may experience more potentially lethal temperatures of 23 C.

Water management in the normal water year represents about 40% of the years over the analysis period. There would be an adverse effect when considering the normal year and frequency of occurrence.

BIO-5: Affect Bull Trout Migratory Life Stages

Changes in streamflows and reservoir elevations and variability would be the same or nearly the same type as described for the proposed action for all reaches except for the Middle Deschutes River and Crooked River, which are described below.

Middle Deschutes

Under Alternative 4 streamflows in the Deschutes River at the CULO gauge are predicted to increase slightly during the winter (mid-October to the end of March) in years 1 through 6 and moderately in years 6 through 20, but of greater magnitude at full implementation. The flow increases in the Middle Deschutes are due to increased releases from Wickiup Reservoir in above-normal and wet years under this alternative (Conservation Measure WR-1).

The increase in winter streamflows over the permit term would have a beneficial effect on the migratory life stage of bull trout in the portion of the reach accessible to this species.

Crooked River

RiverWare modeled streamflows and predicted water temperatures in the Crooked River do not suggest an effect on migratory life stages. Migration windows for entering and moving upstream in the fall and for subadults to leave the Crooked River in the spring before temperatures exceed preference thresholds would not be affected by the alternative. There would be no effect on migratory life stages of this species.

BIO-6: Affect Steelhead Trout Habitat

Changes in streamflows and reservoir elevations and variability would be the same or nearly the same as described for the proposed action for all reaches except for the Middle Deschutes River and Crooked River, which are described below.

Middle Deschutes

Under Alternative 4 streamflows in the Deschutes River at the CULO gauge are predicted to increase slightly during the winter (mid-October to the end of March) in years 1 through 5 and moderately in years 6 through 20 of the permit term, but of greater magnitude at full implementation. The flow increases in the Middle Deschutes are due to increased releases from Wickiup Reservoir in above-normal and wet years under this alternative (Conservation Measure WR-1). These changes in streamflow would benefit habitat for holding and spawning adult steelhead and rearing juvenile steelhead during the winter.

Streamflows decline beginning approximately mid-April with the start of irrigation diversions. During this period steelhead eggs are still in the gravel. However, predicted streamflows during this period and in the fall with the end of irrigation under Alternative 4 are no different than under the no-action alternative. There would be no effect relative to the no-action alternative during these periods.

Because of the small to moderate increase in winter streamflows over the permit term, there would be a beneficial effect on habitat for steelhead trout in the portion of this reach accessible to the species. Adult steelhead holding in the Deschutes River and rearing juvenile steelhead would benefit from the moderate increase in streamflow in the winter.

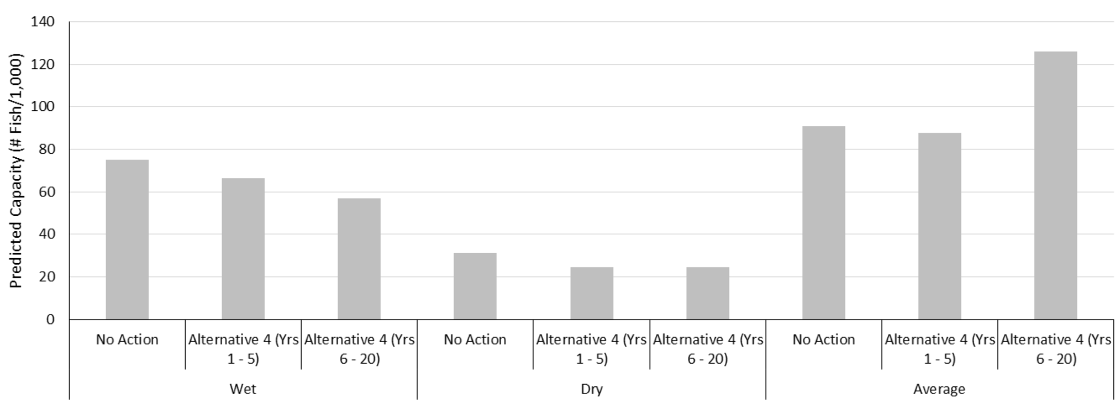
Crooked River

In the Crooked River minimum winter streamflows would increase to 80 cfs under Conservation Measure CR-1. However, adverse irrigation season effects in reaches of the Crooked River described below would also occur and would be of slightly greater magnitude due to further increased storage season releases from Prineville Reservoir to meet the 80 cfs minimum storage season flows under Conservation Measure CR-1. Furthermore, these effects would increase, though only slightly, in the reach between the North Unit ID pumps and Osborne Canyon, despite instream protection of uncontracted storage releases in this reach (Conservation Measure CR-6). This is due to further increased reliance of North Unit ID pumps on the Crooked River to compensate for further decreased Upper Deschutes water supply under Conservation Measure WR-1.

Habitat Model Results

Results of modeling for summer juvenile rearing are inconclusive. Result show a decline or an improvement in capacity under Alternative 4 depending on water year type (Figure 44). Water temperature effects are largely influencing these results.

Figure 44. Juvenile Steelhead Summer Capacity Estimates for the Mainstem Crooked River under the No-Action Alternative and Alternative 4

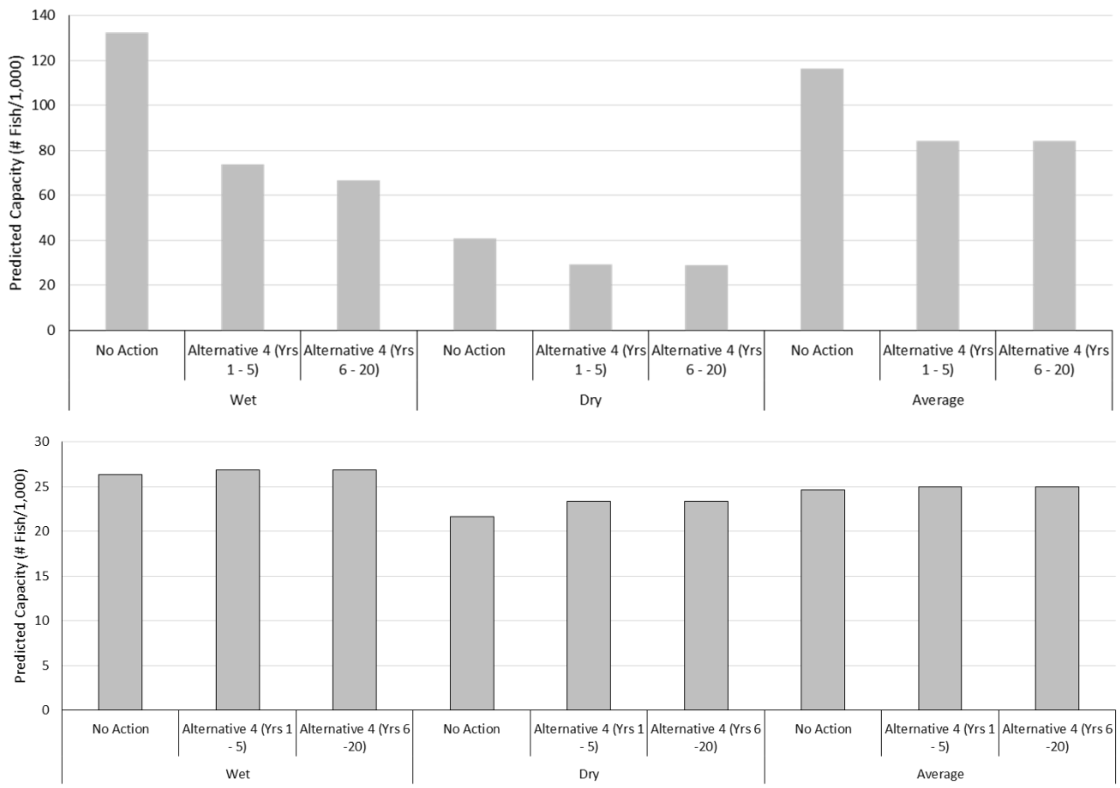


Results of modeling winter juvenile rearing capacity are inconclusive. The decline in capacity under Alternative 4 shown in Figure 45 (top figure) is from effects of summer water temperatures affecting abundance of steelhead in the winter. However, these results may not reflect winter conditions for juvenile rearing with increased minimum streamflows. The results presented in

Figure 45 represent effects of summer maximum water temperatures and winter streamflows on winter capacity (Mount Hood Environmental 2019). It is unclear if higher winter minimum streamflows (Conservation Measure CR-1) would affect summer water temperatures in the Crooked River. Therefore, Figure 45 also presents model results assuming a fixed summer maximum temperature (22 C) under no action and Alternative 4 across the entire permit term. In this analysis steelhead winter capacity increases slightly under Alternative 4 in the dry year type with an increase in winter streamflows consistent with Conservation Measure CR-1

It is likely higher minimum winter streamflows (Conservation Measure CR-1) and summer water temperatures are independent and higher minimum winter streamflows under Alternative 4 would improve winter habitat conditions for juvenile steelhead.

Figure 45. Juvenile Steelhead Winter Capacity Estimates for the Mainstem Crooked River under the No-Action Alternative and Alternative 4 (top variable summer water temperatures and bottom fixed summer water temperatures)



Water Temperature Results

Tables 33 and 34 summarize temperature thresholds and predicted temperatures for steelhead trout egg incubation and juvenile rearing.

Water temperatures during egg incubation would not be affected by water management under Alternative 4 (Table 33). The number of days in the preferred category tended to not change or increased over the permit term for the year types.

Analysis of temperature thresholds for juvenile steelhead rearing suggest an effect of water management on temperatures (Table 34). The number of days in the avoidance category in the wet water year in the reach immediately downstream of Bowman Dam increased from 33 days under the no-action alternative to 63 days under Alternative 4 by the end of the permit term. In addition, there were more warm days in the normal water year toward the end of the permit term. The number of suboptimal days increased from 77 days to 105 days in the reach immediately downstream of Bowman Dam (CR-10). The number of days in the stress/disease category increased in reaches CR-9 and CR-8.

Summary

Habitat model results are inconclusive (Figures 44 and 45). Results suggest an adverse effect on winter capacity (Figure 45 top), but that may not reflect winter streamflows. There would be an adverse effect on steelhead trout habitat because of differences in water temperature under Alternative 4 in the Crooked River in some year types. Adverse irrigation season effects in reaches of the Crooked River described for the proposed action at full implementation in dry and normal water years would also occur and would be of slightly greater magnitude due to further increased storage season releases from Prineville Reservoir to meet the 80 cfs minimum storage season flows under Conservation Measure CR-1. These effects would increase, though only slightly, in the reach between the North Unit ID pumps and Osborne Canyon, despite instream protection of uncontracted storage releases in this reach. This is due to further increased reliance of North Unit ID pumps on the Crooked River to compensate for further decreased Upper Deschutes water supply under Conservation Measure WR-1.

Table 33. Predicted Number of Days within Water Temperature Thresholds for Egg Incubation Steelhead Trout under the No-Action Alternative and Alternative 4

		Wet Water Year			Dry Water Year			Normal Water Year		
Reach	Life Stage Thresholds	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)
Steelhead Trout Egg Incubation Temperature Thresholds										
CR - 10	Preference <=11.1 C	62	62	62	53	53	52	63	69	95
	SubOptimal >11.1 C & <=15 C	32	32	32	64	62	63	59	49	24
	Stress/Disease >15 C	28	28	28	5	7	7	0	4	3
CR - 9	Preference <=11.1 C	51	57	57	49	49	49	49	58	82
	SubOptimal >11.1 C & <=15 C	36	29	29	7	4	4	70	34	34
	Stress/Disease >15 C	35	36	36	66	69	69	3	30	6
CR - 8	Preference <=11.1 C	57	57	57	50	49	49	51	55	72
	SubOptimal >11.1 C & <=15 C	30	30	30	7	7	7	57	36	44
	Stress/Disease >15 C	35	35	35	65	66	66	14	31	6
CR - 7	Preference <=11.1 C	56	57	57	53	53	53	54	55	70
	SubOptimal >11.1 C & <=15 C	35	34	34	48	45	45	50	58	44
	Stress/Disease >15 C	31	31	31	21	24	24	18	9	8
CR - 6	Preference <=11.1 C	54	54	54	54	54	53	55	55	55
	SubOptimal >11.1 C & <=15 C	26	26	26	27	27	28	29	56	56
	Stress/Disease >15 C	42	42	42	41	41	41	38	11	11
CR - 5	Preference <=11.1 C	44	44	44	46	48	48	43	46	46
	SubOptimal >11.1 C & <=15 C	28	28	28	6	4	4	12	8	34
	Stress/Disease >15 C	50	50	50	70	70	70	67	68	42
CR - 4	Preference <=11.1 C	43	45	45	38	39	39	28	27	27
	SubOptimal >11.1 C & <=15 C	26	24	24	13	12	12	21	22	24
	Stress/Disease >15 C	53	53	53	71	71	71	73	73	71
CR - 3	Preference <=11.1 C	47	47	47	50	50	50	48	48	48
	SubOptimal >11.1 C & <=15 C	24	23	23	3	3	3	6	6	8
	Stress/Disease >15 C	51	52	52	69	69	69	68	68	66
CR - 2	Preference <=11.1 C	45	45	45	47	47	47	39	38	38
	SubOptimal >11.1 C & <=15 C	25	25	25	6	6	6	15	16	32
	Stress/Disease >15 C	52	52	52	69	69	69	68	68	52

Table 34. Predicted Number of Days within Water Temperature Thresholds for Juvenile Steelhead Trout under the No-Action Alternative and Alternative 4

		Wet Water Year			Dry Water Year			Normal Water Year		
Reach	Life Stage Thresholds	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)
Steelhead Trout Juvenile Rearing Temperature Thresholds										
CR - 10	Preference <=14.0 C	203	203	203	239	238	238	285	260	257
	SubOptimal >14 C & <=19 C	126	99	96	87	74	74	77	102	105
	Avoidance >19 C & <22 C	33	60	63	24	25	25	0	0	0
	Stress/Disease >22 C	0	0	0	12	25	25	0	0	0
CR - 9	Preference <=14.0 C	199	201	201	170	186	186	249	211	239
	SubOptimal >14 C & <=19 C	149	104	105	92	77	76	63	54	25
	Avoidance >19 C & <22 C	14	57	56	38	31	32	16	29	30
	Stress/Disease >22 C	0	0	0	62	68	68	34	68	68
CR - 8	Preference <=14.0 C	207	209	209	194	194	194	249	224	254
	SubOptimal >14 C & <=19 C	103	96	104	75	80	79	66	64	36
	Avoidance >19 C & <22 C	52	57	42	63	59	60	20	16	15
	Stress/Disease >22 C	0	0	7	30	29	29	27	58	57
CR - 7	Preference <=14.0 C	206	204	204	212	217	216	218	238	241
	SubOptimal >14 C & <=19 C	92	86	91	95	87	87	95	54	50
	Avoidance >19 C & <22 C	62	63	45	55	58	59	44	54	44
	Stress/Disease >22 C	2	9	22	0	0	0	5	16	27
CR - 6	Preference <=14.0 C	203	203	203	205	208	207	203	213	227
	SubOptimal >14 C & <=19 C	72	71	72	95	100	100	107	76	63
	Avoidance >19 C & <22 C	77	60	57	62	54	55	30	42	38
	Stress/Disease >22 C	10	28	30	0	0	0	22	31	34
CR - 5	Preference <=14.0 C	199	201	201	166	177	178	176	174	189
	SubOptimal >14 C & <=19 C	68	55	53	59	49	48	68	84	73
	Avoidance >19 C & <22 C	51	51	61	63	63	62	66	30	27
	Stress/Disease >22 C	44	55	47	74	73	74	52	74	73
CR - 4	Preference <=14.0 C	202	201	201	179	179	179	171	173	172
	SubOptimal >14 C & <=19 C	45	36	36	19	19	19	40	48	75
	Avoidance >19 C & <22 C	50	49	48	48	39	39	51	58	37
	Stress/Disease >22 C	65	76	77	116	125	125	100	83	78
CR - 3	Preference <=14.0 C	208	204	204	197	197	197	191	191	191
	SubOptimal >14 C & <=19 C	60	62	61	35	33	33	58	69	76
	Avoidance >19 C & <22 C	43	34	34	55	52	52	45	32	27
	Stress/Disease >22 C	51	62	63	75	80	80	68	70	68
CR - 2	Preference <=14.0 C	215	213	214	196	196	196	195	195	199
	SubOptimal >14 C & <=19 C	61	61	59	61	54	53	66	84	85
	Avoidance >19 C & <22 C	51	67	69	63	72	72	54	17	14
	Stress/Disease >22 C	35	21	20	42	40	41	47	66	64

BIO-7: Affect Steelhead Trout Migratory Life Stages

Changes in streamflows and reservoir elevations and variability would be the same or nearly the same type as described for the proposed action for all reaches except for the Middle Deschutes River and Crooked River, which are described below.

Middle Deschutes

Under Alternative 4 streamflows in the Deschutes River at the CULO gauge are predicted to increase slightly during the winter (mid-October to the end of March) in years 1 through 5 and moderately in years 6 through 20 of the permit term, but of greater magnitude at full implementation. The flow increases in the Middle Deschutes are due to increased releases from Wickiup Reservoir in above-normal and wet years under this alternative (Conservation Measure WR-1).

Streamflows decline beginning approximately mid-April with the start of irrigation diversions when smolts would be migrating to sea. However, predicted streamflows during this period under Alternative 4 are no different than under the no-action alternative. While there would be a small to moderate increase in winter streamflows over the permit term, they would be insufficient to suggest a beneficial effect. Thus, there would be no effect relative to the no-action alternative during this period.

Crooked River

In the Crooked River minimum winter streamflows would increase to 80 cfs under Conservation Measure CR-1.

The analysis considered the effects of water management on adult migration and temperature thresholds (Table 35), smolt migration and temperature thresholds (Table 36), and any evidence that streamflows may impair adult or juvenile migration.

There was no evidence that Alternative 4 streamflows were affecting water temperatures across the permit term compared to the no-action alternative for all three water year types (Tables 35 and 36). In general it appears there were more days that water temperatures were in the preferred category under Alternative 4 possibly suggesting a beneficial effect.

There would be no effect on migratory life stages of steelhead trout in this reach.

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Table 35. Predicted Number of Days within Water Temperature Thresholds for Adult Migrant Steelhead Trout under the No-Action Alternative and Alternative 4

		Wet Water Year			Dry Water Year			Normal Water Year		
Reach	Life Stage Thresholds	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)
Steelhead Trout Adult Migration Temperature Thresholds										
CR - 10	Preference <=12.8 C	147	147	147	162	159	159	155	156	155
	SubOptimal >12.8 C & <=14 C	9	8	8	5	4	4	23	23	22
	Avoidance >14.4 C & <21 C	23	24	24	12	16	16	1	0	2
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0
CR - 9	Preference <=12.8 C	147	151	151	141	160	160	155	155	155
	SubOptimal >12.8 C & <=14 C	13	11	11	12	2	2	5	7	7
	Avoidance >14.4 C & <21 C	19	17	17	21	12	12	19	17	17
	Delay >21 C & <=23.9 C	0	0	0	2	2	2	0	0	0
CR - 8	Preference <=12.8 C	152	152	152	168	170	170	164	162	162
	SubOptimal >12.8 C & <=14 C	14	17	17	5	3	3	14	15	15
	Avoidance >14.4 C & <21 C	13	10	10	6	6	6	1	2	2
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0
CR - 7	Preference <=12.8 C	151	151	151	144	159	159	155	156	155
	SubOptimal >12.8 C & <=14 C	12	11	11	14	5	5	5	6	7
	Avoidance >14.4 C & <21 C	16	17	17	21	15	15	19	17	17
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0
CR - 6	Preference <=12.8 C	150	151	151	148	159	159	154	154	154
	SubOptimal >12.8 C & <=14 C	12	11	11	11	4	4	5	6	5
	Avoidance >14.4 C & <21 C	17	17	17	20	16	16	20	19	20
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0
CR - 5	Preference <=12.8 C	151	153	153	138	148	150	150	150	149
	SubOptimal >12.8 C & <=14 C	14	9	9	12	11	9	5	5	6
	Avoidance >14.4 C & <21 C	14	17	17	29	20	20	24	24	24
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0
CR - 4	Preference <=12.8 C	160	156	156	152	156	156	154	154	154
	SubOptimal >12.8 C & <=14 C	7	8	9	8	5	4	2	3	3
	Avoidance >14.4 C & <21 C	12	15	14	19	18	19	23	22	22
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0
CR - 3	Preference <=12.8 C	166	164	164	173	169	169	160	160	161
	SubOptimal >12.8 C & <=14 C	5	4	5	2	6	6	12	13	12
	Avoidance >14.4 C & <21 C	8	11	10	4	4	4	7	6	6
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0
CR - 2	Preference <=12.8 C	166	165	165	173	173	173	162	162	162
	SubOptimal >12.8 C & <=14 C	6	5	5	2	2	2	17	17	17
	Avoidance >14.4 C & <21 C	7	9	9	4	4	4	0	0	0
	Delay >21 C & <=23.9 C	0	0	0	0	0	0	0	0	0

Table 36. Predicted Number of Days within Water Temperature Thresholds for Steelhead Trout Smolts under the No-Action Alternative and Alternative 4

		Wet Water Year			Dry Water Year			Normal Water Year		
Reach	Life Stage Thresholds	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)
Steelhead Trout Smolt Migration Temperature Thresholds										
CR - 10	Preference <=13.6 C	46	45	46	67	66	63	89	82	86
	Delay > 13.6 C	45	46	45	24	25	28	2	9	5
CR - 9	Preference <=13.6 C	42	42	42	21	21	21	67	47	76
	Delay > 13.6 C	49	49	49	70	70	70	24	44	15
CR - 8	Preference <=13.6 C	41	41	41	22	21	21	51	48	79
	Delay > 13.6 C	50	50	50	69	70	70	40	43	12
CR - 7	Preference <=13.6 C	42	42	42	51	48	48	55	74	79
	Delay > 13.6 C	49	49	49	40	43	43	36	17	12
CR - 6	Preference <=13.6 C	41	41	41	39	39	38	40	43	56
	Delay > 13.6 C	50	50	50	52	52	53	51	48	35
CR - 5	Preference <=13.6 C	38	37	37	20	20	20	22	19	29
	Delay > 13.6 C	53	54	54	71	71	71	69	72	62
CR - 4	Preference <=13.6 C	36	36	36	18	18	18	16	16	16
	Delay > 13.6 C	55	55	55	73	73	73	75	75	75
CR - 3	Preference <=13.6 C	37	37	37	22	21	21	22	21	21
	Delay > 13.6 C	54	54	54	69	70	70	69	70	70
CR - 2	Preference <=13.6 C	37	37	37	21	21	21	21	21	22
	Delay > 13.6 C	54	54	54	70	70	70	70	70	69

BIO-8: Affect Spring Chinook Salmon Habitat

Changes in streamflows and reservoir elevations and variability would be the same or nearly the same type as described for the proposed action for all reaches except for the Middle Deschutes River and Crooked River, which are described below.

Middle Deschutes

Under Alternative 4 streamflows in the Deschutes River at the CULO gauge are predicted to increase slightly during the winter (mid-October to the end of March) in years 1 through 5 and moderately in years 6 through 20, but of greater magnitude at full implementation. The flow increases in the Middle Deschutes are due to increased releases from Wickiup Reservoir in above-normal and wet years under this alternative (Conservation Measure WR-1).

Streamflows decline beginning approximately mid-April with the start of irrigation diversions. During this period Chinook eggs may still be in the gravel, but likely spring Chinook fry that recently emerged from the gravel are free swimming and are present along shallow bank or pools in the Middle Deschutes River. However, predicted streamflows during this period and in the fall with the end of irrigation under the Alternative 4 are no different than the no-action alternative. Thus, there would be no effect relative to the no-action alternative during this period.

There would be no effect on spring Chinook in the accessible portion of the Deschutes River. The relatively small to moderate increases in winter streamflows over the permit term likely are not enough to suggest a beneficial effect for this species.

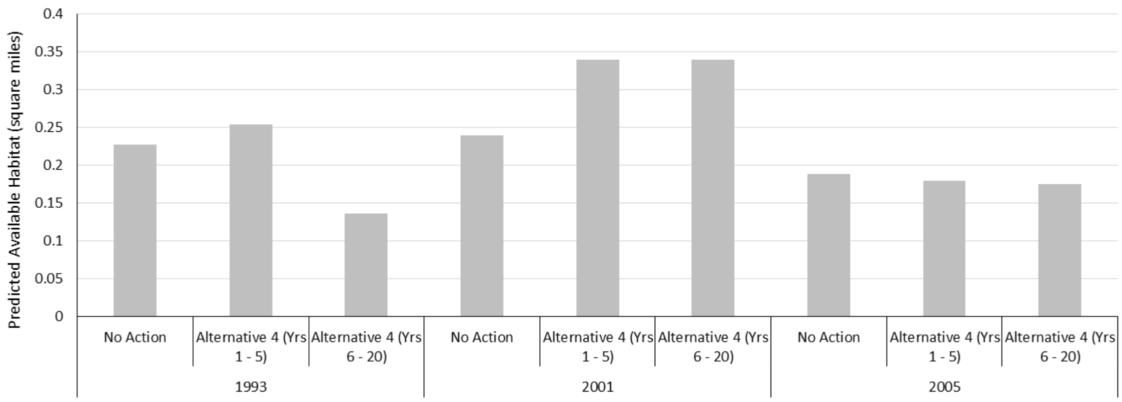
Crooked River

In the Crooked River minimum winter streamflows would increase to 80 cfs under Conservation Measure CR-1. However, adverse irrigation season effects in reaches of the Crooked River described below would also occur and would be of slightly greater magnitude due to further increased storage season releases from Prineville Reservoir to meet the 80 cfs minimum storage season flows under Conservation Measure CR-1. Furthermore, these effects would increase, though only slightly, in the reach between the North Unit ID pumps and Osborne Canyon, despite instream protection of uncontracted storage releases in this reach (Conservation Measure CR-6). This is due to further increased reliance of North Unit ID pumps on the Crooked River to compensate for further decreased Upper Deschutes water supply under Conservation Measure WR-1.

Habitat Model Results

Results of modeling available summer habitat for Chinook juvenile rearing are inconclusive. Effects of water management on available habitat and water temperatures are not suggesting any particular trend between the no-action alternative and Alternative 4 (Figure 46).

Figure 46. Estimate of Juvenile Chinook Summer Habitat Availability for the Mainstem Crooked River under the No-Action Alternative and Alternative 3



Water Temperature Results

The results of spring Chinook juvenile rearing temperature thresholds are listed in Table 37.

The number of days in the stress/disease category in the wet water year in the reach immediately downstream of Bowman Dam increased from 28 days under the no-action alternative to 61 days under Alternative 4 by the end of the permit term. There were more warm days in the normal water year toward the end of the permit term. The number of stress/disease days increased from 41 days to 67 days in the reach immediately downstream of Bowman Dam (CR-10). The number of days in the optimal category decreased from 47 days to 24 days in reach CR - 9, downstream of the canyon reach and from 53 days to 25 days in reach CR–8, upstream of Prineville. In CR-9 the number of days in the lethal category increased from 34 days to 68 days and in CR-8 the number of days in the lethal category increased from 27 days to 57 days.

Effects of water management on water temperature in lower reaches (CR-7 through CR-2) tended to be more variable as temperatures were warmer under the no-action alternative and effects of water management from Bowman Dam have less of an influence on water temperatures (Berger et al. 2019). Overall there was a tendency for more days in the stress/disease and lethal categories under the proposed action.

Water temperatures thresholds were not explicitly evaluated for adult spring Chinook holding through the summer in the Crooked River. However, similar to the proposed action, the additional number of warm days toward the end of the permit term indicate a worsening of habitat conditions for spring Chinook adults holding through the summer.

Summary

Habitat model results are inconclusive, results suggest no trend toward better or worsening amount of available habitat. However, these results do not reflect variation in summer streamflows and cumulative effects of summer water temperatures. Similar to the proposed action, there would be an adverse effect toward the end of the permit term based on the wet, dry, and normal year type water temperature simulations. The adverse effect would occur earlier in the permit term under Alternative 4.

Table 37. Predicted Number of Days within Water Temperature Water Temperature Thresholds for Juvenile Spring Chinook (June–September) under the No-Action Alternative and Alternative 4

		Wet Water Year			Dry Water Year			Normal Water Year		
Reach	Life Stage Thresholds	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)
Chinook Juvenile Rearing Temperature Thresholds										
CR - 10	Preference <=15.6 C	9	9	9	46	48	48	81	61	55
	Sub-optimal (>15.6 & <=19.1)	85	54	52	43	28	28	41	61	67
	Stress/Disease >19.1 & <=22 C	28	59	61	21	21	21	0	0	0
	Lethal >22.0 C	0	0	0	12	25	25	0	0	0
CR - 9	Preference <=15.6 C	9	9	9	9	14	14	47	22	24
	Sub-optimal (>15.6 & <=19.1)	103	62	61	28	28	27	26	4	3
	Stress/Disease >19.1 & <=22 C	10	51	52	28	16	17	15	28	27
	Lethal >22.0 C	0	0	0	57	64	64	34	68	68
CR - 8	Preference <=15.6 C	9	9	9	4	8	8	53	22	25
	Sub-optimal (>15.6 & <=19.1)	63	57	67	37	42	42	23	27	25
	Stress/Disease >19.1 & <=22 C	50	56	39	51	43	43	19	15	15
	Lethal >22.0 C	0	0	7	30	29	29	27	58	57
CR - 7	Preference <=15.6 C	10	9	9	15	15	15	31	22	25
	Sub-optimal (>15.6 & <=19.1)	55	49	55	58	51	51	42	30	27
	Stress/Disease >19.1 & <=22 C	55	55	36	49	56	56	44	54	43
	Lethal >22.0 C	2	9	22	0	0	0	5	16	27
CR - 6	Preference <=15.6 C	7	6	6	7	5	5	4	20	20
	Sub-optimal (>15.6 & <=19.1)	30	33	35	57	67	67	66	30	31
	Stress/Disease >19.1 & <=22 C	75	55	51	58	50	50	30	41	37
	Lethal >22.0 C	10	28	30	0	0	0	22	31	34
CR - 5	Preference <=15.6 C	0	0	0	0	0	0	0	9	2
	Sub-optimal (>15.6 & <=19.1)	30	22	22	6	7	7	16	14	21
	Stress/Disease >19.1 & <=22 C	48	45	53	50	50	49	54	25	26
	Lethal >22.0 C	44	55	47	66	65	66	52	74	73
CR - 4	Preference <=15.6 C	0	0	0	0	0	0	0	0	0
	Sub-optimal (>15.6 & <=19.1)	25	18	18	0	0	0	5	17	12
	Stress/Disease >19.1 & <=22 C	32	28	27	25	16	16	26	27	32
	Lethal >22.0 C	65	76	77	97	106	106	91	78	78
CR - 3	Preference <=15.6 C	7	5	5	4	4	4	5	7	8
	Sub-optimal (>15.6 & <=19.1)	22	24	24	11	12	12	18	29	24
	Stress/Disease >19.1 & <=22 C	42	31	30	42	37	37	34	16	22
	Lethal >22.0 C	51	62	63	65	69	69	65	70	68
CR - 2	Preference <=15.6 C	13	12	12	3	4	4	9	10	8
	Sub-optimal (>15.6 & <=19.1)	34	33	32	32	26	26	21	34	36
	Stress/Disease >19.1 & <=22 C	40	56	58	50	57	56	46	12	14
	Lethal >22.0 C	35	21	20	37	35	36	46	66	64

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BIO-9: Affect Spring Chinook Salmon Migratory Life Stages

Changes in streamflows and reservoir elevations and variability would be the same or nearly the same type as described for the proposed action for all reaches except for the Middle Deschutes River and Crooked River, which are described below.

Middle Deschutes

There would be no effect on migrating spring Chinook in the accessible portion of the Deschutes River. The relatively small to moderate increase in winter streamflows over the permit term were likely not enough to suggest a beneficial effect for this species.

Crooked River

Water Temperature

The results of adult migration temperature thresholds are listed in Table 38. Smolt migration thresholds are listed in Table 39.

Similar to the proposed action, Alternative 4 would have no effect on migrating spring Chinook salmon adults attempting to move upstream in the spring or downstream migrating smolts because of water temperature effects on these life stages would be minor. However, the effect of water temperature on adult spring Chinook salmon migration habitat in July and August would be potentially adverse because the potential for migration effects exist but are not conclusive based on the available data.

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Table 38. Predicted Number of Days within Water Temperature Water Temperature Thresholds for Migrating Adult Spring Chinook (March–June) under the No-Action Alternative and Alternative 4

		Wet Water Year			Dry Water Year			Normal Water Year		
Reach	Life Stage Thresholds	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)
Chinook Adult Spring Migration Temperature Thresholds										
CR - 10	Preference <= 19.0 C	122	122	122	122	122	122	122	122	122
	Avoidance >19.4 C & <= 21 C	0	0	0	0	0	0	0	0	0
	Delay >21.0 C & <= 25.0 C	0	0	0	0	0	0	0	0	0
	Lethal >25.0 C	0	0	0	0	0	0	0	0	0
CR - 9	Preference <= 19.0 C	121	117	122	99	91	91	122	117	119
	Avoidance >19.4 C & <= 21 C	1	5	0	13	19	19	0	1	1
	Delay >21.0 C & <= 25.0 C	0	0	0	10	12	12	0	4	2
	Lethal >25.0 C	0	0	0	0	0	0	0	0	0
CR - 8	Preference <= 19.0 C	106	112	120	96	93	93	122	117	119
	Avoidance >19.4 C & <= 21 C	14	8	2	17	18	19	0	2	1
	Delay >21.0 C & <= 25.0 C	2	2	0	9	11	10	0	3	2
	Lethal >25.0 C	0	0	0	0	0	0	0	0	0
CR - 7	Preference <= 19.0 C	108	114	122	122	122	122	122	122	122
	Avoidance >19.4 C & <= 21 C	14	8	0	0	0	0	0	0	0
	Delay >21.0 C & <= 25.0 C	0	0	0	0	0	0	0	0	0
	Lethal >25.0 C	0	0	0	0	0	0	0	0	0
CR - 6	Preference <= 19.0 C	107	106	108	122	122	122	122	118	119
	Avoidance >19.4 C & <= 21 C	5	12	14	0	0	0	0	4	3
	Delay >21.0 C & <= 25.0 C	10	4	0	0	0	0	0	0	0
	Lethal >25.0 C	0	0	0	0	0	0	0	0	0
CR - 5	Preference <= 19.0 C	104	104	104	75	75	75	96	110	114
	Avoidance >19.4 C & <= 21 C	2	4	15	20	19	19	24	6	3
	Delay >21.0 C & <= 25.0 C	16	14	3	27	28	28	2	4	4
	Lethal >25.0 C	0	0	0	0	0	0	0	2	1
CR - 4	Preference <= 19.0 C	84	84	84	53	53	53	59	70	97
	Avoidance >19.4 C & <= 21 C	19	19	19	11	11	11	21	27	15
	Delay >21.0 C & <= 25.0 C	5	10	19	38	38	38	41	20	6
	Lethal >25.0 C	14	9	0	20	20	20	1	5	4
CR - 3	Preference <= 19.0 C	102	101	100	69	66	66	78	89	96
	Avoidance >19.4 C & <= 21 C	4	4	5	11	11	11	17	19	16
	Delay >21.0 C & <= 25.0 C	13	12	17	41	44	44	27	11	8
	Lethal >25.0 C	3	5	0	1	1	1	0	3	2
CR - 2	Preference <= 19.0 C	95	95	95	80	80	80	89	107	112
	Avoidance >19.4 C & <= 21 C	11	12	13	22	22	22	28	7	6
	Delay >21.0 C & <= 25.0 C	16	15	14	20	20	20	5	8	4
	Lethal >25.0 C	0	0	0	0	0	0	0	0	0

Table 39. Predicted Number of Days within Water Temperature Water Temperature Thresholds for Migrating Smolt Spring Chinook under the No-Action Alternative and Alternative 4

		Wet Water Year			Dry Water Year			Normal Water Year		
Reach	Life Stage Thresholds	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)	No Action	Alternative 4 (Yrs 1–5)	Alternative 4 (Yrs 6–20)
Chinook Smolt Migration Temperature Thresholds										
CR - 10	Preference <=20 C	120	120	120	120	120	120	120	120	120
	Delay > 20 C	0	0	0	0	0	0	0	0	0
CR - 9	Preference <=20 C	120	120	120	120	116	116	120	120	120
	Delay > 20 C	0	0	0	0	4	4	0	0	0
CR - 8	Preference <=20 C	120	120	120	114	112	112	120	120	120
	Delay > 20 C	0	0	0	6	8	8	0	0	0
CR - 7	Preference <=20 C	120	120	120	120	120	120	120	120	120
	Delay > 20 C	0	0	0	0	0	0	0	0	0
CR - 6	Preference <=20 C	120	120	120	120	120	120	120	120	120
	Delay > 20 C	0	0	0	0	0	0	0	0	0
CR - 5	Preference <=20 C	120	120	120	108	108	108	114	120	120
	Delay > 20 C	0	0	0	12	12	12	6	0	0
CR - 4	Preference <=20 C	115	116	116	86	85	85	94	92	120
	Delay > 20 C	5	4	4	34	35	35	26	28	0
CR - 3	Preference <=20 C	120	120	120	104	102	102	113	111	120
	Delay > 20 C	0	0	0	16	18	18	7	9	0
CR - 2	Preference <=20 C	120	120	120	109	108	108	113	118	120
	Delay > 20 C	0	0	0	11	12	12	7	2	0

BIO-10: Affect Sockeye Salmon Habitat

Changes in streamflows and reservoir elevations and variability would be the same or nearly the same type as described for the proposed action for all reaches except for the Middle Deschutes River and Crooked River, which are described below.

Middle Deschutes

Under Alternative 4 streamflows in the Deschutes River at the CULO gauge are predicted to increase slightly during the winter (mid-October to the end of March) in years 1 through 6 and moderately in years 6 through 20.

Streamflows decline beginning approximately mid-April with the start of irrigation diversions, about the time sockeye fry would be emerging from the gravel to migrate to Lake Billy Chinook. However, predicted streamflows under Alternative 4 are no different than the no-action alternative during this period and in the fall at the end of irrigation when sockeye adults may be attempting to spawn. There would be no effect relative to the no-action alternative.

Because of the relatively small increase in winter flows over the permit term and patterns of use by sockeye, there would be no adverse effect on habitat for sockeye salmon in the reach accessible to this species.

Crooked River

Adult sockeye salmon may enter the Crooked River in the fall to spawn in the lower section of the river, downstream of Opal Springs hydroelectric project. Eggs would remain in the gravel through the winter. Newly emerged fry would migrate to Lake Billy Chinook in the spring for juvenile rearing. The limited use by sockeye suggests any effects of water management on sockeye salmon habitat would be limited to availability of spawning and egg incubation habitat in the lower river, downstream of Opal Springs hydroelectric project.

Under the Alternative 4, modeled streamflows in the Crooked River at the Opal node in the lower river (Reaches CR-1.2 and CR-1.1; RMs 4–0) are relatively unchanged compared to the no-action alternative for the entire permit term. The changes in flow from upstream water management are too small in the context of the high volume groundwater inflow upstream of the Opal node to result in effects on the species in this reach. Therefore, there would be no effect on habitat for sockeye salmon in the portion of the Crooked River used by sockeye salmon for spawning.

BIO-11: Affect Sockeye Salmon Migratory Life Stages

Changes in streamflows and reservoir elevations and variability would be the same or nearly the same type as described for the proposed action for all reaches except for the Middle Deschutes River and Crooked River, which are described below.

Middle Deschutes

Under Alternative 4 streamflows in the Deschutes River at the CULO gauge are predicted to increase slightly during the winter (mid-October to the end of March) in years 1 through 6 and moderately in years 6 through 20.

Streamflows decline beginning approximately mid-April with the start of irrigation diversions, about the time sockeye fry would be emerging from the gravel to migrate to Lake Billy Chinook. However, predicted streamflows under Alternative 4 are no different than the no-action alternative during this period and in the fall at the end of irrigation when sockeye adults may be attempting to enter the Deschutes River to spawn. Thus, there would be no effect relative to the no-action alternative.

Because of the relatively small increase in winter flows over the permit term and patterns of use by sockeye salmon, there would be no effect on migratory life stages for this species in the portion of the reach accessible to the species.

Crooked River

Adult sockeye salmon may enter the Crooked River in the fall to spawn in the lower section of the river, downstream of the Opal Springs hydroelectric project. The limited use by sockeye salmon suggests any effects of water management on sockeye salmon migration habitat would be limited to the lower river, downstream of the Opal Springs hydroelectric project. Under Alternative 4, RiverWare modeled streamflows in the Crooked River at the Opal node in the lower river are unchanged or change slightly (less than 2%) compared to the no-action alternative for the entire permit term. The changes in flow are too small to result in migration effects on sockeye salmon when considered in context with the high volume of groundwater inflow upstream of the Opal node. Therefore, there would be no effect on adult or juvenile migration life stages for this species in the portion of the Crooked River likely used by sockeye salmon for spawning and egg incubation.

BIO-12: Affect Redband Trout Habitat

Changes in streamflows and reservoir elevations and variability and therefore effects on redband trout habitat under Alternative 4 compared to the no-action alternative would be the same or nearly the same type as described for the proposed action for all reaches except for Wickiup Reservoir, the Upper and Middle Deschutes River, and the Crooked River.

Wickiup Reservoir

Adverse effects in Wickiup Reservoir would also be the same type as described for the proposed action but of greater magnitude because variability in reservoir volume and elevation over the year would be of greater magnitude.

Upper Deschutes River

In the Upper Deschutes River, increased winter streamflows and decreased summer streamflows and associated benefits for redband trout would be the same type as described for the proposed action but of greater magnitude at full implementation due to increased releases from Wickiup Reservoir in above-normal and wet years under this alternative (Conservation Measure WR-1). In addition, implementation of habitat restoration activities funded through Conservation Measure DR-2 would further increase beneficial effects in this reach.

Crooked River

There would be a beneficial effect of higher minimum winter streamflows under Alternative 4, consistent with study findings by Porter and Hodgson (2016). They concluded low flows during the winter were a factor negatively effecting redband trout habitat the Crooked River. The habitat model developed for steelhead for the Deschutes Basin HCP analysis supports their findings. Higher winter streamflows would increase habitat capacity for juvenile steelhead. The same conclusion is applicable to juvenile redband trout.

However, under Alternative 4, there would be an overall adverse effect on redband trout habitat because of an increase in number of days of warm water temperature due to changes in timing of release of water from Prineville Reservoir reported by Berger et al. (2019). The effects on water temperatures under Alternative 4 in a dry year are more severe compared to the proposed action and Alternative 3. The number of stress/disease days in CR-10 in a dry year under Alternative 4 would increase by 13 days under Alternative 4 compared to a decrease in number of days under the proposed action and Alternative 3. The effect of water management would be much less in this key reach compared to downstream reaches, which experience more warming with change in streamflow. Warming of water temperatures in downstream reaches would affect redband trout movement in the Crooked River and their ability to occupy habitats elsewhere in the Crooked River.

Alternative 4 would have an adverse effect on redband trout habitat in the Crooked River.

BIO-13: Affect Nonnative Resident Trout Habitat

Effects on nonnative resident trout under Alternative 4 would be the same type as described for the proposed action in all geographic areas except the Crooked River, which would experience the same effects as described for redband trout under Alternative 4.

BIO-14: Affect Summer/Fall Chinook Salmon Habitat

Summer/Fall Chinook salmon distribution is limited to the Lower Deschutes, downstream of the Pelton-Round Butte Complex. Under the Alternative 4 streamflows in the Lower Deschutes River at the Madras gauge are predicted to increase slightly during the winter. The increase in streamflows are considered minor. There would be no effect on habitat used by this species in the Lower Deschutes River.

BIO-15: Affect Kokanee Salmon Habitat

Effects on kokanee salmon habitat and migratory life stages under Alternative 4 would be the same type as described for the proposed action except Wickiup Reservoir.

Wickiup Reservoir

The predicted more extreme variation in reservoir elevations and lower volumes over the permit term will adversely affect kokanee habitat in the reservoir to a greater extent compared to the proposed action and Alternative 3. Effects will be extreme over the entire permit term.

The extreme variation in reservoir volume over the year likely will cause additional effects on the population by entrainment at the dam outlet and downstream displacement of kokanee salmon into the Deschutes River.

There would be an adverse effect overall because of extremely low reservoir elevations and volumes in most years and extreme seasonal differences.

BIO-16: Affect Native Non-Trout and Non-Game Fish Habitat

Effects on native non-trout and non-game fish habitat under Alternative 4 compared to the no-action alternative would be the same type as described for the proposed action in all reaches except the Upper Deschutes River, Wickiup Reservoir and the Crooked River. Beneficial and potential adverse effects on the Upper Deschutes River would be of greater magnitude and with implementation of habitat restoration activities funded through Conservation Measure DR-2 under Alternative 4 could offset potential adverse effects and increase beneficial effects in this reach3. Adverse effects in Wickiup Reservoir would be the same type as described for the proposed action and Alternative 3, but of greater magnitude because within-year variability in reservoir volume and elevation would be greater. Adverse effects in the Crooked River would also be the same type as described for the proposed action but of slightly greater magnitude because of slightly warmer temperatures in the summer. The duration of these adverse effects would be between the proposed action and Alternative 3.

BIO-17: Affect Freshwater Mollusk Habitat

Effects on freshwater mollusk habitat would be the same type as described for the proposed action for all reaches except for the Crooked River, which is described below. On the Deschutes River, there would be a higher magnitude of increased fall and winter flows and decreased irrigation season flows compared to the proposed action; however, the overall effects on species habitat would be the same type as described under the proposed action.

Crooked River

Crater Lake Tightcoil and Evening Field Slug

The most important habitat element for Crater Lake tightcoil and evening field slug is perennially inundated soil. Under Alternative 4, flows increase in fall/ winter months in most years, but decrease especially in middle and upper reaches in late summer in many years. This could dry out the necessary perennially inundated habitat. Therefore, overall effects on would be adverse.

Floater Species Mussels

Floater species mussels have primarily been found in the lower Crooked River, with habitat just above the Northern Irrigation Unit Pump Diversion and further downstream. May through August is the critical period of reproduction and juvenile establishment for these mussels. While flows increase in May and June on average in the reaches measured by the CAPO gauge, they decrease significantly in July through September. Flows in reaches measured by the NUID gauge decrease in median flows on average during this time period. Therefore, overall effects on would be adverse.

Floater species mussels are not known to be present in Ochoco and McKay Creeks. However, flows in Ochoco and McKay creeks would be unchanged; therefore, there would be no effect on this species if present.

Western Pearlshell Mussels

Western pearlshell mussels have records and suitable habitat throughout the Crooked River, and the critical period of reproduction and juvenile establishment is during May and June. Because flows under alternative 4 increase for many reaches as compared to no-action flows during this time period, there would be a beneficial effect for Western pearlshell mussels.

Western Ridged Mussels

Western ridged mussels have records and suitable habitat throughout the Crooked River, and the critical period of reproduction and juvenile establishment is June through August. Because of the increases in flow during the initial reproductive period on average in many reaches, but overall decreases in flows as compared to No-action during the latter part of their reproductive period (especially in August) in many reaches, there would be no adverse effect on Western ridged mussels.

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Appendix 3.5-A
Agricultural Uses and Agricultural Economics Technical Supplement

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Introduction

This appendix describes how Deschutes Basin irrigation districts and other irrigators affected by the proposed action and alternatives (Alternatives 3 and 4) may respond to changes in the water supply available for irrigation diversion, and also how these responses may change the value of agricultural production and the economic contribution of agricultural production. This appendix identifies and quantifies how agricultural water management and application to crops may change under each alternative, with the primary purpose of identifying and quantifying the potential effects on agricultural land use and cropping pattern. Two primary types of responses to reductions in agricultural water diversions are described and analyzed:

- **Increased agricultural water use efficiency.** Agricultural water use efficiency as used in this analysis is the proportion of irrigation water that is diverted (or pumped from groundwater) used productively by the crop and not lost to seepage (e.g., infiltration into the ground) or evaporation. For example, if for every 100 acre-feet (af) of water diverted, 60 af is water used by the crop (through crop evapotranspiration [ET])[1] and 40 af is lost to seepage or evaporation, then the agricultural water use efficiency is 60%.[2] Agricultural water use efficiency may be increased through financial investments in district infrastructure (such as piping district canals) and on-farm infrastructure (such as converting to more efficient sprinkler and drip irrigation technologies). Increasing water use efficiency reduces the amount of diversion water required to produce a given level of crop output. Investing in water use efficiency requires upfront capital investment but reduces the effect on agricultural crop production of a reduction in water available for irrigation diversions.
- **Reduced use of water by crops.** Farmers may respond to water supply shortages by applying less water to their farmland. This may be accomplished through various mechanisms: a) farmers may maintain their crop mixture and acreage and apply less water than the crops need (deficit irrigating), which reduces yield; b) farmers may shift some or all of their acreage to less water-intensive crops (changing crop mix); c) farmers may reduce the number of acres they irrigate (potentially using these acres for dry pasture/grazing); and/or d) farmers may reduce the number of acres they farm in a given year (fallowing some acres).

Based on the estimated reduced use of water by crops, and the associated acres of reduced irrigation, the analysis then estimates the potential change in the value of agricultural production and the associated change in the economic contribution of agriculture (in terms of jobs and income supported).

There are eight sections to this appendix. The first provides an overview of methods, assumptions, and data sources. The second describes acreage and crop water use under existing conditions. The

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[1] Evapotranspiration is the sum of the evaporation (E) from soil and plant surfaces and transpiration (T) which is vaporization that occurs inside of the plant leaves.

[2] Note that agricultural water use efficiency can be measured as the ratio of water used by the crop to water withdrawn (as used here), or it may be measured as the ratio of agricultural yield to water withdrawn.

third describes the water available for diversion and identifies the districts that are affected by the proposed action and alternatives. The fourth outlines the estimated agricultural water use efficiency and conservation investments through time for each district. The fifth estimates water supply available for crop consumptive use for each district through time (after accounting for diversion volumes under each alternative and efficiency improvements). The sixth estimates on-farm responses to changes in water supplies and projects impacts on cropping pattern, acreage, and yields. The seventh estimates the change in agricultural production value and associated economic contribution. The eighth provides references cited in the previous sections.

Methods, Key Assumptions, and Data Sources

This section describes methods/key assumptions/data sources used to estimate the responses to changes in irrigation water supplies (methods/assumptions/data sources used to estimate the economic changes resulting from these responses is included in the seventh section addressing economics). There is significant annual variability in hydrology in both the Crooked River and Upper Deschutes Subbasins. Dry years result in much lower flows (and hence reduced water supplies available for diversion) than wet years. Consistent with other resource analyses, this analysis focuses on three water year types: wet (80th percentile water available for diversions), median (50th percentile water available for diversions), and dry water years (20th percentile water available for diversions).[3] It is important to note that 20% of water years are drier than the dry water year analyzed in this analysis. The impacts of the alternatives on irrigation water supplies (and therefore agriculture) would be more severe for extreme dry water years than the impacts estimated for the dry year presented in this analysis.

The study area for the socioeconomic analysis is Deschutes, Jefferson, and Crook Counties. For the agricultural land use and agricultural economics analysis, the focus is the agricultural land area that receives irrigation water from the Deschutes and Crooked River Basins (including Whychus Creek, Tumalo Creek, and Crescent Creek) in these counties. This includes the Deschutes Basin Board of Control (DBBC) permit applicant districts (referred to collectively as the DBBC districts), as well as other lands (referred to herein as Other Irrigated Lands) receiving irrigation water through the following non-DBBC diversions: Walker Irrigation District (ID), People's Canal, Low Line Canal, Crooked River Central Canal, Rice Baldwin Canal, and the small private canal above Feed Canal.

Within the study area, the agricultural analysis focused on the districts that are projected to experience a change in water supply availability (i.e., amount of water available for diversion) under the proposed action and alternatives. For these districts, the analysis evaluated water supply availability relative to crop water demand for periods within the irrigation season. This is because the effect on water supplies is more acute in the high demand irrigation months of June, July, and August. For example, for a given water year with a 15% annual water supply reduction under an alternative, the average effect on water supplies in June and July may be a 35% reduction. Because of this variation in water supplies within a water year type, this analysis separately analyzed acreage impacts in May, June/July, and August/September. (Irrigation water supplies in April and October were not separately analyzed as water availability was much higher in these months relative to crop demand compared to the other months.) The three irrigation subseason periods of

[3] For example, in dry year, which is equivalent to the 20th percentile of streamflow, streamflow conditions would be as dry or drier in 2 out of 10 years; in wet years (80th percentile) streamflow conditions would be as dry or drier in 8 out of 10 years and therefore as wet or wetter in 2 out of 10 years.

May, June/July, and August/September were selected because these roughly correspond to the irrigation months determining each hay cutting, assuming three cuttings of hay (with cuttings occurring, roughly, in early June, late July/early August, and late September/early October).

To estimate impacts on acreage, this analysis took a six-step approach (*key data sources are provided in italics*):

1. Estimated current crop water demand for irrigation water for each district based on crop mix and annual water use by crop. (See *Existing Conditions: Crop Acreage and Crop Water Demand*.)
   a. *District crop acreage and cropping pattern: Publications including basin publications, district reports, and modernization plan documents; interviews with district managers and Oregon State University extension agent; North Unit Crop Acreage report for 2013–2018.*
   b. *Crop water use: Bureau of Reclamation AgriMET Cooperative Agricultural Weather Network evapotranspiration data for the Madras station (MRSO), the Bend station (BEWO), and the Powell Butte station (POBO).*
2. Identified the DBBC districts and Other Irrigated Lands that are projected to face a change in the availability of diversion (i.e., supplies differ in one or more of the proposed action and alternatives compared to the no-action alternative). Analyze only those DBBC districts/Other Irrigated Lands that are projected to face a change in diversion water availability in these years (hereafter, referred to as 'potentially affected districts'). Identify but do not quantitatively evaluate the impacts on districts that may face a change in the water availability of diversion water in extremely dry years. (See *Water Available for Diversion under the Proposed Action and Alternatives.)*
   a. *Water available for irrigation diversion: RiverWare model provided the estimated amount of water available for irrigation diversion for each district primary diversion canal for each alternative and wintertime flow level.*
3. Estimated the agricultural water use efficiency in the Deschutes Basin over time for affected DBBC districts and Other Irrigated Lands, taking into account the potential range of district conveyance and on-farm efficiency improvements that may occur in the future. This is done for each affected district for each year over the 30-year analysis period. Develop a high conservation scenario (with the highest likely feasible district and on-farm conservation improvements) and a low conservation scenario (with the lowest likely feasible district and on-farm conservation improvement). (See *Agricultural Water Use Efficiency*.) A range is necessary as there is significant uncertainty regarding the timing and magnitude of future conservation projects. Many district efficiency projects are currently going through the process of obtaining permits and approval for funding; the level of available funding will determine the magnitude and rate of district water conservation. There is also uncertainty regarding the level of on-farm efficiency improvements that may be adopted as these projects are completed at the discretion of the landowner/producer
   a. *DBBC district and on-farm conservation: district modernization planning and permitting documents, district agricultural water management and conservation plans, district on-farm efficiency studies, interviews with district managers, interviews with irrigation equipment supplies and Oregon State University extension, Deschutes Basin studies and planning documents with information on agricultural water management and resource planning in the basin.*
4. Estimated crop water supply (after taking into account canal and on-farm efficiencies) available to meet crop water demand (ET) by applying agricultural water use efficiencies to the water available for diversion (with diversions estimated by the RiverWare model for a historical dry and median water year), and identified reductions in crop water supply by alternative and

conservation scenario. This was done for each district for each irrigation subseason (May, June/July, and August/September) in each year over the analysis period. (See *Water Available for Crops (Accounting for Efficiency.*)

5. Estimated how farmers would respond to any shortages in meeting crop water requirements in terms of changes to cropping pattern, acreage, and yields. This was done for each district in each irrigation subseason in each year over the analysis period for both the low and the high conservation scenarios. (See *Farm Response to Crop Water Shortages*.)
    a. *Information on responses to shortages: Interviews with district managers, North Unit ID board member, and Oregon State University Extension; publications from Oregon State University Extension; North Unit Crop Acreage reports from 2008 to 2018 that show how crop acreage and mix has fluctuated over time in North Unit ID; economic literature on on-farm response to water shortages.*

To reflect the uncertainty in the type, timing, and magnitude of responses by agricultural water users (both in increasing efficiency and in responding to shortages), this analysis used ranges to estimate the effect of the alternatives on agricultural land use and agricultural production.

Key Assumptions

Following is a description of the key analysis assumptions.

1. There are no alternative water supplies available to farmers. Additional groundwater development in the Deschutes Basin must be mitigated (through such mechanisms as leases, transfers, conserved water projects, etc.) and there are no other unallocated surface water sources.
2. With the exception of Lone Pine ID and Swalley ID, all water conserved from piping of district canals (conveyance efficiency improvements) is dedicated to instream flow, as most public grant funding for piping requires dedication to instream flow for the portion of the project funded by the grant. The conserved water amount (reduced seepage) equals the increased instream flow, as well as the district's reduced diversion requirement to meet the same level of patron demand. (i.e., if 100 af per year [af/y] is conserved from piping, then 100 af/y are put back in-stream and the district can divert 100 af/y less to satisfy the same level of patron demand). In the case of Lone Pine ID and Swalley, in accordance with their existing plans for district piping, Lone Pine ID is expecting to retain for its own use 25% of the water conserved through piping (Smith pers. comm).[4] Arnold ID's existing plan also indicates that the District may also retain for its own use 25% of water conserved through piping, but this is not incorporated into the analysis as it will depend future funding arrangements that are as yet not determined.
3. All conserved water from Central Oregon ID would result in increased instream flows. However, it is expected that all summertime water conserved from Central Oregon ID canal piping and on-farm efficiency improvements is made available to North Unit ID, and in turn, North Unit ID would make available its Wickiup stored water for winter releases. This type of water management arrangement has not yet been implemented in Oregon and will likely require close coordination with the Oregon Water Resources Department and other state agencies to implement. The analysis takes this hurdle into account as the low conservation scenario assumes that Central Oregon ID piping proceeds at a slower pace and is entirely funded by Central Oregon ID and North Unit ID.

[4] Subsequent to this analysis, based on its funding arrangements, Lone Pine ID increased the proportion of conserved water that it expects to retain 40%.

4. Apart from Central Oregon ID making conserved water available to North Unit ID, shortages are managed within each district, with no water supply sharing across districts. In other words, each district was separately analyzed and water sharing was not directly modeled across districts as could occur if a basin-wide water market develops. Currently, there are legal barriers to trading water between districts. These barriers may be removed and a basin-wide water market may develop in the future that would enable growers to buy and sell water between districts. The effect of a potential market on water supplies and agricultural production was not evaluated for two reasons: the timing and certainty of water market development are not known, and acreage affected by water shortages is assumed to be grain and forage crops (hay, alfalfa, pasture) in all districts (which limits the difference in value of water across all districts and reduces the economic effect of a water market – or said differently, by assuming grain and forage crops are only affected by the changes in water supply, the analysis has a similar outcome as would result from a water market).
5. The range of feasible conservation investments would be similar across all alternatives. While more district piping and on-farm conservation are likely with greater reduction in water supplies, it is reasonable to assume that some level of conservation would occur in all alternatives. Currently, the DBBC districts are developing modernization plans and going through an environmental review process as part of their pursuit of funding for piping projects. Similarly, on-farm efficiency is increasing in many districts.
6. The proposed action would not result in increased water availability to crops compared to existing median water year conditions. If fully implemented, water conservation from district conveyance and on-farm efficiency projects could result in more water available to agriculture under the proposed action and alternatives than available under existing conditions. Such additional water could result in increased yields or increased irrigated acreage. However, since this is not an effect of the proposed action and alternatives but rather an outcome that would similarly affect all future conditions, the analysis did not consider this potential effect. Furthermore, whether conservation efforts could result in more water being made available to agriculture in the future than under current conditions is uncertain, as districts and growers (and funding agencies) would likely be most incentivized to invest in conservation that would reduce water supply shortfalls rather than increase water supply beyond existing median water year conditions. As such, the analysis capped the total water supply available to the crop (after accounting for conveyance and irrigation efficiencies) in median and dry water year types in all future years to the existing median water supply (the no-action alternative).
7. Because of low growing season rainfall, crop water requirements are met through irrigation, with no crop water requirement met through precipitation. Data from the Bureau of Reclamation Agrimet Station in Madras indicates that total rainfall from May through September averaged less than 3 inches between 2010 and 2018, with some years receiving as little as 1.75 inches during this timeframe (Bureau of Reclamation 2019).
8. When water supply is available, the future crop mix and acreage would remain similar to the current cropping pattern. In particular, the analysis assumed that forage crops would remain the predominant crop in the study area, consistent with decades of agriculture in the region. Because the market and economic potential for large-scale transition to other crops, as well as farmer preference for growing forage to support their own livestock,[5] is speculative, this analysis estimated the effects of changes in water availability assuming the current cropping pattern. To the extent that other relatively lower water-use crops replace forage crops on a wide-scale basis, the effects would likely be overestimated because of the lower water requirement of these crops.

[5] Forage crops contribute to the area’s cattle and dairy production, and are also used to feed horses and other animals raised on many hobby farms in the area.

9. In responding to water supply reductions, farmers would strive to minimize negative effects on farm profits and would reduce water supplies to hay/pasture/grains before reducing water supplies to higher-valued crops such as carrot seed, grass seed, mint, and vegetables. As such, fallowing/deficit irrigating would primarily affect hay/pasture/grain crops. Hay/pasture is the predominant crop in all districts, representing 81% of acreage in all districts excluding North Unit ID (the most crop diversified district), and representing 51% of acreage in North Unit ID (but an estimated 83% of water use in North Unit ID. This is expected to be a reasonable assumption as farms with high value specialty crops also typically have lower valued crops (so at least some on-farm movement of water from lower value to high value crops is possible), or would conceivably be able to purchase water from predominantly hay/pasture/grain crop farmers (resulting in idling of hay/pasture/grain crops). Also, the feasibility of a basin-wide water transaction program is currently being explored in the Deschutes Basin (Central Oregon Irrigation District, 2017), which if developed would facilitate transfers of water to high value crops. To the extent that this does not happen, this analysis may underestimate the impact on agricultural production value and associated economic impact, particularly in NUID.
10. Irrigation water supply in April/May[6] determines the amount of yield in the first cutting of hay, while irrigation water supply in June/July determines the amount of yield in the second cutting of hay, and irrigation water supply in August/September determines the amount of yield in the third cutting of hay (with cuttings occurring, roughly, in early June, late July/early August, and late September/early October).

Existing Conditions: Crop Acreage and Crop Water Demand

This section provides the crop acreage and crop water use data used to estimate total crop water demand by district. **Table 1** presents data on the existing average cropping pattern and irrigated acreage by district. Cropping patterns are based on published documents and interviews with district managers. In total, this analysis estimates 141,000 acres of irrigated lands in the study area. This roughly corresponds to the estimate from the 2012 Census of Agriculture that there were 136,975 acres of irrigated acreage in the three-county area (US Department of Agriculture 2012). Crop mix is fairly similar across irrigation districts, with irrigated lands predominantly planted in forage crops (alfalfa, hay, pasture). North Unit ID is distinct in having much greater crop diversification, including such high value crops as carrot seed, mint, grass seed, and vegetables. Several other districts also have limited acreage of these high value crops. Excluding North Unit ID, approximately 80% of irrigated acreage in DBBC districts is estimated to be in hay or pasture, while approximately 56% of irrigated acreage in North Unit ID is in hay or pasture.

Under existing conditions, it is important to note that irrigation water supply fluctuates based on water year type, with dry water years resulting in lower acreage and/or yields in many districts. The reduction in water supply in dry water years under existing conditions is higher than it has been historically due to the 2016 Settlement Agreement. Under this agreement, the Districts agreed to increased releases of storage water to enhance wintertime flows for the Oregon Spotted Frog.

[6]As April irrigation supply was high across all districts and water year types, only May and not the average of April and May was analyzed to estimate the relative impact of crop water supply changes on acreage/yield for the first cutting of hay.

Existing conditions for Tumalo ID in particular are lower than historic conditions. As part of the Settlement Agreement, Tumalo ID increased its minimum release into Crescent Creek from 6 cfs to 20 to 30 cfs. Under existing conditions, the Districts that face reduced irrigation water supplies and associated reduced acreage/deficit irrigation (due both to historic hydrology and the changes to water management associated with the Settlement Agreement) include Arnold ID, North Unit ID, Lone, Pine ID, Tumalo ID, Three Sisters ID, and potentially Ochoco ID (**Table 2**). Riverware also shows a shortage to COID under existing conditions. However, this shortage is a very small relative to total diversions, and is also projected by district management to be met through improved operational flexibility resulting from planned conveyance efficiency projects (Horrell pers. comm. [a]).

Of these districts, impacts of the proposed action, Alternative 3, or Alternative 4 in median and normal dry water years are limited to Arnold ID, North Unit ID, Lone Pine ID, and potential Ochoco ID. It is uncertain the degree to which Ochoco ID is affected by dry water years. The RiverWare water supply model shows that Ochoco ID did not face water supply shortages during a dry water year during the period of record. However, water allocation history provided by district managers shows that per acre allocation has in the past often been lower than the full allocation, with a possible water supply reduction in existing dry years of up approximately 17%. However, as this analysis is based on RiverWare results, we do not estimate reduced dry year acreage for Ochoco ID under existing conditions. Of the districts currently facing water shortages in dry years, North Unit ID and Arnold ID are the two most affected by the proposed action and alternatives. For these districts, water supply reductions resulting from the proposed action and alternatives in dry water years would exacerbate the existing water supply shortage.

As shown in **Table 2**, under existing conditions, up to approximately 26,400 acres of irrigated acreage may be impacted (deficit irrigated or fallowed), or approximately 20% of median water year acreage. The analysis of potential dry year impacts under existing conditions follows the same methodologies and assumptions for acreage impacts as for the alternatives (as laid out in *Methods, Key Assumptions, and Data Sources*). These impacts represent the maximum acreage that may be impacted. For example, under Existing Conditions in a dry year, the analysis estimates that nearly all grain and forage crops in Tumalo ID is affected. This is not because all of these acres are fallowed, but rather that in a dry water year, irrigation of most forage is cut off in August or September and the farms lose their last cutting of hay or get reduced production from pasture.

Table 1. Existing Conditions Average Irrigated Acreage by DBBC District, Crop Type

	DBBC Districts										
Crop Type	Arnold	Central Oregon	Lone Pine	North Unit	Ochoco	Swalley	Three Sisters	Tumalo	Total, DBBC Districts	Other Irrigated Lands[a]	Total
Other Hay/Pasture	2,700	20,600	700	15,300	8,000	2,700	3,600	4,000	57,600	2,000	59,500
Alfalfa	800	16,900	500	14,100	4,600	0	2,100	1,000	40,000	1,200	41,200
Grains	0	800	400	5,700	1,800	0	1,200	0	9,900	200	10,100
Carrot and Other Seed	0	0	0	6,700	400	0	200	0	7,400	0	7,400
Peppermint/Other Herbs	0	0	500	1,000	200	0	0	0	1,700	0	1,700
Grass Seed/Sod/Nursery	0	400	0	8,500	300	0	0	0	9,300	0	9,300
Other Crops	0	2,900	200	900	0	100	500	1,000	5,700	200	5,900
Urban	500	400	0	0	3,400[b]	1,200	0	0	5,600	300	5,800
Irrigated Acres	4,000	42,100	2,400	52,200	18,700	4,000	7,600	6,000	137,000	4,000	141,000

Sources: Gerdes pers. comm, Farmers Conservation Alliance 2018a, Central Oregon Irrigation District 2012, Horrell pers. comm. [a], Farmers Conservation Alliance 2018c, Farmers Conservation Alliance 2018b, Rieck pers. comm., Britton pers. comm.; Bohl pers. comm., Ochoco Irrigation District 2012, Thalacker pers. comm., Rieck pers. comm., Farmers Conservation Alliance 2018c.

[a] Includes estimated acreage for Walker ID, People's Canal, Low Line Canal, Crooked River Central Canal, Rice Baldwin Canal, and the small private canal above Feed Canal. Acreage estimate based on median year diversion of approximately 28,300 af/y, average crop consumptive water requirement of 3 af/y/acre, and assumed canal efficiency of 60% and on-farm efficiency of 70% (28,300 af/y*0.6*0.7/3 af/y=~4,000 acres). Crop mix is assumed to equal the average crop mix across DBBC districts, excluding North Unit ID.

[b] Includes all small farms, many of which are within Urban Growth Boundary. Irrigated land primarily includes pasture/hay, but also turf and some specialty crops.

Table 2. Existing Conditions Estimated Irrigated Acreage by DBBC District and Crop Type, Dry Water Year

	DBBC Districts											
Crop Type	**Arnold**	**Central Oregon**	**Lone Pine**	**North Unit**	**Ochoco**	**Swalley**	**Three Sisters**	**Tumalo**	**Total, DBBC Districts**	**Other Irrigated Lands[a]**	**Total**	**Change from Median Year**
Other Hay/Pasture												
Alfalfa	2,100	37,000	1,100	19,100	14,400	2,700	4,700	100	81,100	3,300	84,400	-26,400
Grains												
Carrot and Other Seed	0	0	0	6,700	400	0	200	0	7,400	0	7,400	0
Peppermint/Other Herbs	0	0	500	1,000	200	0	0	0	1,700	0	1,700	0
Grass Seed/Sod/Nursery	0	400	0	8,500	300	0	0	0	9,200	0	9,300	0
Other Crops	0	2,900	200	900	0	100	500	1,000	5,700	200	5,900	0
Urban	500	400	0	0	3,400	1,200	0	0	5,600	300	5,800	0
Irrigated Acres	2,600	40,800	1,800	36,200	18,700	4,000	5,300	1,100	110,700	3,800	114,500	0
Change from Median Year	-1,300	-1,400	-500	-16,000	0	0	-2,300	-4,900	-26,400	-100	-26,400	0

Sources: Highland Economics analysis using water supply for the dry water year irrigation diversions estimated by RiverWare for the no-action alternative. Gerdes pers. comm, Farmers Conservation Alliance 2018a, Central Oregon Irrigation District 2012, Horrell pers. comm. [a], Farmers Conservation Alliance 2018c, Farmers Conservation Alliance 2018b, Rieck pers. comm., Britton pers. comm., Bohl pers. comm., Ochoco Irrigation District 2012, Thalacker pers. comm., Rieck pers. comm., Farmers Conservation Alliance 2018c.

[a] Includes estimated acreage for Walker ID People's Canal, Low Line Canal, Crooked River Central Canal, Rice Baldwin Canal, and the small private canal above Feed Canal.

Crop water demand is measured by crop evapotranspiration (ET). Crop ET includes all water that evaporates from soil and plant surfaces and transpiration from the plant to the atmosphere. Crop ET varies by crop (based on crop height, reflection, groundcover, and root characteristics), and by location due to differences in climate, soil, and other environmental factors. Crop ET can also vary by year due to variation in environmental factors such as temperature (e.g., the hotter the year, the higher the ET). As such, this analysis uses data on crop ET from throughout the study area, as well as over a 10-year period in order to best represent the annual average crop water needs for each district.

Data on crop water demand is from the Bureau of Reclamation AgriMET Cooperative Agricultural Weather Network. This network includes several stations that measure crop evapotranspiration (ET) for specific crops grown in the region. This analysis used the crop ET data from the three stations closest to study area irrigated lands: the Madras station (MRSO), the Bend station (BEWO), and the Powell Butte station (POBO). These data provide annual per acre ET totals by crop from 1988 to 2015 (more recent data were not available). This analysis used the average ET by crop from 2006 to 2015, as provided in **Table 3**. Each district was assigned to an AgriMET station based on geographical proximity; the station assignment and associated crop ET for each district is identified in **Table 4**. Due to variation in crop mix as well as variation in ET requirements by location in the basin, the weighted average per acre ET for grain and forage crops (see last row in **Table 4**) varies among the districts from 2.3 af/y per acre in Lone Pine ID to 2.8 af/y per acre in North Unit ID. These ET estimates by district are the per acre crop consumptive demand used in the analysis to estimate effects on grain and forage acreage of reductions in water supplies.

Table 3. Average Annual Crop Water Demand (ET) at Deschutes Basin AgriMet Weather Stations, 2006–2015

	AgriMET Station (Acre-feet per year)		
Crop	**Madras**	**Powell Butte**	**Bend**
Alfalfa	3.3	3.0	2.5
Pasture	2.6	3.1	2.0
Hay	3.3	3.1	2.5
Carrot Seed	1.0	N/A	N/A
Peppermint	2.2	2.1	N/A
Bluegrass Seed	1.4	1.4	N/A
Winter Grain	1.9	1.9	1.6
Spring Grain	2.1	1.9	1.6
Lawn	N/A	2.9	2.4

Source: Highland Economics analysis of Bureau of Reclamation 2016.

Table 4. Annual per Acre Crop Water Demand (Evapotranspiration, ET) at Deschutes Basin AgriMet Weather Stations (acre-feet per year)

Crop Type	Arnold	Central Oregon	Lone Pine	North Unit	Ochoco	Swalley	Three Sisters	Tumalo	Other Irrigated Lands
Station	*Bend*	*Average of Bend, Powell Butte*	*Powell Butte*	*Madras*	*Powell Butte*	*Bend*	*Powell Butte*	*Bend*	*Average of Bend, Powell Butte, Madras*
Grass Hay/Pasture	2.5	2.8	3.1	3.3	3.1	2.5	3.1	2.5	3.0
Alfalfa	2.5	2.7	3.0	3.3	3.0	2.5	3.0	2.5	2.9
Grains	1.6	1.8	1.9	2.0	1.9	1.6	1.9	1.6	1.8
Carrot/ Other Seed	N/A	N/A	N/A	1.0	N/A	N/A	N/A	N/A	1.0
Peppermint/ Other Herbs	N/A	2.1	2.1	2.2	2.1	N/A	N/A	/A	2.1
Grass Seed/Sod/ Nursery		1.4	1.4	1.4	1.4		1.4		1.4
Other Crops	1.6	1.8	1.9	2.0	1.9	1.6	1.9	1.6	1.8
Urban (Turf)[a]	2.4	2.6	2.9	2.6	3.1	2.4	2.9	2.4	2.6
Weighted Average Grain and Forage Crops (Hay/Pasture, Alfalfa)	*2.5*	*2.7*	*2.3*	*2.8*	*2.7*	*2.5*	*2.5*	*2.5*	*2.7*

Source: Highland Economics analysis of Bureau of Reclamation 2016.

[a] For Ochoco, 'urban' crop water use per acre is set at the hay/pasture crop water demand as most of the acreage classified as 'urban' is used for hay/pasture.

Table 5 summarizes total annual crop water demand by district, calculated by multiplying the district acreage by crop with the per acre crop water demand (from **Table 4**). **The table highlights that the vast majority of agricultural diversion water is used to irrigate** grain and forage crops, which are the crops projected in this analysis to be affected by reduced irrigation water diversions (both due to their prevalence and the fact that they are relatively lower valued than other crops grown in the region). As indicated above in **Table 4**, due to variation in crop mix as well as variation in ET requirements by location in the basin, the average per acre ET for these crops varies among the districts from 2.3 af/y per acre in Lone Pine ID to 2.8 af/y per acre in North Unit ID. The proportion of total crop water use by these crops varies from 68% in Swalley ID (which has a relatively high proportion of urban acreage) to 94% in Central Oregon ID, as shown in **Table 5**. This high proportion of water use by grain and forage crops supports the approach/assumption in this analysis that reduced water supplies would affect grain and forage crops, with little to no impact on other crop types.

Since this analysis is by irrigation subseason and not an annual analysis, **Table 6** summarizes grain and forage crop water demand by DBBC districts/Other Irrigated Lands by month. The separation of annual ET into monthly requirements is based on the average percent delivery by DBBC district/Other Irrigated Lands by month in a median water year.[7] This is the basis for estimating the amount of irrigated acreage by month that is affected by reduced irrigation water supplies (i.e., the total reduction in water supply divided by the average per acre crop water demand for that month equals the estimated affected acreage in that month).

[7] Distribution of crop deliveries by month were estimated to best approximate irrigation practices and scheduling under existing conditions, and so were used instead of actual ET crop requirements by month from Agrimet.

Table 5. Annual Consumptive Crop Water Demand (Evapotranspiration, ET) by DBBC District, Crop Type (acre-feet per year)

	DBBC Districts										
Crop Type	Arnold	Central Oregon	Lone Pine	North Unit	Ochoco	Swalley	Three Sisters	Tumalo	DBBC Districts	Other Irrigated Lands	All Lands
Grain	0	1,481	721	11,496	3,411	0	2,274	0	19,382	362	19,744
Forage (Hay/Pasture/Alfalfa)	8,773	104,278	3,720	97,327	38,293	6,763	17,411	12,658	289,222	9,441	298,664
Other crops	1,208	6,888	1,512	22,958	11,096	3,142	1,052	1,602	49,459	1,248	50,707
All Crops	9,981	112,647	5,953	131,781	52,800	9,905	20,737	14,259	358,063	11,051	369,114
% Crop Water by Grain and Forage Crops (Crops Modeled to be Impacted)	88%	94%	75%	83%	79%	68%	95%	89%	86%	89%	86%

Source: Highland Economics analysis.

Table 6. Estimated Annual per Acre Grain and Forage Crop Water Demand (Evapotranspiration, ET) by DBBC District, Month

Subseason	Arnold	Central Oregon	Lone Pine	North Unit	Ochoco	Swalley	Three Sisters	Tumalo	Other Irrigated Lands
May	0.4	0.4	0.4	0.5	0.5	0.4	0.5	0.5	0.4
June/July	0.9	0.9	0.9	1.1	1.0	1.0	1.0	0.9	0.9
August/September	0.9	0.9	0.8	0.7	0.8	0.9	0.6	0.8	0.9
May – September	2.2	2.2	2.1	2.4	2.3	2.4	2.1	2.3	2.2
Annual Total	*2.5*	*2.7*	*2.3*	*2.8*	*2.7*	*2.5*	*2.5*	*2.5*	*2.7*

Source: Highland Economics analysis of RiverWare water delivery by month and ET data.

Water Available for Diversion under the Proposed Action and Alternatives

This section presents the water available for diversion under the proposed action and alternatives, compared to the no-action alternative, as estimated by the RiverWare model. This analysis used output from the model on the monthly total af of delivery to each diversion canal. All diversion canals to a single district were summed into a monthly total diversion supply for each DBBC district/Other Irrigated Lands. Dry water years represent the 20th percentile year (only 20% of years are drier) and the median water years represent the 50th percentile year (half of water years are drier).[8] This section presents the water available for diversion, while the next section accounts for how on-farm and District water conservation measures would affect water available to crops.

Under the proposed action and alternatives, RiverWare results suggest that there would be a marked change in water available (more than one-third of water supply) for diversion in some water year types and permit years compared to the no-action alternative for Arnold ID, Lone Pine ID, and North Unit ID. RiverWare results suggest potential small impacts (less than 5% reductions) to water available for diversion in some water years in some scenarios in Central Oregon ID, Tumalo ID, and Other Irrigated Lands).[9]

There may be some effects that are not reflected in RiverWare results. Specifically, district managers in Ochoco ID expect that if release of Ochoco ID storage water is required to meet the 50 cubic feet per second (cfs) minimum flow requirement under HCP conservation measure CR-1 in a dry year, it could result in a deficit for Ochoco ID of up to 6,000 af) (Rhoden and Scanlon pers. comm). RiverWare does not project this impact in dry water years; therefore, this Ochoco ID deficit is not presented in the quantitative results in the tables. In contrast, while RiverWare identifies a small percentage reduction in water available for diversion by Central Oregon ID (up to 1% reduction under the proposed action and alternatives compared to the no-action alternative), Central Oregon ID management believes that operational improvements from piping and other district initiatives would compensate for these reduced diversions and result in little to no impact on Central Oregon ID patrons. As such, no quantitative impact is estimated for Central Oregon ID. Based on RiverWare modeling and interviews with district managers, there are no expected impacts on Three Sisters ID or Swalley ID of the proposed action and alternatives.

With the exception of very small projected reductions in water availability to Central Oregon ID and Lone Pine ID during wet water years, there are no projected changes in wet water year deliveries under the proposed action and alternatives compared to the no-action alternative. Wet years are thus not analyzed.

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[8] Diversions in an actual past water year were selected for each district that best represented the 80th percentile and 20th percentile water years (based on water available for diversion). As such, the past water year that represents the dry and median water year differs by district.

[9] Other Irrigated Lands includes lands irrigated by the following diversions: Crooked River Central Canal, Low Line Canal, People's Canal, Rice Baldwin, Small Private Above Feed Canal, and Walker Irrigation District.

No-Action Alternative

Operation assumptions for covered facilities are the same under the no-action alternative as existing operations and would therefore not change the amount of water available for diversion under the no-action alternative. However, climate change effects anticipated over the analysis period could affect the amount and timing of water available for diversion under the no-action alternative compared to existing conditions.

Proposed Action

Table 7 summarizes the water available for diversion under the proposed action over the permit term compared to the no-action alternative. As highlighted in the table, Arnold ID, Lone Pine ID, and North Unit ID are the districts primarily affected by the proposed action. Central Oregon ID, Tumalo ID, and Other Irrigated Lands are projected to experience up to a 1% decrease in water supply. As noted above, although not projected in RiverWare nor analyzed quantitatively, Ochoco ID may possibly experience a reduction as discussed above.

Figure 1 shows how the reduction in water is distributed across the irrigation season, highlighting that reductions are more acute typically in June/July/August/September (particularly in July) than the average seasonal reduction. Analysis of full season irrigation reductions would underestimate impacts since more severe shortages in one month would result in greater crop impacts than a smaller impact distributed evenly throughout the season. For this reason, the analysis separately considers crop impacts for three separate time periods within the irrigation season: May, June/July, and August/September.

Figures 2 through **6** summarize RiverWare results on water available for diversion by month and water year type for the potentially affected districts of Arnold ID, Lone Pine ID, North Unit ID, Tumalo ID, and Other Irrigated Lands. The proposed action (over four periods of the permit term) is compared to the no-action alternative.

Table 7. Changes in Annual Water Available (acre-feet) for Diversion by District, under the Proposed Action Compared to the No-Action Alternative, Median and Dry Water Years

District	Years 1–5		Years 6–10		Years 11–20		Years 21–30		% Change
	Median	Dry	Median	Dry	Median	Dry	Median	Dry	
Arnold	-184	-3,972	-184	-4,906	-489	-5,834	-1,730	-7,583	-1 to -30%
Central Oregon	-630	-1,737	-1,090	-2,070	-1,265	-3,222	-1,808	-3,873	0 to -1%
Lone Pine	-37	-818	-49	-1,610	-140	-2,035	-436	-2,306	0 to -21%
North Unit	5,450	6,086	-5,897	-10,907	-11,473	-26,792	-28,482	-54,070	5 to -41%
Ochoco	0	0	0	0	0	0	0	0	0%
Swalley	0	0	0	0	0	0	0	0	0%
Three Sisters	0	0	0	0	0	0	0	0	0%
Tumalo	36	1,231	36	736	36	377	36	-501	4 to -1%
Other Irrigated Lands	-5	-79	-13	-217	-13	-247	-25	-264	0 to -1%
Total	**4,630**	**710**	**-7,198**	**-18,974**	**-13,345**	**-37,752**	**-32,445**	**-68,598**	**1 to -11%**

Figure 1. Water Available for Diversion by Month for Each Water Year Type over the Permit Term for All Irrigated Lands under the Proposed Action as a Percentage of Water Available under the No-Action Alternative

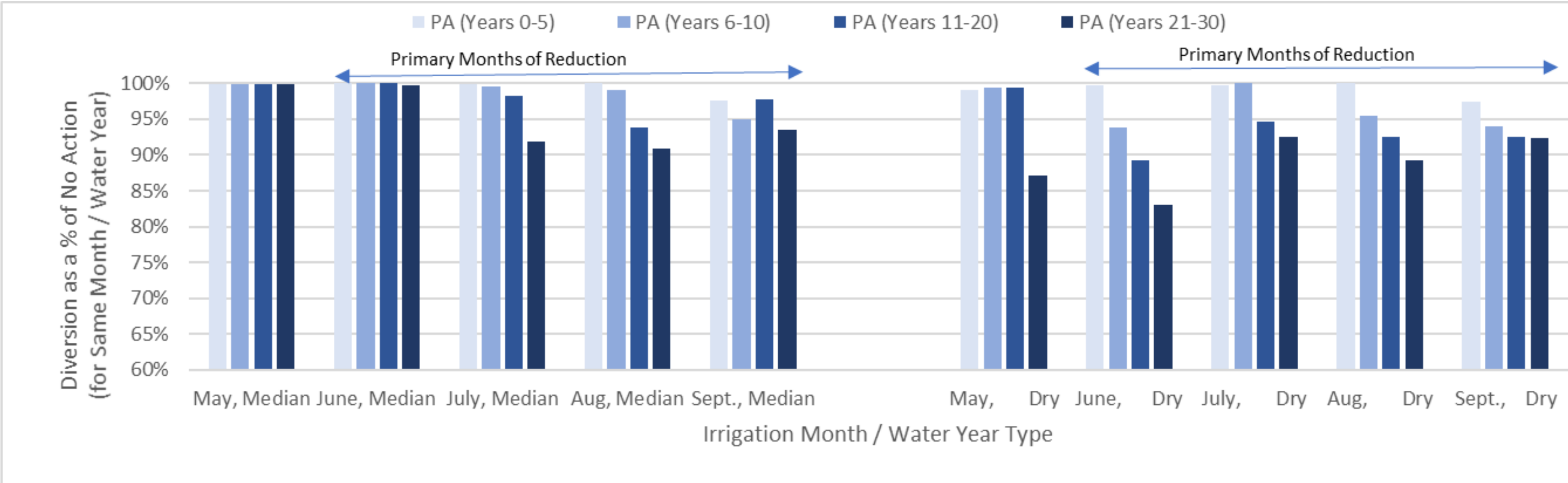


Figure 2. Arnold Irrigation District: Water Available for Diversion under Proposed Action Relative to No-Action Alternative

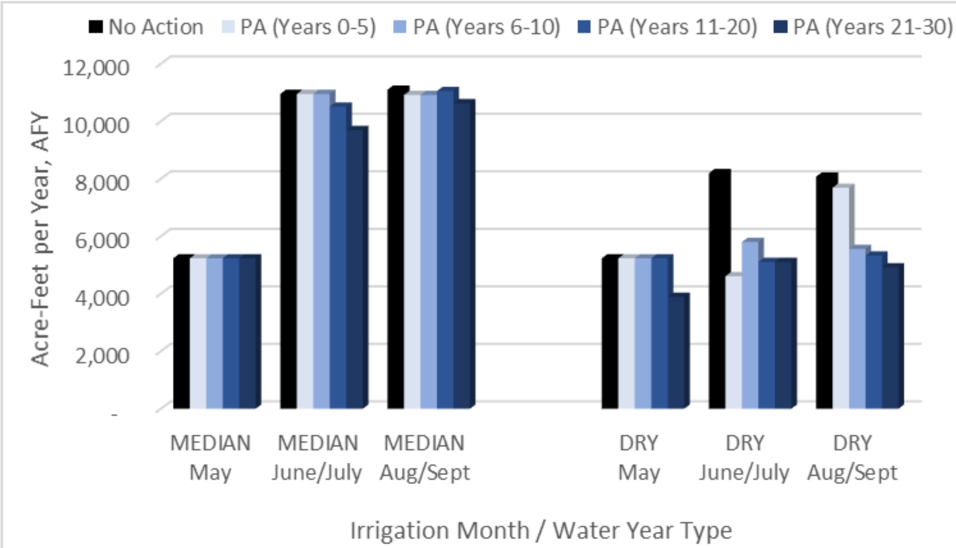


Figure 3. Lone Pine Irrigation District: Water Available for Diversion under Proposed Action Relative to No-Action Alternative

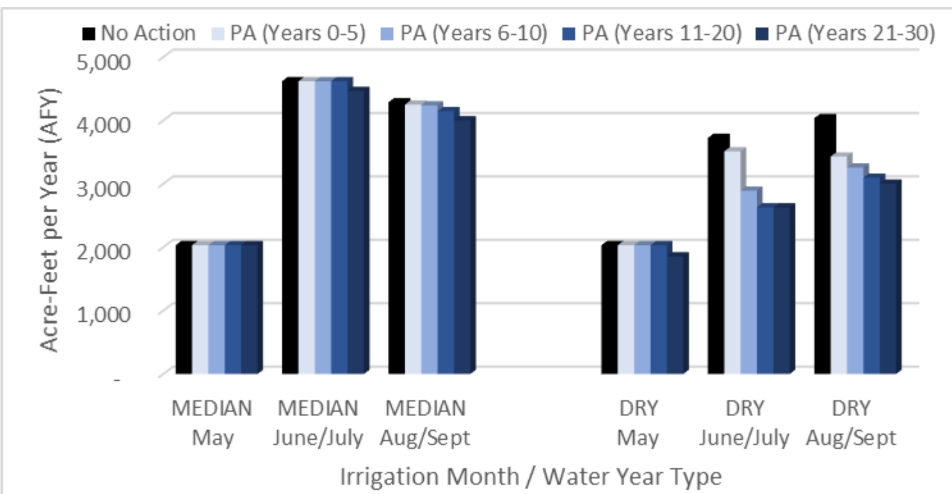


Figure 4. North Unit Irrigation District: Water Available for Diversion under Proposed Action Relative to No-Action Alternative

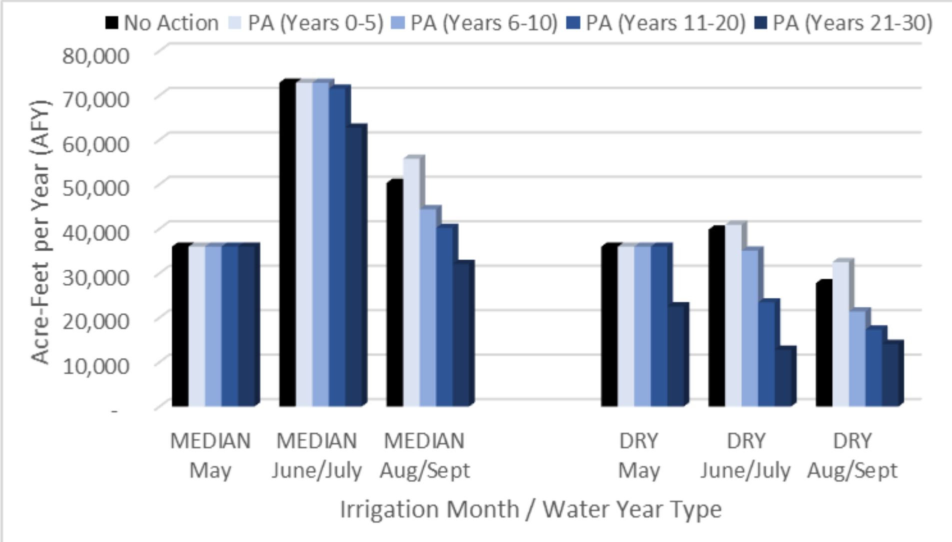


Figure 5. Tumalo Irrigation District: Water Available for Diversion under Proposed Action Relative to No-Action Alternative

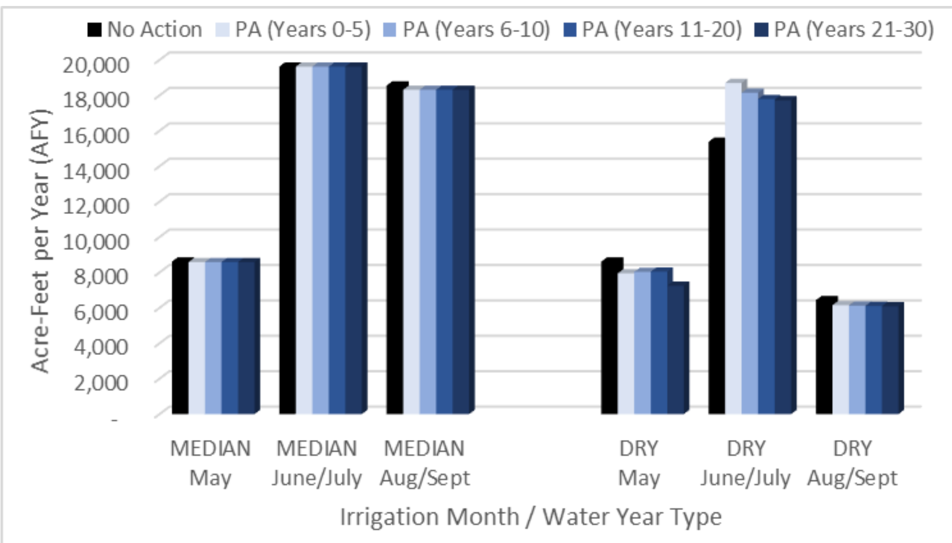
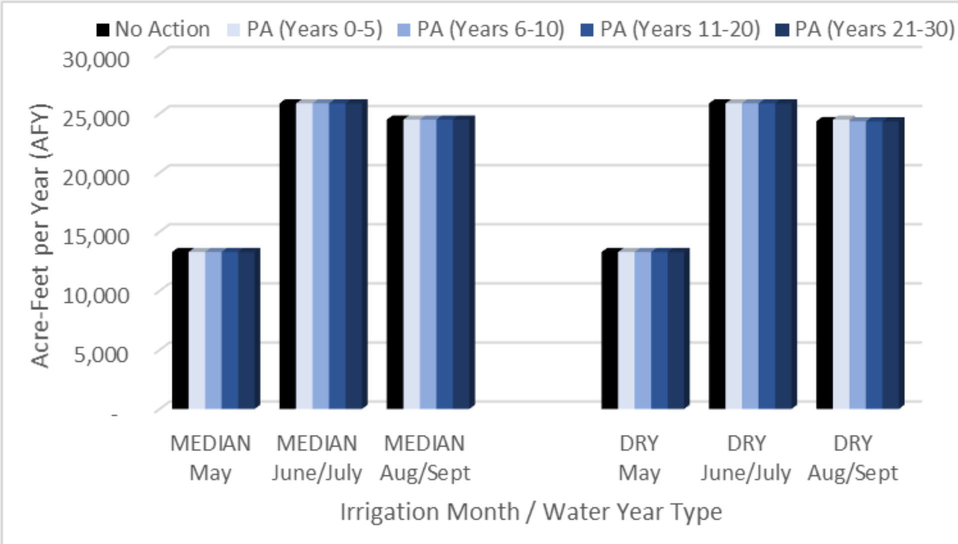


Figure 6. Other Irrigated Lands: Water Available for Diversion under Proposed Action Relative to No-Action Alternative



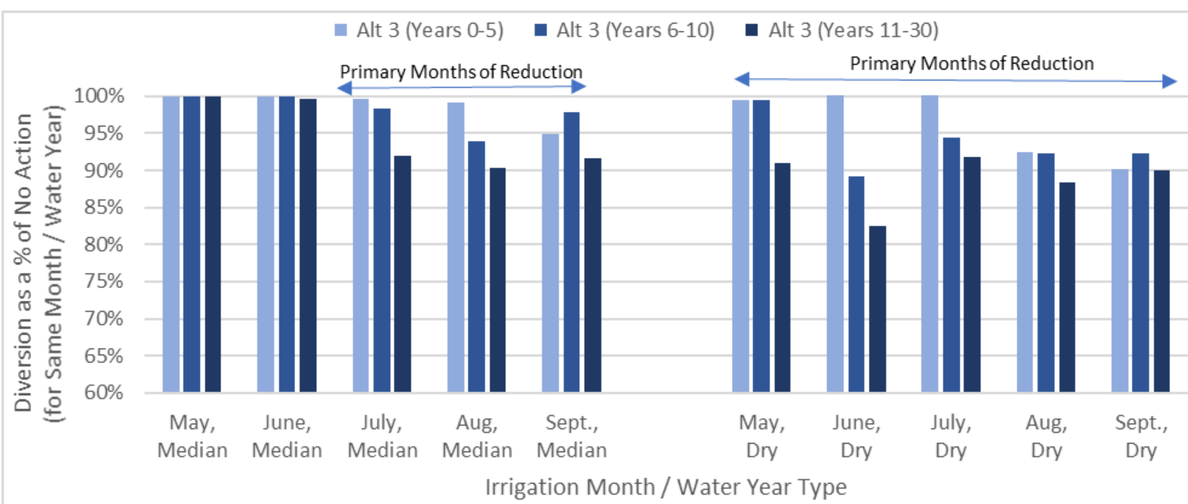
Alternative 3

Table 8 and **Figure 7** summarize the water available for diversion under Alternative 3 over the permit term compared to the no-action alternative. The percent reduction in water available for diversion under Alternative 3 over the entire permit term would be very similar to the changes under the proposed action. The chief difference is that larger reductions in diversions would occur earlier in the permit term under Alternative 3.

Table 8.Changes in Annual Water Available (acre-feet) for Diversion by District under Alternative 3 Compared to the No-Action Alternative, Median and Dry Water Years

	Years 1–5		Years 6–10		Years 11–30		%
District	**Median**	**Dry**	**Median**	**Dry**	**Median**	**Dry**	**Change**
Arnold	-184	-4,906	-489	-5,834	-1,730	-7,583	-1 to -30%
Central Oregon	-1,090	-2,070	-1,265	-3,222	-1,808	-3,873	0 to -1%
Lone Pine	-49	-1,610	-140	-2,035	-436	-2,306	0 to -21%
North Unit	-5,897	-11,212	-11,605	-27,646	-31,461	-55,038	-3 to -41%
Ochoco	0	0	0	0	0	0	0%
Swalley	0	0	0	0	0	0	0%
Three Sisters	0	0	0	0	0	0	0%
Tumalo	36	736	36	377	36	-501	2 to -1%
Other Irrigated Lands	-13	-219	-13	-249	-25	-267	0 to -1%
Total	**-7,197**	**-19,281**	**-13,476**	**-38,609**	**-35,424**	**-69,568**	**-1 to -11%**

Figure 7. Percentage of Water Available for Diversion by Month for Each Water Year Type over the Permit Term for All Irrigated Lands under Alternative 3 as a Percentage of Water Available under the No-Action Alternative



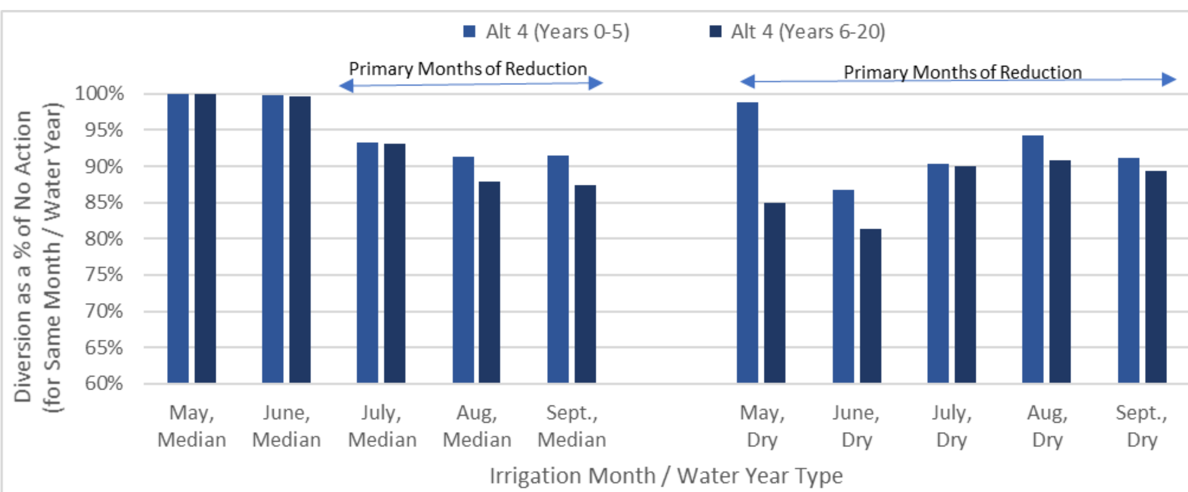
Alternative 4

Table 9 and **Figure 8** summarize the water available for diversion under Alternative 4 over the permit term compared to the no-action alternative. The percent reduction in water available for diversion under Alternative 4 over the permit term would be very similar to the changes under the proposed action. Compared to the proposed action and Alternative 3, larger reductions in diversions would occur earlier in the permit term. Further, North Unit ID would experience a greater percent reduction in water available for diversion (up to -49%) than under the proposed action and Alternative 3 (up to -41% or -42%).

Table 9.Changes in Annual Water Available (acre-feet) for Diversion by DBBC District under Alternative 4 Compared to the No-Action Alternative, Median and Dry Water Years

District	Years 1–5		Years 6–20		% Change
	Median	Dry	Median	Dry	
Arnold	-1,391	-6,225	-1,730	-7,747	-4 to -31%
Central Oregon	-1,543	-3,222	-1,833	-4,049	-1%
Lone Pine	-418	-2,035	-484	-2,306	-4 to -21%
North Unit	-28,819	-35,055	-38,002	-64,050	-15 to -49%
Ochoco	0	0	0	0	0%
Swalley	0	0	0	0	0%
Three Sisters	0	0	0	0	0%
Tumalo	36	363	36	-540	-2 to 1%
Other Irrigated Lands	-25	-248	-25	-265	0 to -1%
Total	**-32,135**	**-46,174**	**-42,013**	**-78,693**	**-4 to -12%**

Figure 8. Percentage of Water Available for Diversion by Month for Each Water Year Type over the Permit Term for All Irrigated Lands under Alternative 4 as a Percentage of Water Available under the No-Action Alternative



Agricultural Water Use Efficiency

Agricultural water use efficiency is a key determinant of the amount of water diverted for agricultural use. The greater the amount of water that is lost to seepage or evaporation (either during conveyance of irrigation water to the crop field or during the irrigation process), the greater the amount of water is required to meet crop water needs. For example, if an acre of alfalfa consumes 3 af/y of water, but canal conveyance efficiency is 55% and on-farm irrigation efficiency is 70%, then to ensure that 3 af/y of water reaches the crop, the diversion requirement is 7.8 af/y, or more than double the crop water requirement.[10]

The surface soils and rocks in much of the Deschutes Basin, due to their volcanic nature, are highly permeable (Lite and Gannett 2002). Due to this high permeability, high water losses from seepage are evident in many irrigation districts in the Deschutes Basin. Much of the irrigation infrastructure in the Deschutes Basin was originally developed in the early 20th century, and consisted of unlined irrigation canals with high seepage rates of 30% or more.

Similarly, historically, much of the farmland in the Deschutes Basin was flood irrigated, which is an irrigation method that typically has a higher seepage rate and evaporation rate relative to many other irrigation methods. In recent years, irrigation districts and farmers in the basin have been making significant investments in improving agricultural water use efficiency in the basin. This includes a number of district piping projects that eliminate seepage from district canals (in the stretches that are piped), and on-farm conversion to more efficient sprinkler and drip irrigation technologies (completed voluntarily by individual farmers). For example, between 2006 and 2013, approximately 40,000 af/y was permanently conserved through a range of projects in the basin (Deschutes River Conservancy and Deschutes Water Alliance 2013). Prior to 2006, 45,360 af/y was permanently conserved in-stream through district piping projects in Central Oregon ID, North Unit ID, Swalley ID, Three Sisters ID, and Tumalo ID (Newton and Perle, Irrigation District Water Efficiency Cost Analysis and Prioritization: DWA Final Report 2006).

Due to these projects, the volume of diversion water required for a given level of crop production has been decreasing over time. In other words, by increasing conveyance and/or on-farm efficiencies, the diversion requirement can be reduced while maintaining the same level of crop production. As such, the effect on agriculture of reducing the amount of water available for diversion depends on the assumed future agricultural water use efficiencies. This analysis accounts for potential future increased conveyance and on-farm efficiencies by using two scenarios regarding future conservation. The analysis includes a low conservation scenario, which assumes only limited future piping occurs to increase district conveyance efficiencies, and there is limited additional on-farm irrigation efficiency improvement. The analysis also includes a high conservation scenario, which assumes that nearly all district piping projects (as outlined in current district planning documents) proceed and higher on-farm irrigation efficiencies are achieved over a realistic timeframe. The high conservation scenario assumes that the Districts are able to obtain outside funding and permits/approvals for the proposed District projects (as yet not obtained for most projects), or that District patrons fully fund both District piping and on-farm improvements (which would likely limit the projects completed and/or slow the timeline of completion). The on-farm efficiency improvements assumed under the high conservation scenario area also outside the control of the Districts and are voluntary measures that may be adopted by District patrons.

[10] The calculation is 3.0 acre-feet / 0.55 / 0.70 = 7.8 acre-feet.

This section briefly describes the past conservation efforts to increase agricultural water use efficiency in the basin, and then focuses on identifying the range of potential conservation projects that may be implemented in the future. The purpose of the section is to project the range of potential agricultural water use efficiency over the analysis period for each district.

Irrigation District Water Efficiency: Piping of Canals

As noted above, piping of district canals is an ongoing effort in the Deschutes Basin. Through 2013, district projects resulted in at least 85,360 af/y of permanent water conservation (Newton and Perle, Irrigation District Water Efficiency Cost Analysis and Prioritization: DWA Final Report 2006) (Deschutes River Conservancy and Deschutes Water Alliance 2013), funded through a combination of user assessments on district patrons and grants obtained from local, state, and federal funding sources. Particularly pertinent to this analysis, there are numerous potential future district piping projects. For the past several years, in an ongoing district modernization effort, Deschutes Basin irrigation districts have been developing System Improvement Plans (SIPs) that quantify water seepage from canals, identify proposed canal segments to be piped, and estimate the water savings and construction costs of piping those segments. These System Improvement Plans are the basis for the districts developing Environmental Assessments (EAs) to support their request for federal funding through the Natural Resources Conservation Service (NRCS). **Table 10** summarizes the status of these proposed district piping projects. The values in the table are estimates only, and the impact of piping on water conservation may be higher in lower than the values presented. Water conservation estimates are based on measurements taken at various locations in the District canal systems, and actual conservation will varies over time and location within a canal system. Conserved water amounts will also vary by water year type.

Table 10. Status of Future Piping of District Canals in the Deschutes Basin

DBBC District	Potential Peak CFS Conservation	Potential Acre-Feet Per Year Conservation	Status	Source
Tumalo	48	15,116	Permitted for federal funding, project to be implemented over next 11 years to 20 years, depending on funding	Tumalo Environmental Assessment, interview with district manager
North Unit	174.4	71,000	System improvement plan developed, no funding procured/applied for	North Unit System Improvement Plan and interviews with district manager
Central Oregon[a]	167.3	53,396	In process of applying for federal permitting/funding	Central Oregon ID System Improvement Plan and interviews with district manager
Swalley	19.2	4,629	Application for federal permitting/funding submitted	Swalley Environmental Assessment
Arnold	32	N/A	System improvement plan developed, funding/permit process not yet completed	Arnold Preliminary Investigative Report, district manager interview
Ochoco	41	N/A	System improvement plan developed, funding/permit process not yet completed	Ochoco Irrigation District System Improvement Plan, district manager interview
Lone Pine	8.8	3,219	System improvement plan developed, funding/permit process not yet completed, but much funding procured	LPID Preliminary Investigative Report, district manager interview

Sources: Black Rock Consulting and Farmers Conservation Alliance 2017; Britton pers. comm; Farmers Conservation Alliance 2018c; Farmers Conservation Alliance 2018a; Farmers Conservation Alliance 2018b; Horrell [b]; Gerdes pers. comm; Horrell pers. comm. [c]; Rhoden and Scanlon pers. comm; Thalacker pers. comm; Rieck pers. comm; Black Rock Consulting and Farmers Conservation Alliance 2018.

[a] This is the piping for which Central Oregon ID is currently seeking funding; total potential cfs conservation from piping in Central Oregon ID is higher.

Based on the data sources in **Table 10**, as well as interviews with district managers, this analysis identified a range of potential district conveyance efficiency improvements over the next 30 years, as presented in **Table 11.** These conveyance efficiencies are a key parameter in estimating how changes in diversions affect changes in crop water supplies. Specifically, conveyance efficiencies are multiplied by the water volume available for diversion for each district in a given irrigation subseason/water year type/permit year to estimate the amount of water delivered to farms in that subseason/water year type/permit year.

In general, the high conservation scenario for district piping assumes that federal funding for piping is procured at the level being sought in the ongoing watershed planning processes being undertaken by the districts in collaboration with the Natural Resources Conservation Service and Farmers

Conservation Alliance. (See for example, the Final Watershed Plan-Environmental Assessment for the Tumalo Irrigation District Modernization Project (Farmers Conservation Alliance 2018b)). Tumalo ID has completed the federal permitting process, and has federal funding for its proposed piping projects procured through 2020. Swalley ID is near completion with the permitting process, while Central Oregon ID, Ochoco ID, Arnold ID, and Lone Pine ID are in the midst of the federal permitting/funding process. The Three Sisters ID has been piping for the last 20 years and will be completely piped in a year (Thalacker pers. comm). Additionally, Lone Pine ID has secured most of the funding necessary for piping and the district manager considers piping to be almost certain to occur (Smith pers. comm).

In the absence of federal funding, only Central Oregon ID plans to pipe in a manner that will result in meaningful conservation of water. Due to the high costs of piping, district managers for Arnold ID and Ochoco ID expect only limited piping would occur without federal funds (Gerdes pers. comm) (Rhoden and Scanlon pers. comm). As such, for the low conservation scenario these districts are assumed to have constant district conveyance efficiency through time. In a low conservation scenario, the Tumalo ID manager estimated that completing the piping projects might require 20 years instead of 10 (Rieck pers. comm). In the low scenario for Lone Pine ID, the same doubling of time required for piping (6 years instead of 3 years) is assumed.

No district piping is assumed for North Unit ID canals even in the high conservation scenario as costs per acre-foot conserved through North Unit ID piping are high relative to other districts (see 2018 Draft Upper Deschutes Basin Study and (Britton pers. comm)). As it is more cost effective, North Unit ID is instead focusing its efforts and financial resources on collaborating with and supporting Central Oregon ID to increase their water savings from piping (which in turn, the districts expect to benefit North Unit ID water supplies) (Britton pers. comm). Because Central Oregon ID water conservation is assumed to benefit North Unit ID, and because the water available for diversion to Central Oregon ID varies minimally between water year types and scenarios, instead of showing district efficiency for Central Oregon ID, this analysis estimates the af of water available to North Unit ID based on conservation projections for Central Oregon ID for each permit year, as shown in **Table 4**. Although not benefiting other water supplies to North Unit ID, the water made available by Central Oregon ID to North Unit would be conveyed in Central Oregon ID pipe for approximately half of the distance to North Unit ID farms. As such, the analysis assumes that once Central Oregon ID piping is complete, the seepage loss for this water will be approximately half of the average seepage loss for North Unit ID farm deliveries (i.e., conveyance efficiency will be 80% instead of 60%), as shown in the last columns of **Table 11**.

Table 11. District Conveyance Efficiencies

	Arnold		Lone Pine		Ochoco		Tumalo		North Unit	Efficiency for Water Made Available by Central Oregon to North Unit	
Year	High	Low	High	Low	High	Low	High	Low	High/Low	High	Low
2019 (Existing Conditions)	61%	61%	80%	80%	59%	59%	54%	54%	60%	60%	60%
2020 (Permit Year 1)	63%	61%	87%	83%	61%	59%	58%	56%	60%	62%	60%
2021	66%	61%	93%	87%	63%	59%	62%	59%	60%	64%	61%
2022	68%	61%	100%	90%	65%	59%	67%	61%	60%	65%	61%
2023	71%	61%	100%	93%	67%	59%	71%	63%	60%	67%	62%
2024	73%	61%	100%	97%	69%	59%	75%	66%	60%	69%	62%
2025	76%	61%	100%	100%	71%	59%	79%	68%	60%	71%	63%
2026	78%	61%	100%	100%	73%	59%	83%	70%	60%	73%	63%
2027	81%	61%	100%	100%	75%	59%	87%	72%	60%	75%	64%
2028	83%	61%	100%	100%	77%	59%	92%	75%	60%	76%	64%
2029	86%	61%	100%	100%	79%	59%	96%	77%	60%	78%	65%
2030	88%	61%	100%	100%	81%	59%	100%	79%	60%	80%	65%
2031	88%	61%	100%	100%	81%	59%	100%	82%	60%	80%	66%
2032	88%	61%	100%	100%	81%	59%	100%	84%	60%	80%	66%
2033	88%	61%	100%	100%	81%	59%	100%	86%	60%	80%	67%
2034	88%	61%	100%	100%	81%	59%	100%	89%	60%	80%	67%
2035	88%	61%	100%	100%	81%	59%	100%	91%	60%	80%	68%
2036	88%	61%	100%	100%	81%	59%	100%	93%	60%	80%	68%
2037	88%	61%	100%	100%	81%	59%	100%	95%	60%	80%	69%
2038	88%	61%	100%	100%	81%	59%	100%	98%	60%	80%	69%
2039–2049	88%	61%	100%	100%	81%	59%	100%	100%	60%	80%	70%, rising to 74% by 2049

Sources: Farmers Conservation Alliance 2018a, Farmers Conservation Alliance 2018c, Farmers Conservation Alliance 2018b, Black Rock Consulting and Farmers Conservation Alliance 2017, Gerdes pers. comm, Rhoden and Scanlon pers. comm, Horrell pers. comm. [b], Rhoden and Scanlon pers. comm, Rieck pers. comm, Britton pers. comm, Smith pers. comm.

Central Oregon ID is currently applying for federal funding to pipe the Pilot Butte Canal, which would result in an estimated 167.3 cfs of water conservation, equal to 53,400 af/y of conserved water once this piping is completed (approximately 319 af per cfs) (Horrell pers. comm [b]). If federal funds are procured, then this piping is projected to be completed over the next 11 years. This equates to approximately 5,340 af/y of additional conserved water each year until 2028, as shown in **Table 12**. If federal funding is not procured, Central Oregon ID expects to continue piping over the next 30 years at an average rate of conservation of 5 cfs per year (as it has averaged in recent years), equivalent to approximately 1,600 af/y of water conservation (5 cfs multiplied by 319 af/y per cfs is approximately 1,600 af/y) (Horrell pers. comm [b]). To allocate these seasonal values to months within the irrigation season, the analysis assumes that water conservation by month is proportionate to total diversion volume by month. Of Central Oregon ID's annual diversions, approximately 16% is in May, 37% is in June/July, and 35% is in August/September. These proportions were applied to the seasonal estimated water conservation to estimate the volume of water conserved in Central Oregon ID in each month that may be available to North Unit ID.

Table 12. Central Oregon Irrigation District, Conserved Water from Piping, Assumed to be Made Available to North Unit Irrigation District

	Season Total		May		June/July		August/ September	
Year	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**
2019 (Existing conditions)	5,340	1,600	859	257	1,954	586	1,855	556
2020 (Permit Year 1)	10,680	3,200	1,717	514	3,908	1,171	3,709	1,111
2021	16,020	4,800	2,576	772	5,863	1,757	5,564	1,667
2022	21,360	6,400	3,434	1,029	7,817	2,342	7,418	2,223
2023	26,700	8,000	4,293	1,286	9,771	2,928	9,273	2,778
2024	32,040	9,600	5,151	1,543	11,725	3,513	11,127	3,334
2025	37,380	11,200	6,010	1,801	13,680	4,099	12,982	3,890
2026	42,720	12,800	6,868	2,058	15,634	4,684	14,836	4,445
2027	48,060	14,400	7,727	2,315	17,588	5,270	16,691	5,001
2028	53,400	16,000	8,585	2,572	19,542	5,855	18,546	5,557
2029	53,400	17,600	8,585	2,830	19,542	6,441	18,546	6,112
2030	53,400	19,200	8,585	3,087	19,542	7,026	18,546	6,668
2031	53,400	20,800	8,585	3,344	19,542	7,612	18,546	7,224
2032	53,400	22,400	8,585	3,601	19,542	8,198	18,546	7,779
2033	53,400	24,000	8,585	3,859	19,542	8,783	18,546	8,335
2034	53,400	25,600	8,585	4,116	19,542	9,369	18,546	8,891
2035	53,400	27,200	8,585	4,373	19,542	9,954	18,546	9,446
2036	53,400	28,800	8,585	4,630	19,542	10,540	18,546	10,002
2037	53,400	30,400	8,585	4,887	19,542	11,125	18,546	10,558
2038	53,400	32,000	8,585	5,145	19,542	11,711	18,546	11,113
2039	53,400	33,600	8,585	5,402	19,542	12,296	18,546	11,669
2040	53,400	35,200	8,585	5,659	19,542	12,882	18,546	12,225
2041	53,400	36,800	8,585	5,916	19,542	13,467	18,546	12,780
2042	53,400	38,400	8,585	6,174	19,542	14,053	18,546	13,336
2043	53,400	40,000	8,585	6,431	19,542	14,639	18,546	13,892
2044	53,400	41,600	8,585	6,688	19,542	15,224	18,546	14,447
2045	53,400	43,200	8,585	6,945	19,542	15,810	18,546	15,003
2046	53,400	44,800	8,585	7,203	19,542	16,395	18,546	15,559
2047	53,400	46,400	8,585	7,460	19,542	16,981	18,546	16,115
2048	53,400	48,000	8,585	7,717	19,542	17,566	18,546	16,670
2049 (Permit year 30)	53,400	49,600	8,585	7,974	19,542	18,152	18,546	17,226

Sources: Highland Economics analysis of Horrell pers. comm [b,c], ; Black Rock Consulting 2016.

On-Farm Water Efficiency: Irrigation and Conveyance

On-farm water conservation investments may include investing in more efficient irrigation technologies and equipment, lining ponds and on-farm canals, and changing irrigation timing. By reducing the amount of water lost to seepage or evaporation, more efficient irrigation systems or more efficient on-farm conveyance systems reduce the amount of water that needs to be delivered to the farm to meet a given level of crop water need. While most lands throughout the basin are irrigated with sprinklers, there are some flood irrigated lands in the basin, which tend to have much lower irrigation efficiency. Even for lands that are irrigated with sprinklers, there is variation in efficiency among different types of sprinklers, between different nozzle sizes, and with different irrigation management and timing. Efficiency of flood may vary from 30 to 45% while efficiency of sprinkler methods, including sprinkler guns, hand lines, wheel lines, and center pivots may vary from 55 to 95% (Central Oregon Irrigation District 2012).

This analysis estimates current on-farm efficiency by comparing historical diversions (as reported by district managers and the 2013 Deschutes Water Planning Initiative Water Supply Goals and Objectives report) with conveyance efficiencies and average crop water requirement (as estimated under *Existing Conditions: Crop Acreage and Crop Water Demand*). Also taken into consideration were previous estimates of on-farm efficiency, including data from district modernization reports, the 2006 Irrigation District Water Efficiency Study (Newton and Perle, Irrigation District Water Efficiency Cost Analysis and Prioritization DWA Final Report 2006), and the 2013 report on the Deschutes Water Planning Initiative Water Supply Goals and Objectives (Deschutes River Conservancy and Deschutes Water Alliance 2013) as well as interviews with district managers, Oregon State University Extension, and with local area irrigation equipment providers (Bohle pers. comm [a]), (Gerdes pers. comm) (Rhoden and Scanlon pers. comm), (Rieck pers. comm), (Britton pers. comm), (Horrell pers. comm [b])). In general, with the exception of North Unit ID, districts are estimated to have on-farm irrigation efficiency of approximately 65 to 70% currently.

Districts have no direct control over on-farm efficiency improvements. However, districts that have been piping have noted that piping often spurs patrons to invest in more efficient irrigation technologies (partly to take advantage of the pressurized water that often comes with piping) (Thalacker pers. comm) (Rieck pers. comm), with increases in irrigation efficiency of 10% or more. As identified by a Central Oregon ID study, piping of district canals and pressurization of water to patron turnouts can decrease by 50% the cost to patrons of converting from flood irrigation to more efficient irrigation technologies (Central Oregon Irrigation District 2017). As such, with increased piping in the high conservation scenario, this analysis also assumes increased on-farm irrigation efficiency.

Specifically, this analysis assumes that average on-farm efficiency in nearly all districts would increase to 80% in the high conservation scenario (**Table 13**). North Unit ID is currently estimated to have an irrigation efficiency of 87%, reflecting partly the use by some patrons of drip irrigation, which can approach 100% irrigation efficiency. Due to the differences between North Unit ID and other districts (crops grown, size of farms, etc.), this analysis does not expect that on-farm irrigation efficiencies in other DBBC districts and irrigated lands would reach the same level as those in North Unit ID, even in the high conservation scenario. Growers in districts with predominantly lower-value crops like hay and pasture are less likely to have the financial resources and management capacity to invest in expensive irrigation technology that would optimize on-farm efficiency (Oregon Environmental Council 2012).

Regarding Central Oregon ID water conservation from on-farm efficiency improvements, this analysis estimates the amount of conserved water using data from two studies of Central Oregon ID on-farm efficiency: the 2011 Central Oregon ID Water Management Conservation Plan and the 2017 Preliminary On-Farm Efficiency Study. The 2011 Central Oregon ID Water Management Conservation Plan estimated that 40% of Central Oregon ID patrons were flood irrigating (or approximately 16,850 acres, assuming 40% of 42,133 acres) (Central Oregon Irrigation District 2012). The remaining 60% were using a sprinkler method, including sprinkler guns, hand lines, wheel lines, and center pivots with efficiency varying from 55 to 95%. By 2017, the 2017 Central Oregon ID Preliminary On-Farm Efficiency Study estimated that there were 11,240 acres that were flood irrigated (Central Oregon Irrigation District 2017).[11] Using these data, from 2011 to 2017 there was likely a conversion of 5,610 acres from flood irrigation to sprinkler irrigation. On an average annual basis, this equates to approximately 800 acres converted per year conserving approximately 1,160 af/y of additional water per year.[12]

In the low conservation scenario, this analysis assumes that Central Oregon ID patrons continue to conserve water at approximately this rate (1,000 af/y) until the 5,610 acres are converted to sprinkler irrigation (over the course of 14 years, assuming 800 acres per year), for approximately 14,000 af/y of cumulative conservation.[13] In the high conservation scenario, the analysis assumes that this conservation rate is doubled, to 2,000 af/y per year and continues through the analysis period (60,000 af/y cumulatively, see **Table 14**). Consultation with the Central Oregon ID district manager indicated that these are reasonable estimates (Horrell pers. comm [b]). As a proportion of total potential on-farm conservation, this also appears reasonable. The 2017 Central Oregon ID Preliminary On-Farm Efficiency Study estimates that 48,255 af/y annually could be conserved by on-farm irrigation improvements and 35,284 af/y from piping of private ditches (downstream of Central Oregon ID delivery points), for a total potential of 83,539 af/y. As such, conservation of 14,000 af/y (in the low scenario) equates to approximately 17% of potential on-farm conservation, while conservation of 60,000 af/y (in the high scenario) equates to 74% of potential on-farm conservation.

[11] The calculation is: 16,850 acres -11,240 acres =5,610 acres.

[12] The calculation is: 5,610 acres / 7 years = ~800 acres / year.

[13] The calculation is: 11,240 acres / 800 acres per year = ~14 years.

Table 13. Estimated On-Farm Efficiencies by DBBC District and Permit Year

	Arnold		Lone Pine		Ochoco		Tumalo		Other Irrigated Lands	North Unit
Year	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High/Low**	**High/Low**
2019 (Existing Conditions)	65%	65%	67%	67%	70%	70%	70%	70%	65%	87%
2020 (Permit Year 1)	66%	65%	68%	67%	71%	70%	71%	71%	65%	87%
2021	68%	66%	69%	67%	72%	70%	72%	71%	65%	87%
2022	69%	66%	70%	68%	73%	70%	73%	72%	65%	87%
2023	70%	67%	72%	68%	74%	70%	74%	72%	65%	87%
2024	72%	67%	73%	68%	75%	70%	75%	73%	65%	87%
2025	73%	68%	74%	69%	75%	70%	75%	73%	65%	87%
2026	75%	68%	75%	69%	76%	70%	76%	74%	65%	87%
2027	76%	69%	76%	69%	77%	70%	77%	74%	65%	87%
2028	77%	69%	78%	69%	78%	70%	78%	75%	65%	87%
2029	79%	70%	79%	70%	79%	70%	79%	75%	65%	87%
2030	80%	70%	80%	70%	80%	70%	80%	76%	65%	87%
2031	80%	70%	80%	70%	80%	70%	80%	76%	65%	87%
2032	80%	70%	80%	70%	80%	70%	80%	77%	65%	87%
2033	80%	70%	80%	70%	80%	70%	80%	77%	65%	87%
2034	80%	70%	80%	70%	80%	70%	80%	78%	65%	87%
2035	80%	70%	80%	70%	80%	70%	80%	78%	65%	87%
2036	80%	70%	80%	70%	80%	70%	80%	79%	65%	87%
2037	80%	70%	80%	70%	80%	70%	80%	79%	65%	87%
2038	80%	70%	80%	70%	80%	70%	80%	80%	65%	87%
2039–2049	80%	70%	80%	70%	80%	70%	80%	80%	65%	87%

Sources: Highland Economics analysis and Deschutes River Conservancy and Deschutes Water Alliance 2013; Central Oregon Irrigation District 2017; Newton and Perle, Irrigation District Water Efficiency Cost Analysis and Prioritization DWA Final Report 2006; Gerdes pers. comm; Britton pers. comm; Rieck pers. comm; Rhoden and Scanlon pers. comm; Thalacker pers. comm.

Table 14. Central Oregon ID On-Farm Conservation, Acre-Feet Per Year Cumulative Over Time, Available for Use by North Unit

	Season		May		June/July		August/ September	
Year	High	Low	High	Low	High	Low	High	Low
2019 (Existing Conditions)	2,000	1,000	322	161	732	366	695	347
2020 (Permit Year 1)	4,000	2,000	643	322	1,464	732	1,389	695
2021	6,000	3,000	965	482	2,196	1,098	2,084	1,042
2022	8,000	4,000	1,286	643	2,928	1,464	2,778	1,389
2023	10,000	5,000	1,608	804	3,660	1,830	3,473	1,736
2024	12,000	6,000	1,929	965	4,392	2,196	4,168	2,084
2025	14,000	7,000	2,251	1,125	5,123	2,562	4,862	2,431
2026	16,000	8,000	2,572	1,286	5,855	2,928	5,557	2,778
2027	18,000	9,000	2,894	1,447	6,587	3,294	6,251	3,126
2028	20,000	10,000	3,215	1,608	7,319	3,660	6,946	3,473
2029	22,000	11,000	3,537	1,768	8,051	4,026	7,640	3,820
2030	24,000	12,000	3,859	1,929	8,783	4,392	8,335	4,168
2031	26,000	13,000	4,180	2,090	9,515	4,758	9,030	4,515
2032	28,000	14,000	4,502	2,251	10,247	5,123	9,724	4,862
2033	30,000	14,000	4,823	2,251	10,979	5,123	10,419	4,862
2034	32,000	14,000	5,145	2,251	11,711	5,123	11,113	4,862
2035	34,000	14,000	5,466	2,251	12,443	5,123	11,808	4,862
2036	36,000	14,000	5,788	2,251	13,175	5,123	12,503	4,862
2037	38,000	14,000	6,109	2,251	13,907	5,123	13,197	4,862
2038	40,000	14,000	6,431	2,251	14,639	5,123	13,892	4,862
2039	42,000	14,000	6,752	2,251	15,370	5,123	14,586	4,862
2040	44,000	14,000	7,074	2,251	16,102	5,123	15,281	4,862
2041	46,000	14,000	7,396	2,251	16,834	5,123	15,976	4,862
2042	48,000	14,000	7,717	2,251	17,566	5,123	16,670	4,862
2043	50,000	14,000	8,039	2,251	18,298	5,123	17,365	4,862
2044	52,000	14,000	8,360	2,251	19,030	5,123	18,059	4,862
2045	54,000	14,000	8,682	2,251	19,762	5,123	18,754	4,862
2046	56,000	14,000	9,003	2,251	20,494	5,123	19,449	4,862
2047	58,000	14,000	9,325	2,251	21,226	5,123	20,143	4,862
2048	60,000	14,000	9,646	2,251	21,958	5,123	20,838	4,862
2049 (Permit Year 30)	62,000	14,000	9,968	2,251	22,690	5,123	21,532	4,862

Sources: Highland Economics analysis and Central Oregon Irrigation District 2017; Central Oregon Irrigation District 2012; Horrell pers. comm [b].

Water Available for Crops (Accounting for Efficiency)

To estimate the water supply available to meet crop water requirements (crop ET), this analysis combined water available for diversion data from RiverWare (*Water Available for Diversion under Proposed Action and Alternatives*) with the estimated district conveyance and on-farm efficiencies provided above (*Agricultural Water Use Efficiency*). In other words, water available for diversion in each alternative and water year type over the permit term was multiplied by the estimated conveyance efficiency and on-farm efficiency to estimate total water available by crop in each water year type, permit year, conservation scenario, and alternative. No data are presented for Swalley ID because its water supply would not be affected by the proposed action and alternatives.

Existing Conditions

Table 15 and **Table 16** summarize, respectively, the median and dry water year availability of water to crops under existing conditions by district based on water available for diversion and estimated existing district and on-farm efficiencies. (This is using data from RiverWare for the no-action alternative, which is expected to be very similar to existing conditions). As apparent in comparing values in **Table 15** and **Table 16**, under existing conditions, there is less water available for diversion in some districts in dry water years, particularly (in terms of percentage reductions) in North Unit ID, Arnold ID, Tumalo ID, and Three Sisters ID. For all districts that face a shortage under existing conditions (and likewise the no-action alternative), any reduction in water diversions resulting from the proposed action and alternatives would compound an existing crop water shortage.

As discussed above under assumptions, potential increases in water available to crops are not an effect of the proposed action and alternatives, but rather an outcome that would similarly affect all future conditions. Furthermore, whether conservation efforts could result in more water being made available to agriculture in the future than under existing conditions is uncertain, as districts and growers (and funding agencies) would likely be most incentivized to invest in conservation that would reduce water shortfalls rather than increase water available to crops beyond current conditions. As such, the analysis caps the total water available to the crop (after accounting for conveyance and irrigation efficiencies) in median and dry water year types in all future years to the median existing conditions water available to the crop.

Table 15. Water Available for Diversions and Water Available to Crops by District under Existing Conditions, Median Water Year

District	Water Available for Diversion, acre-feet per year			District Conveyance Efficiency	On-Farm Efficiency	Water Available to Crop, acre-feet per year		
	May	June/July	Aug/Sept			May	June/July	Aug/Sept
Arnold	5,232	10,951	11,099	61%	65%	2,075	4,342	4,401
Central Oregon	46,250	105,279	99,908	68%	60%	18,870	42,954	40,763
Lone Pine[a]	2,031	4,618	4,374	80%	67%	1,089	2,475	2,344
North Unit	37,557	78,202	65,839	60%	87%	19,605	40,822	34,368
Ochoco	22,780	46,965	42,117	59%	70%	9,408	19,396	17,394
Tumalo	8,610	19,622	18,553	54%	70%	3,255	7,417	7,013
Three Sisters	4,243	11,720	6,820	100%	70%	2,983	8,239	4,794
Other Irrigated Lands	5,180	10,516	7,637	60%	65%	2,020	4,101	2,978

Sources: Highland Economics analysis of data provided in sections entitled Water Available for Diversion under the Proposed Action and Alternatives, Agricultural Water Used Efficiency, and Water Available for Crops (Accounting for Efficiency)).

[a] District conveyance efficiency is based on canals within Lone Pine ID, not including conveyance loss in Pilot Butte Canal. The water available for diversion to Lone Pine ID is based on the amount of water at the diversion location on the Pilot Butte Canal.

Table 16. Water Available for Diversions and Water Available to Crops by District under Existing Conditions, Dry Water Year

	Water Available for Diversion			District		Water Available to Crop			
District	**May**	**June/ July**	**Aug/ Sept**	**Conveyance Efficiency**	**On-Farm Efficiency**	**May**	**June/ July**	**Aug/ Sept**	**% of Median (May-Aug)**
Arnold	5,232	7,335	9,367	61%	65%	2,075	2,908	3,714	80%
Central Oregon	46,006	103,030	97,429	68%	60%	18,771	42,036	39,751	98%
Lone Pine[a]	2,031	4,513	4,173	80%	67%	1,089	2,419	2,237	97%
North Unit	37,557	76,332	31,612	60%	87%	19,605	39,845	16,502	80%
Ochoco	22,780	46,965	42,117	59%	70%	9,408	19,396	17,394	100%
Tumalo	5,693	5,740	3,951	54%	70%	2,152	2,170	1,494	33%
Three Sisters	4,626	10,269	5,781	100%	70%	3,252	7,219	4,064	91%
Other Irrigated Lands	5,162	10,411	8,214	60%	65%	2,013	4,060	3,203	102%

Sources: Highland Economics analysis of data provided in sections entitled Water Available for Diversion under the Proposed Action and Alternatives, Agricultural Water Used Efficiency, and Water Available for Crops (Accounting for Efficiency).

[a] District conveyance efficiency is based on canals within Lone Pine ID, not including conveyance loss in Pilot Butte Canal. The water available for diversion to Lone Pine ID is based on the amount of water at the diversion location on the Pilot Butte Canal.

No-Action Alternative

Water available to crops in the no-action alternative is expected to be the same as existing conditions for median water years.[14] However, the water available to crops in dry water years in the no-action alternative is anticipated to increase over time compared to existing conditions due to conservation. **Table 17** summarizes increased water available to crops over the analysis period in dry water years under the no-action alternative compared to existing conditions (from **Table 16**). As highlighted in the table, on-farm and district conservation of water is particularly expected to benefit Arnold ID, Lone Pine ID, North Unit ID, and Tumalo ID. Note that no additional water is assumed to be permanently available for Central Oregon ID (as all conservation is assumed to be made available to North Unit ID), although Central Oregon ID management expects that increased operational efficiencies will result in increased water availability for Central Oregon ID patrons in dry water years.

Table 17. Increased Water Available to Crops by District in No-Action Alternative Compared to Existing Conditions, Dry Water Year (acre-feet per year)

	Low Conservation			High Conservation		
District/ Year	**May**	**June/ July**	**Aug/ Sept**	**May**	**June/ July**	**Aug/ Sept**
Arnold						
2020	0	0	0	0	200	200
2025	0	100	100	0	1,100	1,200
2030	0	200	200	0	1,100	1,200
2040	0	200	200	0	1,100	1,200
2049	0	200	200	0	1,100	1,200
Central Oregon ID						
2020	0	0	0	0	0	0
2025	0	0	0	0	0	0
2030	0	0	0	0	0	0
2040	0	0	0	0	0	0
2049	0	0	0	0	0	0
Lone Pine						
2020	0	200	100	0	300	100
2025	0	500	100	0	500	100
2030	0	500	100	0	500	100
2040	0	500	100	0	500	100
2049	0	500	100	0	500	100

[14] As noted above, because future crop water supply in median water years is not allowed to exceed median crop water supply in existing conditions, there is no increased water supply to crops in future median water years under the no-action alternative.

District/ Year	Low Conservation May	Low Conservation June/ July	Low Conservation Aug/ Sept	High Conservation May	High Conservation June/ July	High Conservation Aug/ Sept
North Unit						
2020	0	1,100	400	0	3,000	1,200
2025	0	3,800	1,500	0	12,200	4,900
2030	0	6,800	2,700	0	17,200	8,300
2040	0	11,500	4,600	0	17,200	10,500
2049	0	15,800	6,300	0	17,200	11,800
Ochoco						
2020	0	0	0	0	500	400
2025	0	0	0	0	2,300	2,300
2030	0	0	0	0	2,300	2,300
2040	0	0	0	0	2,300	2,300
2049	0	0	0	0	2,300	2,300
Three Sisters						
2020	0	0	0	0	0	0
2025	0	0	0	0	0	0
2030	0	0	0	0	0	0
2040	0	0	0	0	0	0
2049	0	0	0	0	0	0
Tumalo						
2020	0	300	100	0	500	200
2025	0	1,600	800	0	1,600	1,400
2030	0	1,600	1,400	0	1,600	2,700
2040	0	1,600	2,700	0	1,600	2,700
2049	0	1,600	2,700	0	1,600	2,700
Other Irrigated Lands						
2020	0	0	0	0	0	0
2025	0	0	0	0	0	0
2030	0	0	0	0	0	0
2040	0	0	0	0	0	0
2049	0	0	0	0	0	0

Proposed Action

Table 18 presents the estimated change in water available to crops by each district under the proposed action compared to the no-action alternative. The alternatives are compared for the same conservation scenario and water year type.

Table 18. Reduction in Water Available to Crops (acre-feet per year) by District under the Proposed Action Compared to the No-Action Alternative

	Dry Water Year						Median Water Year					
	Low Conservation			High Conservation			Low Conservation			High Conservation		
District	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept
Arnold												
2020	0	-1,400	-200	0	-1,500	-200	0	0	0	0	0	0
2025	0	-1,000	-1,000	0	-1,100	-1,300	0	0	0	0	0	0
2030	0	-1,300	-1,200	0	-700	-600	0	0	0	0	0	0
2040	-400	-1,300	-1,300	0	-700	-900	0	-200	0	0	0	0
2049	-400	-1,300	-1,300	0	-700	-900	0	-200	0	0	0	0
Central Oregon ID												
2020	0	0	0	0	0	0	0	0	0	0	0	0
2025	0	0	0	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0	0	0	0	0	0
2040	0	0	0	0	0	0	0	0	0	0	0	0
2049	0	0	0	0	0	0	0	0	0	0	0	0
Lone Pine												
2020	0	-200	-400	0	-300	-300	0	0	0	0	0	0
2025	0	-300	0	0	-100	0	0	0	0	0	0	0
2030	0	-500	0	0	-200	0	0	0	0	0	0	0
2040	0	-500	0	0	-200	0	0	0	0	0	0	0
2049	0	-500	0	0	-200	0	0	0	0	0	0	0
North Unit												
2020	0	600	2,500	0	600	2,500	0	0	0	0	0	0
2025	0	-2,500	-3,300	0	-2,500	-3,300	0	0	-1,500	0	0	0
2030	0	-8,500	-5,500	0	-5,000	-5,500	0	0	-2,600	0	0	0
2040	-1,800	-14,100	-7,100	0	-5,200	-7,100	0	0	-4,900	0	0	0
2049	0	-14,100	-7,100	0	-400	-6,500	0	0	-3,200	0	0	0

	Dry Water Year						Median Water Year					
	Low Conservation			High Conservation			Low Conservation			High Conservation		
District	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept
Ochoco												
2020	0	-1,300	-1,200	0	0	0	0	0	0	0	0	0
2025	0	-1,300	-1,200	0	0	0	0	0	0	0	0	0
2030	0	-1,300	-1,200	0	0	0	0	0	0	0	0	0
2040	0	-1,300	-1,200	0	0	0	0	0	0	0	0	0
2049	0	-1,300	-1,200	0	0	0	0	0	0	0	0	0
Tumalo												
2020	-100	1,300	-100	0	1,100	-100	0	0	0	0	0	0
2025	0	0	-200	0	0	-200	0	0	0	0	0	0
2030	0	0	-200	0	0	-300	0	0	0	0	0	0
2040	0	0	-300	0	0	-300	0	0	0	0	0	0
2049	0	0	-300	0	0	-300	0	0	0	0	0	0
Three Sisters												
2020	0	0	0	0	0	0	0	0	0	0	0	0
2025	0	0	0	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0	0	0	0	0	0
2040	0	0	0	0	0	0	0	0	0	0	0	0
2049	0	0	0	0	0	0	0	0	0	0	0	0
Other Irrigated Lands												
2020	0	0	0	0	0	0	0	0	0	0	0	0
2025	0	0	0	0	0	0	0	0	0	0	0	0
2030	0	0	-100	0	0	-100	0	0	0	0	0	0
2040	0	0	-100	0	0	-100	0	0	0	0	0	0
2049	0	0	-100	0	0	-100	0	0	0	0	0	0

Alternative 3

Table 19 presents the estimated change in water available to crops under Alternative 3 compared to the no-action alternative. The alternatives are compared for the same conservation scenario and water year type. Because the reductions in water available for diversion are occurring earlier in the permit term (with a different level of conservation achieved) in Alternative 3 compared to the proposed action, the reduction in water available to crops may differ for a given diversion reduction.

Table 19. Reduction in Water Available to Crops (acre-feet per year) by District under Alternative 3 Compared to the No-Action Alternative

	Dry Water Year						Median Water Year					
	Low Conservation			High Conservation			Low Conservation			High Conservation		
District	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept
Arnold												
2020	0	-1,000	-1,000	0	-1,000	-1,100	0	0	0	0	0	0
2025	0	-1,300	-1,100	0	-1,500	-1,400	0	0	0	0	0	0
2030	-400	-1,300	-1,300	0	-700	-900	0	-200	0	0	0	0
2040	-400	-1,300	-1,300	0	-700	-900	0	-200	0	0	0	0
2049	-400	-1,300	-1,300	0	-700	-900	0	-200	0	0	0	0
Central Oregon ID												
2020	0	0	0	0	0	0	0	0	0	0	0	0
2025	0	0	0	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0	0	0	0	0	0
2040	0	0	0	0	0	0	0	0	0	0	0	0
2049	0	0	0	0	0	0	0	0	0	0	0	0
Lone Pine												
2020	0	-600	-500	0	-600	-400	0	0	0	0	0	0
2025	0	-500	0	0	-300	0	0	0	0	0	0	0
2030	0	-500	0	0	-200	0	0	0	0	0	0	0
2040	0	-500	0	0	-200	0	0	0	0	0	0	0
2049	0	-500	0	0	-200	0	0	0	0	0	0	0
North Unit												
2020	0	1,800	-7,000	0	1,800	-7,000	0	0	-2,700	0	0	-1,900
2025	0	-8,800	-5,700	0	-8,800	-5,700	0	0	-3,800	0	0	-400
2030	-1,300	-14,900	-8,800	0	-11,400	-8,800	0	0	-8,300	0	0	-2,800
2040	0	-8,800	-8,800	0	0	-8,800	0	0	-6,500	0	0	-600
2049	0	0	-8,800	0	0	-8,200	0	0	-4,700	0	0	0

	Dry Water Year						Median Water Year					
	Low Conservation			High Conservation			Low Conservation			High Conservation		
District	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept
Ochoco												
2020	0	-1,300	-1,200	0	0	0	0	0	0	0	0	0
2025	0	-1,300	-1,200	0	0	0	0	0	0	0	0	0
2030	0	-1,300	-1,200	0	0	0	0	0	0	0	0	0
2040	0	-1,300	-1,200	0	0	0	0	0	0	0	0	0
2049	0	-1,300	-1,200	0	0	0	0	0	0	0	0	0
Tumalo												
2020	-100	1,100	-100	0	1,100	-100	0	0	0	0	0	0
2025	0	0	-200	0	0	-200	0	0	0	0	0	0
2030	0	0	-200	0	0	-300	0	0	0	0	0	0
2040	0	0	-300	0	0	-300	0	0	0	0	0	0
2049	0	0	-300	0	0	-300	0	0	0	0	0	0
Three Sisters												
2020	0	0	0	0	0	0	0	0	0	0	0	0
2025	0	0	0	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0	0	0	0	0	0
2040	0	0	0	0	0	0	0	0	0	0	0	0
2049	0	0	0	0	0	0	0	0	0	0	0	0
Other Irrigated Lands												
2020	0	0	0	0	0	0	0	0	0	0	0	0
2025	0	0	-100	0	0	-100	0	0	0	0	0	0
2030	0	0	-100	0	0	-100	0	0	0	0	0	0
2040	0	0	-100	0	0	-100	0	0	0	0	0	0
2049	0	0	-100	0	0	-100	0	0	0	0	0	0

Alternative 4

Table 20 presents the estimated change in water available to crops under Alternative 4 compared to the no-action alternative. The alternatives are compared for the same conservation scenario and water year type. Because the reductions in water available for diversion are occurring earlier in the permit term (with a different level of conservation achieved) in Alternative 4 compared to the proposed action and Alternative 3, the reduction in water available to crops may differ for a given diversion reduction.

Table 20. Reduction in Water Available to Crops (acre-feet per year) by District under Alternative 4 Compared to the No-Action Alternative

	Dry Water Year						Median Water Year					
	Low Conservation			High Conservation			Low Conservation			High Conservation		
District	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept
Arnold												
2020	-100	-2,200	-200	0	-2,300	-200	0	-400	-100	0	-200	0
2025	-500	-2,200	-300	0	-2,800	-400	0	-300	0	0	0	0
2030	-500	-2,300	-300	0	-2,400	0	0	-200	0	0	0	0
2039	-500	-2,300	-300	0	-2,400	0	0	-200	0	0	0	0
Central Oregon												
2020	0	0	0	0	0	0	0	0	0	0	0	0
2025	0	0	0	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0	0	0	0	0	0
2039	0	0	0	0	0	0	0	0	0	0	0	0
Lone Pine												
2020	0	-700	-600	0	-800	-500	0	0	-100	0	0	0
2025	0	-500	-100	0	-400	0	0	0	0	0	0	0
2030	0	-500	0	0	-200	0	0	0	0	0	0	0
2039	0	-500	0	0	-200	0	0	0	0	0	0	0
North Unit												
2020	0	-11,800	-6,300	0	-11,800	-6,300	0	-3,300	-10,100	0	-1,300	-9,300
2025	-6,600	-15,500	-8,900	-2,800	-15,500	-8,900	0	-500	-13,800	0	0	-10,400
2030	-5,300	-15,500	-8,900	0	-12,000	-8,900	0	0	-12,600	0	0	-7,000
2039	-3,300	-15,500	-8,900	0	-7,200	-8,900	0	0	-10,900	0	0	-5,100
Ochoco												
2020	0	-1,300	-1,200	0	0	0	0	0	0	0	0	0
2025	0	-1,300	-1,200	0	0	0	0	0	0	0	0	0
2030	0	-1,300	-1,200	0	0	0	0	0	0	0	0	0
2039	0	-1,300	-1,200	0	0	0	0	0	0	0	0	0

	Dry Water Year						Median Water Year					
	Low Conservation			High Conservation			Low Conservation			High Conservation		
District	**May**	**June/ July**	**Aug/ Sept**	**May**	**June/ July**	**Aug/ Sept**	**May**	**June/ July**	**Aug/ Sept**	**May**	**June/ July**	**Aug/ Sept**
Tumalo												
2020	-100	1,100	-100	0	1,100	-100	0	0	0	0	0	0
2025	0	0	-200	0	0	-200	0	0	0	0	0	0
2030	0	0	-200	0	0	-300	0	0	0	0	0	0
2039	0	0	-300	0	0	-300	0	0	0	0	0	0
Three Sisters												
2020	0	0	0	0	0	0	0	0	0	0	0	0
2025	0	0	0	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0	0	0	0	0	0
2039	0	0	0	0	0	0	0	0	0	0	0	0
Other Irrigated Lands												
2020	0	0	-100	0	0	-100	0	0	0	0	0	0
2025	0	0	-100	0	0	-100	0	0	0	0	0	0
2030	0	0	-100	0	0	-100	0	0	0	0	0	0
2039	0	0	-100	0	0	-100	0	0	0	0	0	0

Farm Response to Crop Water Shortages: Change in Acreage

This section summarizes how estimated changes in water availability to crops (as presented in ***Water Available for Crops (Accounting for Efficiency)***) translate into changes in farm acreage/crop production. Given the current cropping pattern, growers could respond to reduction in water supplies in the following ways:

- Reduce harvested acreage due to fallowing of lands or crop failure.
- Reduce yields due to deficit irrigation (irrigation less than crop water requirement).

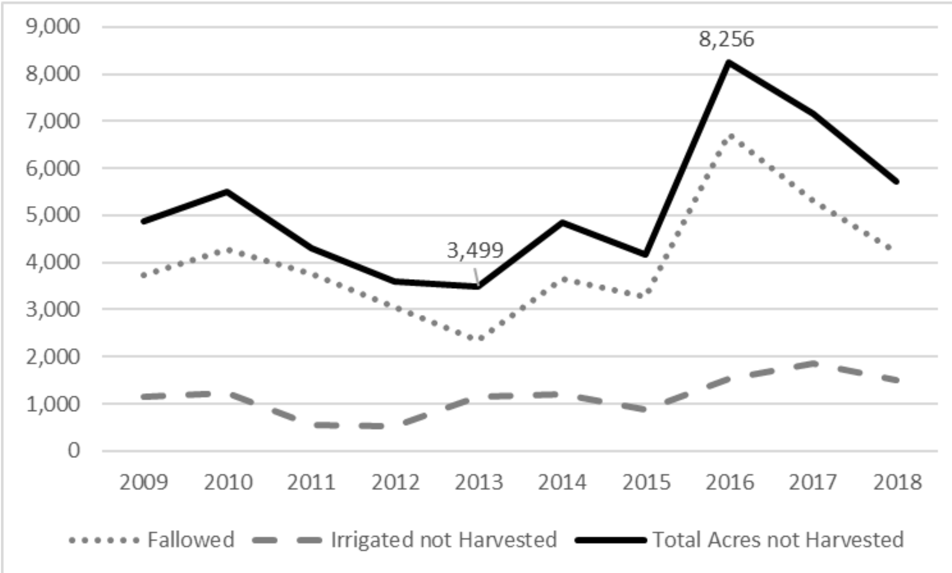
Growers may also transition to lower water use crops if such a transition is economically viable. However, as noted in *Methods, Key Assumptions, and Data Sources,* this analysis assumes that when water supply is available, the future crop mix and acreage will remain similar to the current cropping pattern. In particular, the analysis assumes that forage crops will remain the predominant crop in the study area, which is consistent with the historical agricultural pattern in the region. As the market and economic potential, as well as farmer preference, for large-scale transition to other crops is not known and is speculative, this analysis estimates the effects of changes in water availability assuming the current cropping pattern. To the extent that other relatively lower water use crops replace forage crops on a wide-scale basis, the effects analyzed in this section would likely be overestimated due to the lower water requirement of these crops.

Assuming grower response options are fallowing and deficit irrigation, with a 10% reduction in water availability, a grower could a) reduce water application on all acres by 10%, b) fallow 10% of ground, or c) do a mixture of deficit irrigation and fallowing. As impacts on alfalfa and grass hay yield are roughly linear (i.e., a 10% reduction in water application may result in a 10%, or even more, reduction in yield) (Bohle pers. comm. [a]), the impact on total agricultural production of fallowing and of deficit irrigating may be fairly similar. This analysis assumes that all reductions in water supply result in fallowed acreage (rather than deficit irrigation) for the following reasons:

- Yield responses to water supply are complex, and the effect of reduced water application on yield, particularly of grass hay, may be proportionately greater than the decrease in water application.
- Forage crop quality may suffer with reduced water application (less water can lead to nitrate accumulation in hay, which creates problems in animals) (Bohle pers. comm. [a]).

Lands are fallowed in the study area in all years for various agronomic and farm-specific reasons, but annual acreage data from North Unit ID supports the assumption that more lands are fallowed in dry years. As shown in **Figure 9,** acreage not harvested in the last 10 years in North Unit ID (including both fallowed and irrigated and not harvested lands) has varied from approximately 3,500 acres to 8,250 acres. The highest level of fallowing occurred in 2016, a dry year with low water availability (North Unit Irrigation District 2016).

Figure 9. Annual North Unit ID Acres Not Harvested, 2009–2018



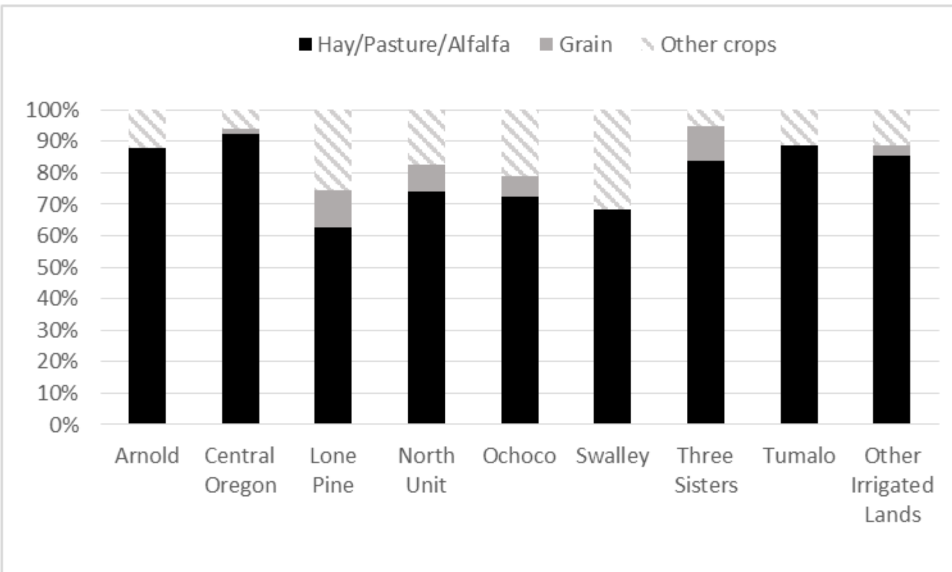
Source: Highland Economics analysis of North Unit ID crop acreage provided by Bohle pers. comm. [b].

When faced with water shortages, the decision to fallow versus deficit irrigate will vary by farm. As a consequence of assuming that all reductions in water supply result in fallowing acreage (rather than deficit irrigation), the estimated impacts on irrigated acreage presented in the summary tables below are expected to be the *maximum* agricultural acreage that may be fallowed in any given scenario/permit year (i.e., the maximum potential expected impact). As such, fewer acres than presented here may be impacted during certain periods of the irrigation season when more irrigation water is available relative to crop water demand.

The subseason analysis shows that many acres would likely be irrigated in April and May (months in which, in nearly all years and in all districts, irrigation water supplies are sufficient to meet crop water demand, see **Figure 1.**) Then, when facing reduced irrigation water supplies in later summer months (when water supplies relative to crop demand are proportionately lower in many districts), growers would deficit irrigate or potentially cease to irrigate these acres for the remainder of the season. The first cutting of alfalfa and grass hay is often at the beginning of June, so with full irrigation water supplies in April and May, one cutting of hay (approximately one-third of annual yield) would likely still be achieved on many of the acres projected to be affected in this section. For example, if estimated impacts in a district are limited to 100 acres in May through July, but are estimated at 500 acres in August/September, the maximum potential acreage impact presented for the year is 500 acres. In summary, if a maximum of 500 acres may be impacted in a given year, it is likely that one cutting, or approximately one-third of yield on these 500 acres would still be feasible on this acreage (this is accounted for in the socioeconomics that analyzes the impacts on total agricultural production value and the agricultural economy).

The analysis also assumes, consistent with economic theory and grower and Oregon State Extension interviews, that growers would minimize negative effects on profit of water supply changes, and would thus seek to limit impacts on higher value, specialty crops (Bohle pers. comm. [a]) (Richards pers. comm). In other words, the analysis assumes that growers would fallow or deficit irrigate grains and forage crops (hay, pasture, and alfalfa) before reducing water to high-value specialty crops such as mint, carrot seed, or grass seed. As highlighted in **Figure 10** below, in all districts, grain and forage crops are the predominant water users (representing at least 75% of crop water requirement across districts affected by the proposed action and alternatives) and so would bear the brunt of reduced water supplies. Nearly all districts have at least some high value, specialty crop acreage such as carrot seed, peppermint, grass seed, and vegetables. However, these specialty crops are typically grown in rotation with grains and alfalfa and thus growers would likely be able to fallow their grain/forage crops and minimize impacts on their specialty crops, or) potentially purchase water from other farms growing predominantly forage crops in their district (Bohle pers. comm. [a]) (Richards pers. comm).

Figure 10. Forage, Grain, and Other Crop Water Requirement by DBBC District: Current Cropping Pattern



Source: Highland Economics analysis of acreage and ET data presented in *Existing Conditions: Crop Acreage and Crop Water Demand*.

In sum, the analysis assumes that growers prioritize irrigating their higher-valued, lower-water use crops. In all alternatives, in all permit years/water year types/conservation scenario combinations, the RiverWare water supply model indicates that there is sufficient water to continue to irrigate the current acreage of these higher-valued crops (i.e., at the district level of analysis it is feasible to only reduce water to forage/grain crops and maintain crop water supply to specialty crops). While reduced water supplies impair the flexibility of growers to increase acreage of these specialty crops, this analysis indicates that continued full irrigation of current acreages of these high-value crops is possible if irrigating these crops is prioritized by growers. (As discussed in the socioeconomics analysis, this prioritization may come at a cost to specialty crop growers if their operation is heavily concentrated in high-value crops and they need to purchase water from other growers with predominantly hay/grain crops.) To the extent that an individual farmer does not have sufficient forage/grain crop acreage to enable on-farm re-allocation of water to high value crops, or is not able to purchase water from other forage/grain crop growers, high-value crops may be impacted.

In general, the findings on potentially affected acreage presented below highlight that three irrigation districts in particular would be affected by the proposed action and alternatives: North Unit ID, Arnold ID, and Lone Pine ID. There are also some very small impacts on Other Irrigated Lands, Tumalo ID, and potentially Central Oregon ID. The water supply model shows minor reduced water availability for Central Oregon ID, but as noted above, Central Oregon ID expects that continued piping as well as modifications to district operations in the shoulder seasons would ensure that this change has little to no effect on patron deliveries (Horrell pers. comm. [a,b]). As described above, there are also potential impacts on Ochoco ID in dry water years that are not projected in RiverWare and not analyzed herein.

Further, the values presented below represent the range in the maximum affected acreage in any one irrigation season, with variation across the permit years, water year types, and conservation scenarios. Water availability to crops moves up and down across the analysis period since conveyance and on-farm conservation increases water supply availability, while the increased instream flow requirements reduce water supply availability.

The subseason impacts are the basis to estimate the maximum affected acreage at any point in the irrigation season shown**.** However, for dry years, the maximum affected acreage in any one subseason for a given district/year/scenario would only necessarily equal the maximum annual impact if the maximum subseason acreage impact in the no-action alternative and proposed action occurs in the same irrigation subseason. This is also true for the alternatives presented below. Also of note is that in some cases, the impact of the proposed action and alternatives does not differ between the low and high conservation scenarios. This is because the same water conservation is assumed under all alternatives, so the impact of the alternatives (i.e., the difference in acreage from the no-action alternative) under both conservation scenarios is similar in some cases.

Agricultural Acreage: No-Action Alternative

In each water year type, the amount of water available for diversion under the no-action alternative would be similar to existing conditions. As such, the average acreage irrigated by district under the no-action alternative is expected to be very similar to the acreage presented above in **Table 1**. Similarly, in the initial years of the analysis period, the no-action alternative dry year agricultural acreage would be similar to existing conditions as presented above in **Table 2**. However, due to water conservation over the analysis period, under no-action alternative, water available to crops in dry water years may increase over time compared to existing conditions, which may lead to increased acreage and/or yields in dry water years over the analysis period. **Table 22** summarizes the effect on irrigated acreage under the no-action alternative in dry water years throughout the analysis period. **Table 23** presents detail on effects by irrigation subseason for a dry year.

Table 21. Estimated Minimum Irrigated Acreage under No-Action Alternative Compared to Existing Condition, Dry Water Year

	DBBC Districts										
Year	Arnold	Central Oregon	Lone Pine	North Unit	Ochoco	Swalley	Three Sisters	Tumalo	Total, DBBC Districts	Other Irrigated Lands	All Lands
Existing Condition Dry	2,600	40,800	1,800	36,200	18,700	4,000	5,300	1,100	110,700	3,800	114,500
No-Action Alternative (Dry Water Year, Low Conservation Scenario)											
2020	2,700	40,800	2,100	37,000	18,700	4,000	5,300	1,300	111,800	3,800	115,700
2025	2,800	40,800	2,400	38,500	18,700	4,000	5,300	1,900	114,400	3,800	118,200
2030	2,900	40,800	2,400	40,100	18,700	4,000	5,300	2,600	116,800	3,800	120,700
2040	2,900	40,800	2,400	42,600	18,700	4,000	5,300	4,000	120,700	3,800	124,600
2049	2,900	40,800	2,400	44,900	18,700	4,000	5,300	4,000	123,000	3,800	126,900
No-Action Alternative (Dry Water Year, High Conservation Scenario)											
2020	2,900	40,800	2,200	38,100	18,700	4,000	5,300	1,400	113,300	3,800	117,200
2025	4,000	40,800	2,400	43,000	18,700	4,000	5,300	2,600	120,700	3,800	124,600
2030	4,000	40,800	2,400	47,600	18,700	4,000	5,300	4,000	126,700	3,800	130,600
2040	4,000	40,800	2,400	50,500	18,700	4,000	5,300	4,000	129,600	3,800	133,500
2049	4,000	40,800	2,400	52,200	18,700	4,000	5,300	4,000	129,600	3,800	133,500

Source: Highland Economics analysis.

Table 22. Estimated Maximum Increased Irrigated Acreage by Subseason under No-Action Alternative Compared to Existing Condition, Dry Water Year

	Low Conservation			High Conservation		
District / Year	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept
Arnold						
2020	0	0	0	0	200	200
2025	0	200	100	0	1,200	1,300
2030	0	300	300	0	1,200	1,300
2040	0	300	300	0	1,200	1,300
2049	0	300	300	0	1,200	1,300
Central Oregon						
2020	0	0	0	0	0	0
2025	0	0	0	0	0	0
2030	0	0	0	0	0	0
2040	0	0	0	0	0	0
2049	0	0	0	0	0	0
Lone Pine						
2020	0	200	200	0	400	200
2025	0	500	200	0	500	200
2030	0	500	200	0	500	200
2040	0	500	200	0	500	200
2049	0	500	200	0	500	200
North Unit						
2020	0	1,000	600	0	2,800	1,600
2025	0	3,600	2,100	0	11,300	6,600
2030	0	6,300	3,700	0	16,000	11,200
2040	0	10,700	6,200	0	16,000	14,000
2049	0	14,700	8,500	0	16,000	15,800
Ochoco						
2020	0	0	0	0	500	400
2025	0	0	0	0	2,400	2,700
2030	0	0	0	0	2,400	2,700
2040	0	0	0	0	2,400	2,700
2049	0	0	0	0	2,400	2,700

	Low Conservation			High Conservation		
		June/	Aug/		June/	Aug/
District / Year	**May**	**July**	**Sept**	**May**	**July**	**Sept**
Three Sisters						
2020	0	0	0	0	0	0
2025	0	0	0	0	0	0
2030	0	0	0	0	0	0
2040	0	0	0	0	0	0
2049	0	0	0	0	0	0
Tumalo						
2020	0	300	100	0	500	200
2025	0	1,600	800	0	1,600	1,500
2030	0	1,600	1,500	0	1,600	2,900
2040	0	1,600	2,900	0	1,600	2,900
2049	0	1,600	2,900	0	1,600	2,900
Other Irrigated Lands						
2020	0	0	0	0	0	0
2025	0	0	0	0	0	0
2030	0	0	0	0	0	0
2040	0	0	0	0	0	0
2049	0	0	0	0	0	0

Source: Highland Economics analysis.

Agricultural Acreage: Proposed Action

Table 24 presents the estimated range of potentially affected irrigated agricultural acreage (fallowed or deficit irrigated) within an irrigation season. The estimate presented is expected to be a maximum impact for any given year as it corresponds to the lowest subseason water supply relative to existing crop water demand within each district. In dry water years under both conservation scenarios, water to crops in the proposed action compared to the no-action alternative would decline in at least one district in at least one summer month. In median water years, under a high conservation scenario, there would be no impacts on acreage. Under a low conservation scenario, there would be impacts that would lead to fallowing or deficit irrigation of crops as show in **Table 24**.

Across all irrigated lands over the permit term in a median water year, fallowing/deficit irrigation may affect 0 to 6,800 acres (up to 5% of acreage under no-action alternative), while a in dry year affected acreage may range from 400 to 11,700 acres (up to 8% of acreage under no-action alternative). **Table 25** and **Table 26** present acreage impacts by district and conservation scenario, while **Table 27** highlights how acreage impacts may vary within each irrigation subseason (May, June/July, and August/September).

Table 23. Range of Potentially Impacted Grain and Forage Acreage (Reduced Irrigation, Possible Fallowing) across All Irrigated Lands, Proposed Action Compared to the No-Action Alternative

Year	Water Year Type			Average, All Water Year Types[a]
	Wet	Median	Dry	
2020	0	0	-400 to -1,300	-100 to -500
2025	0	0 to -2,100	-6,300 to -6,000	-2,200 to -2,700
2030	0	0 to -3,400	-8,400 to -9,300	-2,900 to -4,300
2040	0	0 to -6,800	-10,900 to -11,700	-3,800 to -6,100
2049	0	0 to -4,500	-10,100 to -11,700	-3,500 to -5,400
% Change	0%	0 to -5%	0 to -9%	0 to -4%

Source: Highland Economics analysis.

[a] Average computed assuming that the wet year represents approximately 35% of years (water years in the 65th to 100th percentile), the median represents 30% of water years (water years in the 35th to 65th percentile), and the dry water year represents approximately 35% of water years (water years in the 0th to the 35th percentile).

Table 24. Estimated Maximum Potentially Impacted Acreage by District under the Proposed Action Compared to the No-Action Alternative, Median Water Year

	DBBC Districts								Total, DBBC Districts	Other Irrigated Lands	All Lands
Year	Arnold	Central Oregon	Lone Pine	North Unit	Ochoco	Swalley	Three Sisters	Tumalo			
Low Conservation											
2020	0	0	0	0	0	0	0	0	0	0	0
2025	0	0	0	-2,100	0	0	0	0	-2,100	0	-2,100
2030	0	0	0	-3,400	0	0	0	0	-3,400	0	-3,400
2040	-200	0	0	-6,600	0	0	0	0	-6,800	0	-6,800
2049	-200	0	0	-4,300	0	0	0	0	-4,500	0	-4,500
% Change	0 to -5%	0%	0%	0 to -13%	0%	0%	0%	0%	0 to -5%	0%	0 to -5%
High Conservation											
2020	0	0	0	0	0	0	0	0	0	0	0
2025	0	0	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0	0	0	0	0
2040	0	0	0	0	0	0	0	0	0	0	0
2049	0	0	0	0	0	0	0	0	0	0	0
% Change	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Source: Highland Economics analysis.

Table 25. Estimated Maximum Potentially Impacted Irrigated Acreage by District under the Proposed Action Compared to the No-Action Alternative, Dry Water Year

	DBBC Districts										
Year	Arnold	Central Oregon	Lone Pine	North Unit	Ochoco	Swalley	Three Sisters	Tumalo	Total, DBBC Districts	Other Irrigated Lands	All Lands
Low Conservation											
2020	-1,500	0	-300	700	0	0	0	-200	-1,300	0	-1,300
2025	-1,100	0	-300	-4,500	0	0	0	0	-5,900	-100	-6,000
2030	-1,400	0	-500	-7,300	0	0	0	0	-9,200	-100	-9,300
2040	-1,500	0	-500	-9,600	0	0	0	0	-11,600	-100	-11,700
2049	-1,500	0	-500	-9,600	0	0	0	0	-11,600	-100	-11,700
% Change	-39 to -56%	0%	-13 to -21%	2 to -23%	0%	0%	0%	0 to -15%	-1 to -10%	0 to -3%	-1 to -9%
High Conservation											
2020	-1,600	0	-300	1,500	0	0	0	0	-400	0	-400
2025	-1,500	0	-200	-4,500	0	0	0	0	-6,200	-100	-6,300
2030	-800	0	-200	-7,300	0	0	0	0	-8,300	-100	-8,400
2040	-1,000	0	-200	-9,600	0	0	0	0	-10,800	-100	-10,900
2049	-1,000	0	-200	-8,800	0	0	0	0	-10,000	-100	-10,100
% Change	-20 to -55%	0%	-8 to -14%	4 to -19%	0%	0%	0%	0%	0 to -8%	-3%	0 to -8%

Source: Highland Economics analysis. Note that since the no-action alternative acreage is higher in the high conservation scenario, the percent difference from the no-action alternative for the same reduction in acreage due to the proposed action is lower in the high conservation scenario than in the low conservation scenario.

Table 26. Estimated Maximum Potentially Affected Acreage by Subseason by District under the Proposed Action Compared to the No-Action Alternative

	Dry Water Year						Median Water Year					
	Low Conservation			High Conservation			Low Conservation			High Conservation		
District	May	June /July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept
Arnold												
2020	0	-1,600	-200	0	-1,700	-200	0	0	0	0	0	0
2025	0	-1,100	-1,100	0	-1,300	-1,500	0	0	0	0	0	0
2030	0	-1,500	-1,300	0	-800	-700	0	0	0	0	0	0
2040	-1,000	-1,500	-1,500	0	-800	-1,000	0	-200	0	0	0	0
2049	-1,000	-1,500	-1,500	0	-800	-1,000	0	-200	0	0	0	0
Central Oregon												
2020	0	0	0	0	0	0	0	0	0	0	0	0
2025	0	0	0	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0	0	0	0	0	0
2040	0	0	0	0	0	0	0	0	0	0	0	0
2049	0	0	0	0	0	0	0	0	0	0	0	0
Lone Pine												
2020	0	-600	-1,000	0	-600	-700	0	0	0	0	0	0
2025	0	-700	0	0	-300	0	0	0	0	0	0	0
2030	0	-1,100	0	0	-400	0	0	0	0	0	0	0
2040	0	-1,100	0	0	-400	0	0	0	0	0	0	0
2049	0	-1,100	0	0	-400	0	0	0	0	0	0	0
North Unit												
2020	0	500	3,300	0	500	3,300	0	0	0	0	0	0
2025	0	-2,300	-4,500	0	-2,300	-4,500	0	0	-2,100	0	0	0
2030	0	-7,900	-7,300	0	-4,700	-7,300	0	0	-3,400	0	0	0
2040	-3,400	-13,100	-9,600	0	-4,900	-9,600	0	0	-6,600	0	0	0
2049	0	-13,100	-9,600	0	-400	-8,800	0	0	-4,300	0	0	0

	Dry Water Year						Median Water Year					
	Low Conservation			High Conservation			Low Conservation			High Conservation		
District	May	June /July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept
Ochoco												
2020	0	-1,400	-1,400	0	0	0	0	0	0	0	0	0
2025	0	-1,400	-1,400	0	0	0	0	0	0	0	0	0
2030	0	-1,400	-1,400	0	0	0	0	0	0	0	0	0
2040	0	-1,400	-1,400	0	0	0	0	0	0	0	0	0
2049	0	-1,400	-1,400	0	0	0	0	0	0	0	0	0
Tumalo												
2020	-200	1,300	-200	0	1,100	-200	0	0	0	0	0	0
2025	0	0	-200	0	0	-300	0	0	0	0	0	0
2030	0	0	-300	0	0	-400	0	0	0	0	0	0
2040	0	0	-400	0	0	-400	0	0	0	0	0	0
2049	0	0	-400	0	0	-400	0	0	0	0	0	0
Three Sisters												
2020	0	0	0	0	0	0	0	0	0	0	0	0
2025	0	0	0	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0	0	0	0	0	0
2040	0	0	0	0	0	0	0	0	0	0	0	0
2049	0	0	0	0	0	0	0	0	0	0	0	0
Other Irrigated Lands												
2020	0	-100	0	0	-100	0	0	0	0	0	0	0
2025	0	0	-100	0	0	-100	0	0	0	0	0	0
2030	0	-100	-100	0	-100	-100	0	0	0	0	0	0
2040	0	-100	-100	0	-100	-100	0	0	0	0	0	0
2049	0	-100	-100	0	-100	-100	0	0	0	0	0	0

Source: Highland Economics analysis.

Agricultural Acreage: Alternative 3

Table 28 presents the estimated range of potentially affected irrigated agricultural acreage (fallowed or deficit irrigated) within an irrigation season, with detail by district provided in **Tables 29**, **30, and 31**. The values in **Table 28** represent the range in the maximum affected acreage in any one irrigation season, with variation across the permit years, water year types, and conservation scenarios. Water availability to crops moves up and down across the permit term since conveyance and on-farm conservation increases water supply availability, while the increased instream flow requirements reduce water supply availability. Across all irrigated lands over the permit term in a median water year, fallowing/deficit irrigation may affect 0 to 11,400 acres (up to 8% of acreage under no-action alternative), while a in dry year affected acreage may range from 9,500 to 13,900 acres (7 to 10% of acreage under no-action alternative).

Table 27. Range of Potentially Affected Grain and Forage Acreage (Reduced Irrigation, Possible Fallowing) across All Irrigated Lands under Alternative 3 Compared to the No-Action Alternative

Year	Water Year Type			Average, All Water Year Types[a]
	Wet	Median	Dry	
2020	0	-2,500 to -3,600	-11,400 to -11,500	-4,700 to -5,100
2025	0	-600 to -5,100	-9,500 to -9,800	-3,600 to -4,900
2030	0	-3,700 to -11,400	-13,100 to -13,900	-5,700 to -8,300
2040	0	-800 to -8,900	-13,100 to -13,900	-4,800 to -7,500
2049	0	0 to -6,600	-12,300 to -13,900	-4,300 to -6,800
% Change	0%	0 to -8%	-8 to -17%	-3 to -6%

[a] Average computed assuming that the wet year represents approximately 35% of years (water years in the 65th to 100th percentile), the median or median represents 30% of water years (water years in the 35th to 65th percentile), and the dry water year represents approximately 35% of water years (water years in the 0th to the 35th percentile).

Table 28. Estimated Maximum Potentially Impacted Acreage by District under Alternative 3 Compared to the No-Action Alternative, Median Water Year

	DBBC Districts										
Year	Arnold	Central Oregon	Lone Pine	North Unit	Ochoco	Swalley	Three Sisters	Tumalo	Total, DBBC Districts	Other Irrigated Lands	All Lands
Low Conservation											
2020	0	0	0	-3,600	0	0	0	0	-3,600	0	-3,600
2025	0	0	0	-5,100	0	0	0	0	-5,100	0	-5,100
2030	-200	0	0	-11,200	0	0	0	0	-11,400	0	-11,400
2040	-200	0	0	-8,700	0	0	0	0	-8,900	0	-8,900
2049	-200	0	0	-6,400	0	0	0	0	-6,600	0	-6,600
% Change	-0 to -5%	0%	0%	-7 to -21%	0%	0%	0%	0%	-3 to -8%	0%	-3 to -8%
High Conservation											
2020	0	0	0	-2,500	0	0	0	0	-2,500	0	-2,500
2025	0	0	0	-600	0	0	0	0	-600	0	-600
2030	0	0	0	-3,700	0	0	0	0	-3,700	0	-3,700
2040	0	0	0	-800	0	0	0	0	-800	0	-800
2049	0	0	0	0	0	0	0	0	0	0	0
% Change	0%	0%	0%	0 to -7%	0%	0%	0%	0%	0 to -3%	0%	0 to -3%

Source: Highland Economics analysis. Note that since the no-action alternative acreage is higher in the high conservation scenario, the percent difference from the no-action alternative for the same reduction in acreage due to Alternative 3 would be lower in the high conservation scenario than in the low conservation scenario.

Table 29. Estimated Maximum Potentially Impacted Acreage by DBBC District under Alternative 3 Compared to the No-Action Alternative, Dry Water Year

Year	DBBC Districts										
	Arnold	Central Oregon	Lone Pine	North Unit	Ochoco	Swalley	Three Sisters	Tumalo	Total, DBBC Districts	Other Irrigated Lands	All Lands
Low Conservation											
2020	-1,100	0	-700	-9,400	0	0	0	-200	-11,400	-100	-11,500
2025	-1,300	0	-500	-7,600	0	0	0	0	-9,400	-100	-9,500
2030	-1,500	0	-500	-11,800	0	0	0	0	-13,800	-100	-13,900
2040	-1,500	0	-500	-11,800	0	0	0	0	-13,800	-100	-13,900
2049	-1,500	0	-500	-11,800	0	0	0	0	-13,800	-100	-13,900
% Change	-41 to -52%	0%	-21 to -33%	-20 to -29%	0%	0%	0%	0 to -15%	-8 to -11%	-3%	-8 to -12%
High Conservation											
2020	-1,200	0	-700	-9,400	0	0	0	0	-11,300	-100	-11,400
2025	-1,700	0	-400	-7,600	0	0	0	0	-9,700	-100	-9,800
2030	-1,000	0	-200	-11,800	0	0	0	0	-13,000	-100	-13,100
2040	-1,000	0	-200	-11,800	0	0	0	0	-13,000	-100	-13,100
2049	-1,000	0	-200	-11,000	0	0	0	0	-12,200	-100	-12,300
% Change	-25 to -43%	0%	-8 to -32%	-18 to -25%	0%	0%	0%	0%	-8 to-10%	-3%	-8 to -10%

Source: Highland Economics analysis. N/A=Not Applicable. Note that since the no-action alternative acreage is higher in the high conservation scenario, the percent difference from the no-action alternative for the same reduction in acreage due to Alternative 3 would be lower in the high conservation scenario than in the low conservation scenario.

Table 30. Estimated Maximum Potentially Impacted Acreage by Subseason by District under Alternative 3 Compared to the No-Action Alternative

	Dry Water Year						Median Water Year					
	Low Conservation			High Conservation			Low Conservation			High Conservation		
District	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept
Arnold												
2020	0	-1,100	-1,100	0	-1,100	-1,200	0	0	0	0	0	0
2025	0	-1,400	-1,300	0	-1,700	-1,600	0	0	0	0	0	0
2030	-1,000	-1,500	-1,500	0	-800	-1,000	0	-200	0	0	0	0
2040	-1,000	-1,500	-1,500	0	-800	-1,000	0	-200	0	0	0	0
2049	-1,000	-1,500	-1,500	0	-800	-1,000	0	-200	0	0	0	0
Central Oregon												
2020	0	0	0	0	0	0	0	0	0	0	0	0
2025	0	0	0	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0	0	0	0	0	0
2040	0	0	0	0	0	0	0	0	0	0	0	0
2049	0	0	0	0	0	0	0	0	0	0	0	0
Lone Pine												
2020	0	-1,400	-1,300	0	-1,500	-1,000	0	0	0	0	0	0
2025	0	-1,200	0	0	-800	0	0	0	0	0	0	0
2030	0	-1,100	0	0	-400	0	0	0	0	0	0	0
2040	0	-1,100	0	0	-400	0	0	0	0	0	0	0
2049	0	-1,100	0	0	-400	0	0	0	0	0	0	0
North Unit												
2020	0	1,700	-9,400	0	1,700	-9,400	0	0	-3,600	0	0	-2,500
2025	0	-8,100	-7,600	0	-8,100	-7,600	0	0	-5,100	0	0	-600
2030	-2,400	-13,800	-11,800	0	-10,600	-11,800	0	0	-11,200	0	0	-3,700
2040	0	-8,100	-11,800	0	0	-11,800	0	0	-8,700	0	0	-800
2049	0	0	-11,800	0	0	-11,000	0	0	-6,400	0	0	0

	Dry Water Year						Median Water Year					
	Low Conservation			High Conservation			Low Conservation			High Conservation		
District	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept
Ochoco												
2020	0	-1,400	-1,400	0	0	0	0	0	0	0	0	0
2025	0	-1,400	-1,400	0	0	0	0	0	0	0	0	0
2030	0	-1,400	-1,400	0	0	0	0	0	0	0	0	0
2040	0	-1,400	-1,400	0	0	0	0	0	0	0	0	0
2049	0	-1,400	-1,400	0	0	0	0	0	0	0	0	0
Tumalo												
2020	-200	1,100	-200	0	1,100	-200	0	0	0	0	0	0
2025	0	0	-300	0	0	-300	0	0	0	0	0	0
2030	0	0	-300	0	0	-400	0	0	0	0	0	0
2040	0	0	-400	0	0	-400	0	0	0	0	0	0
2049	0	0	-400	0	0	-400	0	0	0	0	0	0
Three Sisters												
2020	0	0	0	0	0	0	0	0	0	0	0	0
2025	0	0	0	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0	0	0	0	0	0
2040	0	0	0	0	0	0	0	0	0	0	0	0
2049	0	0	0	0	0	0	0	0	0	0	0	0
Other Irrigated Lands												
2020	0	0	-100	0	0	-100	0	0	0	0	0	0
2025	0	-100	-100	0	-100	-100	0	0	0	0	0	0
2030	0	-100	-100	0	-100	-100	0	0	0	0	0	0
2040	0	-100	-100	0	-100	-100	0	0	0	0	0	0
2049	0	-100	-100	0	-100	-100	0	0	0	0	0	0

Source: Highland Economics analysis.

Agricultural Acreage: Alternative 4

Table 32 presents the estimated range of potentially affected irrigated agricultural acreage (fallowed or deficit irrigated) within an irrigation season, with detail by district provided in **Tables 33**, **34, and 35**. The values in **Table 32** represent the range in the maximum affected acreage in any one irrigation season, with variation across the permit years, water year types, and conservation scenarios. Water availability to crops moves up and down across the permit term since conveyance and on-farm conservation increases water supply availability, while the increased instream flow requirements reduce water supply availability. Across all irrigated lands over the permit term, in a median water year fallowing/deficit irrigation may affect 9,400 to 18,900 acres (5 to 13% of acreage under no-action alternative), while a in dry year affected acreage may range from 13,400 to 16,400 acres (11 to 14% of acreage under no-action alternative).

Table 31. Range of Potentially Impacted Grain and Forage Acreage (Reduced Irrigation, Possible Fallowing) across All Irrigated Lands under Alternative 4 Compared to the No-Action Alternative

	Water Year Type			Average, All Water Year Types[a]
Year	**Wet**	**Median**	**Dry**	
2020	0	-12,500 to -14,200	-13,400 to -14,000	-8,500 to -9,200
2025	0	-14,000 to -18,900	-15,800 to -16,400	-10,700 to -11,400
2030	0	-9,400 to -17,100	-15,300 to -15,400	-8,200 to -10,500
2039	0	-6,800 to -14,800	-15,300 to -15,500	-7,400 to -9,900
% Change	0%	-5 to -13%	-11 to -14%	-5 to -8%

[a] Average computed assuming that the wet year represents approximately 35% of years (water years in the 65th to 100th percentile), the median or median represents 30% of water years (water years in the 35th to 65th percentile), and the dry water year represents approximately 35% of water years (water years in the 0th to the 35th percentile).

Table 32. Estimated Maximum Potentially Impacted Acreage by District under Alternative 4 Compared to the No-Action Alternative, Median Water Year

	DBBC Districts										
Year	Arnold	Central Oregon	Lone Pine	North Unit	Ochoco	Swalley	Three Sisters	Tumalo	Total, DBBC Districts	Other Irrigated Lands	All Lands
Low Conservation											
2020	-500	0	-100	-13,600	0	0	0	0	-14,200	0	-14,200
2025	-400	0	0	-18,500	0	0	0	0	-18,900	0	-18,900
2030	-200	0	0	-16,900	0	0	0	0	-17,100	0	-17,100
2039	-200	0	0	-14,600	0	0	0	0	-14,800	0	-14,800
% Change	-5 to -13%	0%	0 to -4%	-26 to -35%	0%	0%	0%	0%	-10 to-14%	0%	-10 to-13%
High Conservation											
2020	0	0	0	-12,500	0	0	0	0	-12,500	0	-12,500
2025	0	0	0	-14,000	0	0	0	0	-14,000	0	-14,000
2030	0	0	0	-9,400	0	0	0	0	-9,400	0	-9,400
2039	0	0	0	-6,800	0	0	0	0	-6,800	0	-6,800
% Change	0%	0%	0%	-13 to -27%	0%	0%	0%	0%	-5 to -10%	0%	-5 to-10%

Source: Highland Economics analysis. Note that since the no-action alternative acreage is higher in the high conservation scenario, the percent difference from the no-action alternative for the same reduction in acreage due to Alternative 4 would be lower in the high conservation scenario than in the low conservation scenario.

Table 33. Estimated Maximum Potentially Impacted Acreage by District under Alternative 4 Compared to the No-Action Alternative, Dry Water Year

	DBBC Districts								Total,	Other	
Year	Arnold	Central Oregon	Lone Pine	North Unit	Ochoco	Swalley	Three Sisters	Tumalo	DBBC Districts	Irrigated Lands	All Lands
Low Conservation											
2020	-2,300	0	-800	-10,700	0	0	0	-100	-13,900	-100	-14,000
2025	-2,400	0	-600	-13,100	0	0	0	-200	-16,300	-100	-16,400
2030	-2,500	0	-600	-12,000	0	0	0	-200	-15,300	-100	-15,400
2040	-2,500	0	-600	-12,000	0	0	0	-300	-15,400	-100	-15,500
% Change	-85 to -86%	0%	-38%	-25 to -34%	0%	0%	0%	-8 to -11%	-12 to -14%	-3%	-12 to -14%
High Conservation											
2020	-2,500	0	-800	-9,900	0	0	0	-100	-13,300	-100	-13,400
2025	-3,100	0	-400	-12,000	0	0	0	-200	-15,700	-100	-15,800
2030	-2,700	0	-200	-12,000	0	0	0	-300	-15,200	-100	-15,300
2039	-2,700	0	-200	-12,000	0	0	0	-300	-15,200	-100	-15,300
% Change	-68 to -86%	0%	-8 to -36%	-24 to -28%	0%	0%	0%	-7 to -8%	-12 to -13%	-3%	-11 to -13%

Source: Highland Economics analysis. Note that since the no-action alternative acreage is higher in the high conservation scenario, the percent difference from the no-action alternative for the same reduction in acreage due to Alternative 4 would be lower in the high conservation scenario than in the low conservation scenario.

Table 34. Estimated Maximum Potentially Impacted Acreage by Subseason by DBBC District under Alternative 4 Compared to the No-Action Alternative

	Dry Water Year						Median Water Year					
	Low Conservation			High Conservation			Low Conservation			High Conservation		
District	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept
Arnold												
2020	-200	-2,400	-200	0	-2,600	-200	0	-500	-100	0	-200	0
2025	-1,300	-2,500	-400	0	-3,100	-400	0	-400	0	0	0	0
2030	-1,200	-2,600	-400	0	-2,700	0	0	-200	0	0	0	0
2039	-1,200	-2,600	-400	0	-2,700	0	0	-200	0	0	0	0
Central Oregon												
2020	0	0	0	0	0	0	0	0	0	0	0	0
2025	0	0	0	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0	0	0	0	0	0
2039	0	0	0	0	0	0	0	0	0	0	0	0
Lone Pine												
2020	0	-1,700	-1,500	0	-1,800	-1,200	0	0	-100	0	0	0
2025	0	-1,300	-200	0	-900	0	0	0	0	0	0	0
2030	0	-1,200	-100	0	-500	0	0	0	0	0	0	0
2039	0	-1,200	-100	0	-500	0	0	0	0	0	0	0
North Unit												
2020	0	-10,900	-8,500	0	-10,900	-8,500	0	-3,100	-13,600	0	-1,200	-12,500
2025	-12,500	-14,400	-12,000	-5,300	-14,400	-12,000	0	-400	-18,500	0	0	-14,000
2030	-9,900	-14,400	-12,000	0	-11,200	-12,000	0	0	-16,900	0	0	-9,400
2039	-6,300	-14,400	-12,000	0	-6,700	-12,000	0	0	-14,600	0	0	-6,800
Ochoco												
2020	0	-1,400	-1,400	0	0	0	0	0	0	0	0	0
2025	0	-1,400	-1,400	0	0	0	0	0	0	0	0	0
2030	0	-1,400	-1,400	0	0	0	0	0	0	0	0	0
2039	0	-1,400	-1,400	0	0	0	0	0	0	0	0	0

	Dry Water Year						Median Water Year					
	Low Conservation			High Conservation			Low Conservation			High Conservation		
District	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept
Tumalo												
2020	-200	1,100	-200	0	1,100	-200	0	0	0	0	0	0
2025	0	0	-300	0	0	-300	0	0	0	0	0	0
2030	0	0	-300	0	0	-400	0	0	0	0	0	0
2039	0	0	-400	0	0	-400	0	0	0	0	0	0
Three Sisters												
2020	0	0	0	0	0	0	0	0	0	0	0	0
2025	0	0	0	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0	0	0	0	0	0
2039	0	0	0	0	0	0	0	0	0	0	0	0
Other Irrigated Lands												
2020	0	-100	-100	0	-100	-100	0	0	0	0	0	0
2025	0	-100	-100	0	-100	-100	0	0	0	0	0	0
2030	0	-100	-100	0	-100	-100	0	0	0	0	0	0
2039	0	-100	-100	0	-100	-100	0	0	0	0	0	0

Source: Highland Economics analysis.

Agricultural Production Value and Economic Contribution

The gross value of crop production (i.e., total gross value at the farmgate of crops produced) depends on the acreage in production (as estimated in the sections above), as well as the yields and prices of each crop. The economic contribution to the community of agricultural production, in turn, depends on the jobs and income supported by this level of crop production. Following a brief discussion of methods and data, this section summarizes both the crop production value and the economic contribution of crop production under existing conditions, and the EIS alternatives.

As noted above, the high conservation scenario assumes investment in on-farm and District water conservation, which would serve to maintain agricultural production value and the economic contribution of agriculture. However, to the extent that these investments are funded by District patrons (and not outside funding sources), this represents an economic cost to patrons. For example, one proposed Central Oregon ID piping projects expected to cost approximately $40 million may require approximately $843,000 in annual payments by Central Oregon ID and North Unit ID districts (assuming the districts are responsible for 50% of the cost), which would represent approximately a 10% increase in the operating costs of the two districts (approximately 12% in COID and approximately 9% in NUID) (Bozett pers. comm.;). However, this is just one small element of all Central Oregon ID proposed piping. According to the Central Oregon ID System Improvement Plan (Black Rock Consulting, 2016), piping the Pilot Butte Canal would cost approximately $183 million, and piping the Central Oregon Canal would cost approximately $238 million. As such, depending on funding mechanisms and the level of piping implemented, costs to patrons may go up by a much larger percentage in Central Oregon ID and North Unit ID. Similarly, depending on the funding mechanisms and level of infrastructure investments, patron costs in other districts may also rise to fund district and on-farm efficiency improvements.

In terms of economic contribution to the local study area, these investments in irrigation efficiency and District piping will redirect some patron spending to irrigation infrastructure and away from other types of spending. As this is a redirection of household spending in the local area and not a reduction of spending, the net effect of investments in irrigation infrastructure on the total employment and income in the local study area is likely small.

Methods, Key Assumptions, Data Sources

To estimate impacts on agricultural production value, this analysis took a four-step approach (*key data sources are provided in italics*):

1. Estimate the value per acre of forage and grain production based on county data on yield and prices.
    a. Yield data is for the last 5 years as reported by the *US Department of Agriculture National Agricultural Statistics Service (NASS)*.
    b. Price data is from the *US Department of Commerce Economic Research Service (ERS)* 5-year normalized average for all hay and all wheat in the State of Oregon.

2. Estimate the approximate value of forage and grain production in each irrigation subseason based on estimated timing of cutting and yield of each cutting. *Data on yield by cutting from the Central Oregon Agricultural Research and Extension Center.*

3. Estimate the change in forage and grain production value under the EIS alternatives by combining the impacted acreage by subseason estimated in above (*Farm Response to Crop Water Shortages: Change in Acreage*) with the value of forage/grain production in each subseason.

4. Estimate the direct, indirect and induced effects (i.e., ripple effects) of changes in agricultural production value on employment (full- and part-time jobs) and labor income (employee compensation and proprietor income)[15] in agriculture and supporting sectors. Effects were estimated using *IMPLAN economic models* of each county in the study area. Indirect effects include effects on jobs and income in sectors providing inputs to the agricultural sector, such as farm equipment suppliers, seed suppliers, and legal and financial services. Induced effects include effects on industries that are supported by spending of agricultural income including retail and service businesses. The sum of direct, indirect, and induced effects is the total economic contribution of agricultural production.

    a. The analysis is a multi-regional analysis estimating the total economic contribution (including indirect and induced ripple effects) of crop production in Crook, Deschutes, and Jefferson Counties. The multi-regional analysis enables estimation of the total economic contribution of agricultural production in each county to that county (e.g., the effect in Crook County of Crook County agriculture), as well as the spillover economic contribution from the other counties (e.g., Deschutes and Jefferson) that arises as businesses and consumers purchase goods/services from across county boundaries. As the retail and services center of the region, Deschutes County in particular experiences measurable effects from agricultural production in the other two counties.

    b. The analysis adjusted the employment data in the farm sectors in IMPLAN data to match the *5-year average farm worker employment reported for each county in the study area* (see **Figure 12**) from the *Oregon Department of Employment* (the ratio of employment in each IMPLAN agricultural sector was maintained).

    c. The analysis adjusted IMPLAN output data for grain and forage crops (the gross value of agricultural production) to match the total value of these crops, by county, as estimated in this section (and presented in **Table 60**).

    d. The analysis adjusted all other IMPLAN data for grain and forage crops proportionate to the output adjustment. In other words, if grain and forage output was increased by 10% in a county, then other economic values such as total proprietor income and taxes paid were also increased by 10%.

[15] The net economic value of agricultural production is the net profit (above wages/salaries and management labor costs) of farm operations, so labor income (much of which is a cost to farm operations) should not be interpreted as the net economic value.

In addition to the key assumptions outlined above regarding the methodology to estimate acreage impacts on forage and grain production, key assumptions include the following.

1. The county average yield data and the state-level price data provide a good representation of the average value produced per acre in the study area (acknowledging that agricultural production value per acre varies substantially from farm to farm).
2. Prices are not affected by the reduction in production in Central Oregon counties as forage and grain are commodity markets, with both forage and grain being shipped out of Central Oregon to many other markets.
3. The impact on yield of forage crops provides an acceptable proxy for the impact of yield of grain crops (grain crops are relatively low acreage compared to forage crops).
4. Once an acre ceases to receive irrigation water, the analysis assumes that the forage or grain crop goes dormant and that it does not provide additional cuttings for the rest of the season. In other words, if a 100-acre impact is estimated for June/July (with no yield assumed for that grass hay cutting), but there is then full irrigation water availability in August/September (with an estimated 0 acres impacted as shown in above in the *Farm Response to Crop Water Shortages: Change in Acreage* section), the analysis still assumes that there is no yield from those 100 acres in August/September. This is because yield recovery in that season is expected to be minimal after a crop goes dormant).
5. The analysis assumes all forage acres have three cuttings and spreads the total average county hay cutting across the three cuttings. The analysis does not include revenue from grazing due to the relatively small income from pasture relative to forage production (estimated at less than 10% of forage revenue, as discussed below). To the extent that farms manage their forage such that the bulk of hay production occurs in the first or second cuttings (which are generally least affected by water reductions), with aftermath grazing later in the season, then the analysis may overestimate forage production value impacts. The potential for overestimation of impacts, however, is reduced by the fact that after-grazing revenue is not included in the analysis.
6. As only forage and grain crop acreage is modeled to be affected by reduced irrigation water supplies (as estimated in the previous section), the value of other crop production is assumed to be unaffected. As noted above, to the extent that specialty crops are adversely affected, the analysis may underestimate economic impacts. Barring extensive changes in water supplies due to climate change, the potential for high value specialty crops to be impacted is expected to be limited, however, for the following reasons:
    - Forage/grain crops account for approximately 80% of crop water usage in Jefferson and Crook counties (**Table 5**),, where nearly all specialty crops in the region are grown
    - The feasibility of a basin-wide water transaction program is currently being explored (Central Oregon Irrigation District, 2017), which if developed would facilitate transfers of water to high value crops between districts and farmers, and
    - Perhaps most importantly, because of projected conservation through time (even in the low conservation scenario) that would increase water available to North Unit ID (where the majority of specialty crop acreage is grown), the available water supplies under the proposed action dry year are expected to be close to the amount of water available to crops

in North Unit ID under the existing condition dry water year (i.e., before projected future conservation).[16]

7. Farm employment and labor income change proportionately with changes in crop production value (i.e., if forage and grain production value decreases by 10%, then forage and grain employment and income also decreases by 10%).

Data on Forage and Grain Gross Production Value Per Acre by Season and Subseason

This section summarizes the per acre forage and grain production value across the irrigation season based on average county yields and prices. As the vast majority of acreage in the study area is in forage crops, the analysis models the impact on forage/grain yield based on yield impacts on forage crops (specifically hay crops). The section then presents data on forage yield dependent on each irrigation subseason (May, June/July, and August/September), and estimates the production value per acre for each irrigation subseason. **Tables 35, 36, and 37** present the data used to estimate the average annual per acre production value from forage and grain crops for each district (presented in **Table 38**), which varies from approximately $920 per acre in North Unit to approximately $700 to $720 per acre in other districts. In addition to hay yield, many acres of hay are also 'after-grazed' by livestock and provide some additional value. The additional value of grazing after hay production is likely small (less than approximately 10 percent) relative to the per acre average forage/grain production value and is not included in this analysis. (The rental rate for an entire season of irrigated pasture in the study area (as estimated by NASS survey data from 2014 to 2017) is less than $35 per acre, although average rental value based on forage production level (animal unit month supported) may be up to approximately $80 per acre. However, there is acreage that is used solely as pasture and is not harvested for hay. By assuming all forage acreage is used to produce hay, the analysis may actually overestimate total average forage production value per acre.)

[16] In permit years 1 through 5, reduced water available for diversion (compared to the no-action alternative) to North Unit ID in a dry water year are estimated at 6,100 acre-feet per year, but conserved water available to North Unit ID in Year 1 are estimated at 5,200 acre-feet per year (low conservation scenario). In permit years 6 through 10, reduced water available for diversion to North Unit ID in a dry water are estimated at 10,900 acre-feet per year, but conserved water available to North Unit ID in Year 6 are estimated at 18,200 acre-feet per year (low conservation scenario). In permit years 11 through 20, reduced water available for diversion to North Unit ID in a dry water year are estimated at 26,800 acre-feet per year, but conserved water available to North Unit ID in Year 11 are estimated at 31,200 acre-feet per year (low conservation scenario). In permit years 21 through 30, reduced water available for diversion to North Unit ID in a dry water year are estimated at 54,100 acre-feet per year, but conserved water available to North Unit ID in Year 1 is estimated at 49,000 acre-feet per year (low conservation scenario).

Table 35. Estimated 5-Year Average Hay Yield [a]

County	Yield (Tons/Acre)		Acreage (Percent)		Average All Hay Yield (Tons/Acre)
	Alfalfa	Other Hay	Alfalfa	Other Hay	
Crook	4.7	2.6	42%	58%	3.4
Deschutes	4.1	2.9	40%	60%	3.4
Jefferson	5.6	3.5	50%	50%	4.5
All Counties	4.9	2.9	44%	56%	3.8

Source: U.S. Department of Agriculture, National Agricultural Statistics Service 2010–2017.

[a] Using the most recent 5 years of data available, usually 2012–2017. Due to non-reporting of data in some years, the most recent 5 years of available data goes back to 2010 for some data.

Table 36. Estimated 5-Year Average Wheat Yield [a]

County	Yield (Bushels/Acre)		Acreage (Percent)		Average All Wheat Yield (Bushels/Acre)
	Spring	Winter	Spring	Winter	
Crook	86.3	111.9	32%	68%	103.7
Deschutes	N/A2	88.9	0%[b]	100%	88.9
Jefferson	107.8	126.2	47%	53%	117.6
All Counties	105.1	119.6	42%	58%	113.6

Source: U.S. Department of Agriculture, National Agricultural Statistics Service 2010–2017.

[a] Using the most recent 5 years of yield data available from NASS, usually 2012–2017. Due to non-reporting of data in some years, the most recent 5 years of available data goes back to 2010 for some data.

[b] There is likely spring wheat grown in Deschutes County, but it is not reported by NASS.

Table 37. Estimated 5-Year Average Yield, Price, and Revenue per Acre for Wheat and Hay by County

County	Yield (ton/bushel)[a]	Price per ton/bushel	Revenue Per Acre
All Hay			
Crook	3.4	$209.63	$721
Deschutes	3.4	$209.63	$716
Jefferson	4.5	$209.63	$950
All Counties	3.8	$209.63	$794
All Wheat			
Crook	103.7	$6.65	$690
Deschutes	88.9	$6.65	$591
Jefferson	117.6	$6.65	$782
All Counties	113.6	$6.65	$755

Source: U.S. Department of Agriculture, National Agricultural Statistics Service for yields, 2010–2017. Economic Research Service 2018 Normalized 5-Year State Average Prices for all hay and all wheat.

[a] Hay yield is measured in tons; wheat yield is measured in bushels.

Table 38. Average Revenue per Acre for Wheat and Hay by District

District	Average Revenue/Acre		Acres		Average Revenue/Acre for Hay/Pasture and Grains Combined
	Hay/Pasture	Wheat	Hay/Pasture	Wheat	
Arnold	$716	$591	1,876	0	$716
Central Oregon	$716	$591	37,498	843	$713
Lone Pine	$721	$690	1,225	377	$714
North Unit	$950	$782	29,400	5,703	$923
Ochoco	$721	$690	12,574	1,783	$717
Swalley	$716	$591	2,669	0	$716
Three Sisters	$716	$591	5,717	1,189	$694
Tumalo	$716	$591	5,000	0	$716
Other Irrigated Lands	$721	$690	3,151	194	$720

Source: Highland Economics Analysis of District acreage and U.S. Department of Agriculture, National Agricultural Statistics Service data.

This analysis estimates potential impacts of reduced water available to crops on a subseason basis based on the cutting periods for grass hay and alfalfa. **Table 39** summarizes data from the Central Oregon Agricultural Research and Extension Center on the cutting periods and yield by cutting for orchard grass hay and alfalfa hay. The yields at the Research and Extension Center exceed average yields in the study area (yields are often much higher at research centers where production is at a smaller scale and is highly managed), but this analysis assumes that the proportion of yield in each cutting would be similar across the study area. As shown in **Table 39**, alfalfa and grass hay may have three to four cuttings each irrigation season. The analysis assumes that the yield in the first cutting of grass hay or alfalfa hay (completed in late May or early June) is dependent on the availability of irrigation water in May (it is also dependent on irrigation water available in April, but that is not assessed in this analysis as irrigation water supplies in April across the proposed action and alternatives are nearly always 100% of demand). Similarly, the analysis assumes that the yield in the second cutting of grass hay and the second/third cuttings of alfalfa hay that occur in early to late July are dependent on the availability of irrigation water in the June/July subseason. Finally, the analysis assumes that the yield in the final cutting of grass hay and alfalfa hay is dependent on the availability of irrigation water in the September/October subseason.

Table 40 summarizes the expected yield that is dependent on each irrigation subseason: approximately 40% of the season's yield is dependent on the water availability in the May irrigation subseason, approximately 40% is dependent on the June/July irrigation subseason, and approximately 20% is dependent on the September/October subseason. **Table 41** applies these percentages to the average annual revenue per acre for forage and hay crops for each District, as presented in **Table 38**.

Table 39. Alfalfa and Orchard Grass Yield by Cutting at Central Oregon Agricultural Research and Extension Center

Cutting Period	Key Irrigation Month(s) Determining Yield	Yield (ton/acre)		% Yield for Season	
		Orchard grass	Alfalfa	Orchard grass	Alfalfa
Late May/early June	May	3.28	3.69	50%	30%
Early July	June		3.17		26%
End of July	June/July	2.14		33%	
Early August	July		2.34		19%
Mid-September–Mid-October	August/September	1.16	3.17	18%	26%

Sources: Highland Economics analysis of Bohle et al.1992; Butler et al. 2015.

Table 40. Summary of Alfalfa and Orchard Grass Yield by Irrigation Subseason

Irrigation Subseason	Season Yield: % Dependent on Each Irrigation Subseason		
	Orchard Grass hay	Alfalfa hay	Average
May	49.8%	29.9%	39.9%
June/July	32.5%	44.5%	38.5%
August/September	17.6%	25.6%	21.6%
Season	100%	100%	100%

Sources: Highland Economics analysis of Bohle et al. 1992; Butler et al. 2015.

Table 41. Forage/Grain Revenue per Acre Dependent on Each Irrigation Subseason

District	Average Per Acre Revenue for Forage/Grain Crops Dependent on Each Irrigation Subseason			
	Annual	May	June/July	August/September
Arnold	$716	$286	$286	$143
Central Oregon	$713	$285	$285	$143
Lone Pine	$714	$286	$286	$143
North Unit	$923	$369	$369	$185
Ochoco	$717	$287	$287	$143
Swalley	$716	$286	$286	$143
Three Sisters	$694	$278	$278	$139
Tumalo	$716	$286	$286	$143
Other Irrigated Lands	$720	$288	$288	$144

Source: Highland Economics analysis.

As noted throughout this analysis, the approach assumes that farmers prioritize irrigating higher value/lower water use specialty crops (grass seed/peppermint/vegetable seed) and deficit irrigate or fallow the lower value/higher water use grain and forage crops. However, it is possible that some high value specialty crops may be affected by reduced water supply availability as well. For this reason, and to illustrate the potential economic impact if high value crops were to be affected, **Table 42** summarizes the value per acre and the value per AF of available water for specialty crops in the region. The value per acre of these crops from 2009 to 2013 (the most recent years for which published data are available from the Central Oregon Agriculture Research and Extension Center) is approximately $2,400, which with inflation equals approximately $2,750 in 2019 dollars.

Table 42. Per Acre Revenue from Central Oregon Specialty Crops (Vegetable Seed, Grass Seed, Peppermint, Other)

Year	Acreage	Crop Gross Revenue	Gross Revenue/Acre (Nominal)	Gross Revenue/Acre (2019$)
2013	14,053	$32,251,908	$2,300	$2,530
2012	13,256	$34,116,580	$2,570	$2,860
2011	12,882	$35,455,537	$2,750	$3,120
2010	13,269	$29,807,165	$2,250	$2,640
2009	14,279	$31,160,736	$2,180	$2,610
Average	13,548	$32,558,385	$2,410	$2,750

Source: Highland Economics Analysis of Central Oregon Agriculture Research and Extension Center 2013, 2012, 2011, 2010, 2009; Bureau of Labor Statistics 2019.

Approximately 90% of specialty crop acreage in the region are grown in Jefferson County, with most of the remainder in Crook County (Central Oregon Agriculture Research and Extension Center, 2013, 2012, 2011, 2010, 2009). The gross production value per acre for specialty crops is roughly 300% the gross value of forage/crop production in Jefferson County (approximately $2,750 versus approximately $920 per acre). However, the crop water requirement (as presented in **Table 4** above) for specialty crops is roughly one-half the crop water requirement for grain/forage crops.[17] As such, the gross production value per AF of water use on specialty crops is approximately 600% the gross production value per AF of water use on grain/forage crops. As highlighted in **Table 5**, water use for forage and grain crops is approximately 80% of total water use in Jefferson County and Crook County irrigation districts, with specialty crops accounting for the remaining 20% of water use.

The ***largest*** potential economic impacts that could result (assuming current cropping patterns) would occur if farmers did not prioritize high value crops but instead reduced water proportionally to all crops, regardless of economic value. This is not a realistic outcome but is presented as the theoretical upper bound of potential adverse impacts if high value crops were affected. Under this scenario, 80% of the economic impacts estimated in the sections below would occur as projected (i.e., would be impacts on forage/grain), and approximately 20% of the water reductions would instead affect high value crops, with the associated production value impacts approximately 6 times higher than estimated (as the gross value per acre-foot of water reduction is approximately 6 times higher). The employment and income effects for a given level of agricultural production value are generally similar, so the agricultural income and employment effects per AF of water use would also be approximately 6 times higher for specialty crops than for forage/grain production. Increasing 20% of the estimated effects by 600%, results in a total impact of approximately 200%.[18] In

[17] For example, for the Madras station in Jefferson County, the per acre forage/grain production crop ET requirement is 2.8 AF/acre, while peppermint is 2.2 AF/acre, grass seed is 1.4 AF/acre, and carrot seed is 1.0 AF/acre.

[18] For example, if the sections below estimate an impact of $4 million in forage/grain production value, then 80% of this impact is $3.2 million, and 20% of this impact is $0.8 million. If the $0.8 million impact is increased by 600%, to

summary, under a hypothetical worst-case scenario where farmers do not prioritize high-value crops, the total economic impacts on Jefferson County and Crook County gross agricultural production value, agricultural jobs, and agricultural income, would be approximately double those estimated in the sections below.

Agricultural Production Value

This section describes agricultural production value (total gross value at the farmgate of crops produced) under existing conditions, and then estimates the potential change in value under EIS alternatives. These changes are based on the data in **Table 41**, and the estimated potential change in irrigated agricultural acreage presented in the above section (Farm Response to Crop Water Shortages: Change in Acreage). This section presents the potential change in crop production value under the EIS alternatives.

Existing Conditions

This section summarizes total agricultural production value in the study area under existing conditions. As presented in **Table 43**, according to the 2017 Census of Agriculture (U.S. Department of Agriculture 2019), total crop sales in the study area in 2017 were nearly $83.5 million, of which $54.8 million was in Jefferson County, $16.5 million was in Deschutes County and $12.1 million was in Crook County. Total 2017 crop acreage harvested in the study area was estimated at 109,420, of which 96,235 acres were irrigated (approximately 90% of all harvested cropland in the study area). As the acreage and the per acre production value of dryland cropping is relatively low in the region, nearly all crop production value is from irrigated lands. Note that the acreage under existing conditions in all Districts is estimated at approximately 140,000 acres (Table 1), indicating that this analysis may overestimate the average total irrigated acreage in the study area. To the extent this is the case, the analysis overestimates the economic impact of reduced irrigation water supplies.

As highlighted in Table 42, the average crop sales value per irrigated acre varies widely in the study area, from approximately $400 per acre in Crook County to approximately $690 per acre in Deschutes County, up to approximately $1,310 per acre in Jefferson County.[19] The higher value in Jefferson County reflects the high value of specialty crops such as mint, grass seed, and vegetable seed that are grown on a higher percentage of acres in Jefferson County than elsewhere in the study area. The relatively low crop sales value per irrigated acre in Crook County reflects the fact that much of Crook County crop production is forage used on-farm to support animal production and animal sales and thus does not count as 'crop sales'.[20] Animal sales in Crook County are the highest in the study area at $32.5 million, representing 57% of animal sales in the study area. Forage crop production in Deschutes and Jefferson County also supports animal production and sales, with total study area animal sales in 2017 estimated at $57.3 million. Combined, animal and crop sales in the study area in 2017 totaled $140.8 million, of which 59% was crop sales.

$4.8 million, the total impact would $8 million ($3.2 million plus $4.8 million), or double the estimated impact based on forage/grain production value (i.e., 80% + 120% X 20% = 200%).

[19] This estimate is derived assuming all crop sales are derived from irrigated lands. Actual value of crop sales per irrigated acre are slightly lower than these estimates as some value is produced from dryland farmed acres.

[20] The average annual value of forage and grain production in Crook County in the period 2012 to 2017 is over 200% of the value of 2017 crop sales in the county.

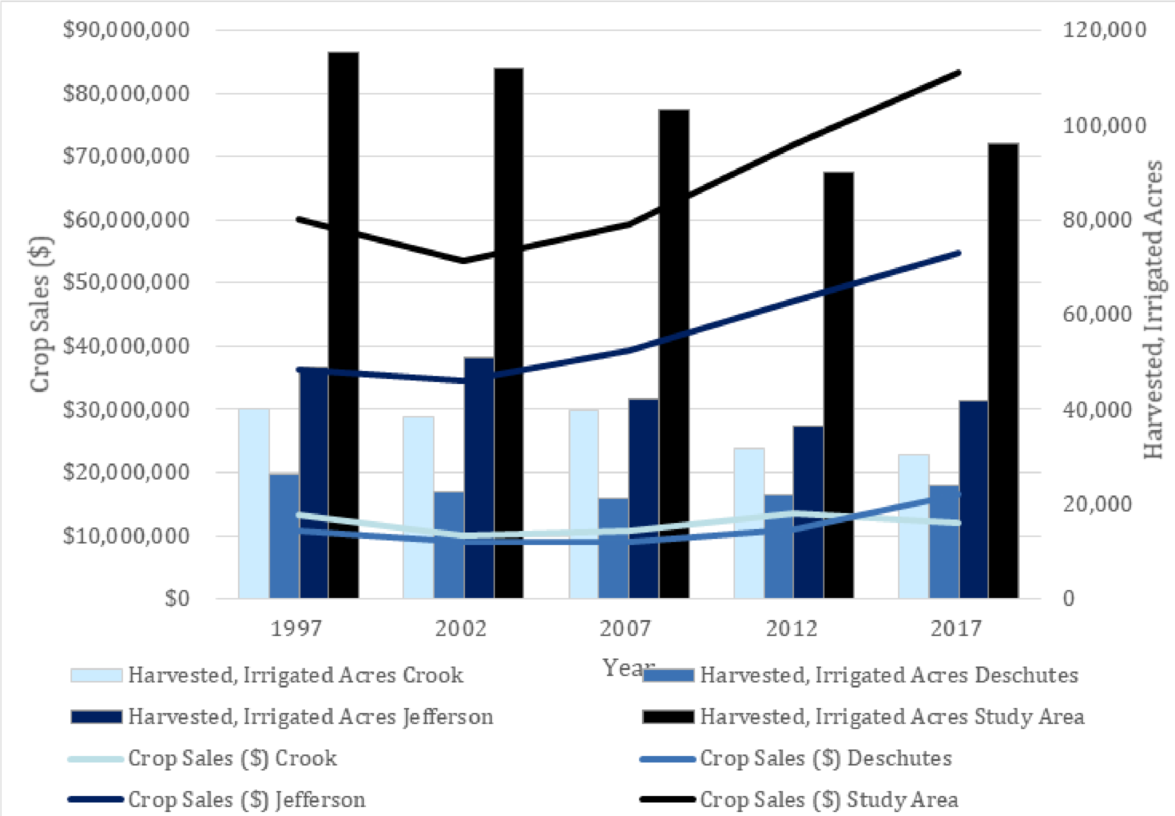
Table 43. Harvested, Total Crop and Animal Sales in Study Area, 2017

Production Type	Crook	Deschutes	Jefferson	Study Area
Crop Production				
Crop Sales	$12,094,000	$16,543,000	$54,792,000	$83,429,000
Harvested, Irrigated Acres	30,421	23,983	41,831	96,235
Approx. Sales per Irrigated Acre	$398	$690	$1,310	$867
Animal Production				
Animal Sales (including products)	$32,470,000	$12,226,000	$12,645,000	$57,341,000
Agricultural (Crop and Animal) Production				
Crop and Animal Sales	$44,564,000	$28,769,000	$67,437,000	$140,770,000
% Crop Sales	27%	58%	81%	59%

Source: Highland Economics analysis of U.S. Department of Agriculture, National Agricultural Statistics Service data from the 2017 U.S. Census of Agriculture.

Figure 11 highlights how crop sales and irrigated acreage may have generally shifted over the last 20 years, with the bars representing irrigated acres and the lines representing crop sales. In viewing these data, it is important to note that the Census of Agriculture captures crop production in one year, and does not account for variation occurring in that year due to water availability or weather. However, the data indicate that in Jefferson County (dark blue line and bars), harvested, irrigated acreage may have trended downwards, but total crop sales have shifted upwards (representing increasing crop sales per acre harvested). Harvested, irrigated acreage in Crook County may be trending downward over the last 20 years, but the pattern in Deschutes County is more mixed, with a potential downward trend from 1997 to 2007, but trending upwards again since 2007 (though still lower than the 1997 levels). Value of crop production in Crook and Deschutes Counties appears to have been more or less stable since 1997.

Figure 11. Harvested, Irrigated Acreage and Total Crop Sales from 1997 to 2017



Source: U.S. Department of Agriculture, National Agricultural Statistics Service 1997, 2002, 2007, 2012, 2017 Census of Agriculture.

Applying the per acre forage and grain revenue (from Table 41) to the acreage irrigated in each District (from Table 1) under existing conditions median year provides the estimated total forage/grain production value by District under existing conditions in a median year, as shown in **Table 44**. **Table 45** summarizes how production value may change in a dry year under existing conditions. Across all districts, forage/grain production is estimated at $85.2 million under existing conditions in an average water year. This exceeds the value of crop sales in the region for 2017 as reported by the U.S. Census of Agriculture, for two reasons: 1) much of the forage production in the study area is used on-farm for livestock feed and is not sold (and, therefore, not included in crop sales statistics), and 2) the reported irrigated acreage in the 2017 census is lower than the District-reported irrigated acreage used in this analysis.

Table 44. Estimated Annual Forage/Grain Production Value by District under Existing Conditions, Median Water Year

	Forage/Grain	
District	**Acreage**	**Production Value**
Arnold	1,876	$1,342,000
Central Oregon	38,341	$27,329,000
Lone Pine	1,602	$1,144,000
North Unit	35,103	$32,383,000
Ochoco	14,357	$10,300,000
Swalley	2,669	$1,910,000
Three Sisters	6,906	$4,794,000
Tumalo	5,000	$3,578,000
Other Irrigated Lands	3,345	$2,407,000
Total	109,198	$85,186,000

Source: Highland Economics analysis of District acreage and U.S. Department of Agriculture, National Agricultural Statistics Service data.

Table 45. Estimated Annual Forage/Grain Production Value by District under Existing Conditions, Dry Water Year Compared to Median Water Year

	Acreage Impact			Change in Production Value				Production Value
District	**May**	**June/ July**	**Aug/ Sept**	**May**	**June/July**	**Aug/Sept**	**Season**	**Season**
Arnold	0	-1,230	-1,330	$0	-$351,000	-$190,000	-$541,000	$801,000
Central Oregon	-80	-1,090	-1,380	-$23,000	-$310,000	-$196,000	-$529,000	$26,800,000
Lone Pine	0	-530	-530	$0	-$152,000	-$76,000	-$228,000	$915,000
North Unit	0	-16,000	-16,000	$0	-$5,903,000	-$2,952,000	-$8,855,000	$23,528,000
Ochoco	0	0	0	$0	$0	$0	$0	$10,300,000
Swalley	0	0	0	$0	$0	$0	$0	$1,910,000
Three Sisters	0	-1,610	-4,860	$0	-$447,000	-$675,000	-$1,122,000	$3,672,000
Tumalo	-2,250	-160	-330	-$645,000	-$44,000	-$47,000	-$736,000	$2,841,000
Other Irrigated Lands	-10	-40	-70	-$2,000	-$12,000	-$10,000	-$12,011,000	$2,382,000
Total	-2,340	-20,660	-24,500	-$670,000	-$7,219,000	-$4,146,000	-$24,022,000	$73,149,000

Source: Highland Economics analysis.
Note: Change in production value in August/September may be lower even if affected acreage is higher or the same because the value of the final cutting of hay is expected to be lower than other cuttings.

No-Action Alternative

As the amount of water available for diversion under the no-action alternative would be similar to existing conditions, the average agricultural production value under the no-action alternative is expected to be very similar to the value presented above in **Table 44.** Similarly, in the initial years of the analysis period, the no-action dry year agricultural production value would be similar to existing conditions as presented above in **Table 45**. However, due to water conservation over the analysis period, under the no-action alternative, water available to crops in dry water years may increase over time compared to existing conditions. This may lead to increased acreage and/or yields in dry water years over the analysis period. **Table 46** summarizes the estimated effect on irrigated acreage under the no-action alternative in dry water years throughout the analysis period. **Table 47** presents detail on effects by irrigation subseason for a dry year.

Table 46. Estimated Potential Increase in Annual Forage/Grain Production Value by District under the No-Action Alternative Compared to Existing Conditions, Dry Water Year

	DBBC Districts										
Year	Arnold	Central Oregon	Lone Pine	North Unit	Ochoco	Swalley	Three Sisters	Tumalo	Total, DBBC Districts	Other Irrigated Lands	All Lands
Low Conservation											
2020	$0	$0	$86,000	$480,000	$0	$0	$0	$100,000	$666,000	$0	$666,000
2025	$71,000	$0	$172,000	$1,715,000	$0	$0	$0	$572,000	$2,530,000	$0	$2,530,000
2030	$129,000	$0	$172,000	$3,008,000	$0	$0	$0	$673,000	$3,982,000	$0	$3,982,000
2040	$129,000	$0	$172,000	$5,092,000	$0	$0	$0	$873,000	$6,266,000	$0	$6,266,000
2049	$129,000	$0	$172,000	$6,992,000	$0	$0	$0	$873,000	$8,166,000	$0	$8,166,000
High Conservation											
2020	$114,000	$0	$143,000	$1,328,000	$0	$0	$0	$172,000	$1,757,000	$0	$1,757,000
2025	$715,000	$0	$172,000	$5,388,000	$0	$0	$0	$673,000	$6,948,000	$0	$6,948,000
2030	$715,000	$0	$172,000	$7,970,000	$0	$0	$0	$873,000	$9,730,000	$0	$9,730,000
2040	$715,000	$0	$172,000	$8,487,000	$0	$0	$0	$873,000	$10,247,000	$0	$10,247,000
2049	$715,000	$0	$172,000	$8,819,000	$0	$0	$0	$873,000	$10,579,000	$0	$10,579,000

Source: Highland Economics analysis.

Table 47. Estimated Potential Increase in Annual Forage/Grain Production Value by Subseason Under No-Action Alternative Compared to Existing Condition, Dry Water Year

District / Year	Low Conservation				High Conservation			
	May	June/July	Aug/Sept	Total	May	June/July	Aug/Sept	Total
Arnold								
2020	$0	$0	$0	$0	$0	$57,000	$57,000	$114,000
2025	$0	$57,000	$14,000	$71,000	$0	$343,000	$372,000	$715,000
2030	$0	$86,000	$43,000	$129,000	$0	$343,000	$372,000	$715,000
2040	$0	$86,000	$43,000	$129,000	$0	$343,000	$372,000	$715,000
2049	$0	$86,000	$43,000	$129,000	$0	$343,000	$372,000	$715,000
Central Oregon								
2020	$0	$0	$0	$0	$0	$0	$0	$0
2025	$0	$0	$0	$0	$0	$0	$0	$0
2030	$0	$0	$0	$0	$0	$0	$0	$0
2040	$0	$0	$0	$0	$0	$0	$0	$0
2049	$0	$0	$0	$0	$0	$0	$0	$0
Lone Pine								
2020	$0	$57,000	$29,000	$86,000	$0	$114,000	$29,000	$143,000
2025	$0	$143,000	$29,000	$172,000	$0	$143,000	$29,000	$172,000
2030	$0	$143,000	$29,000	$172,000	$0	$143,000	$29,000	$172,000
2040	$0	$143,000	$29,000	$172,000	$0	$143,000	$29,000	$172,000
2049	$0	$143,000	$29,000	$172,000	$0	$143,000	$29,000	$172,000
North Unit								
2020	$0	$369,000	$111,000	$480,000	$0	$1,033,000	$295,000	$1,328,000
2025	$0	$1,328,000	$387,000	$1,715,000	$0	$4,170,000	$1,218,000	$5,388,000
2030	$0	$2,325,000	$683,000	$3,008,000	$0	$5,904,000	$2,066,000	$7,970,000
2040	$0	$3,948,000	$1,144,000	$5,092,000	$0	$5,904,000	$2,583,000	$8,487,000
2049	$0	$5,424,000	$1,568,000	$6,992,000	$0	$5,904,000	$2,915,000	$8,819,000

District / Year	Low Conservation				High Conservation			
	May	June/July	Aug/Sept	Total	May	June/July	Aug/Sept	Total
Ochoco								
2020	$0	$0	$0	$0	$0	$0	$0	$0
2025	$0	$0	$0	$0	$0	$0	$0	$0
2030	$0	$0	$0	$0	$0	$0	$0	$0
2040	$0	$0	$0	$0	$0	$0	$0	$0
2049	$0	$0	$0	$0	$0	$0	$0	$0
Three Sisters								
2020	$0	$0	$0	$0	$0	$0	$0	$0
2025	$0	$0	$0	$0	$0	$0	$0	$0
2030	$0	$0	$0	$0	$0	$0	$0	$0
2040	$0	$0	$0	$0	$0	$0	$0	$0
2049	$0	$0	$0	$0	$0	$0	$0	$0
Tumalo								
2020	$0	$86,000	$14,000	$100,000	$0	$143,000	$29,000	$172,000
2025	$0	$458,000	$114,000	$572,000	$0	$458,000	$215,000	$673,000
2030	$0	$458,000	$215,000	$673,000	$0	$458,000	$415,000	$873,000
2040	$0	$458,000	$415,000	$873,000	$0	$458,000	$415,000	$873,000
2049	$0	$458,000	$415,000	$873,000	$0	$458,000	$415,000	$873,000
Other Irrigated Lands								
2020	$0	$0	$0	$0	$0	$0	$0	$0
2025	$0	$0	$0	$0	$0	$0	$0	$0
2030	$0	$0	$0	$0	$0	$0	$0	$0
2040	$0	$0	$0	$0	$0	$0	$0	$0
2049	$0	$0	$0	$0	$0	$0	$0	$0

Source: Highland Economics analysis.

Proposed Action

Table 48 presents the estimated range of changes in forage/grain production value within an irrigation season. In dry water years under both conservation scenarios, production value in the proposed action compared to the no-action alternative would decline in the following districts: Arnold, Lone Pine, NUID, Tumalo and Other Irrigated Lands. In median water years, under the high conservation scenario, there would be no impacts on production value. Under the low conservation scenario, there would be impacts that would lead to reduced crop production value as shown in **Table 48**.

Across all irrigated lands over the permit term in a median water year, changes in annual forage/grain production value may range from $0 to -$2.5 million (up to 4% of forage/grain production value under the no-action alternative), while a in dry year annual changes in agricultural production value may range from -$1.0 million to -$9.9 million (up to 13% of forage/grain production value under the no-action alternative). Across all water year types, the annual average forage/grain production value may decrease by 5% compared to the no-action alternative. When considering the value of all agricultural production in the county (all crop and animal sales), agricultural production value may fall by up to 3% across all water year types.

Table 49 and **Table 50** present change in estimated forage production value by district and conservation scenario, while **Table 51** highlights how forage production value impacts vary within each irrigation subseason (May, June/July, and August/September).

Table 48. Range of Potential Change in Annual Forage/Grain Production Value across All Irrigated Lands, Proposed Action Compared to the No-Action Alternative

Year	Water Year Type			Average, All Water Year Types[a]
	Wet	Median	Dry	
2020	$0	$0 to $0	-$1,073,000 to -$1,187,000	-$376,000 to -$415,000
2025	$0	$0 to -$1,162,000	-$2,452,000 to -$2,494,000	-$858,000 to -$1,222,000
2030	$0	$0 to -$1,882,000	-$3,695,000 to -$5,574,000	-$1,293,000 to -$2,516,000
2040	$0	$0 to -$3,796,000	-$4,222,000 to -$10,007,000	-$1,478,000 to -$4,641,000
2049	$0	$0 to -$2,523,000	-$2,415,000 to -$8,752,000	-$845,000 to -$3,820,000
% Change (Forage/Grain Production Value)[b]	0%	0 to -4%	0 to -13%	0 to -5%
% Change Agricultural Sales[c]				0 to -3%

Source: Highland Economics analysis.

[a] Average computed assuming that the wet year represents approximately 35% of years (water years in the 65th to 100th percentile), the median or median represents 30% of water years (water years in the 35th to 65th percentile), and the dry water year represents approximately 35% of water years (water years in the 0th to the 35th percentile).

[b] Relative to estimated forage/grain production value under existing conditions, as presented in Tables 43 and 44.

[c] Relative to total study area animal and crop sales as estimated in the 2017 Census of Agriculture.

Table 49. Estimated Potential Change in Annual Forage/Grain Production by District under the Proposed Action Compared to the No-Action Alternative, Median Water Year

	DBBC Districts										
Year	Arnold	Central Oregon	Lone Pine	North Unit	Ochoco	Swalley	Three Sisters	Tumalo	Total, DBBC Districts	Other Irrigated Lands	All Lands
Low Conservation											
2020	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2025	$0	$0	$0	-$1,162,000	$0	$0	$0	$0	-$1,162,000	$0	-$1,162,000
2030	$0	$0	$0	-$1,882,000	$0	$0	$0	$0	-$1,882,000	$0	-$1,882,000
2040	-$143,000	$0	$0	-$3,653,000	$0	$0	$0	$0	-$3,796,000	$0	-$3,796,000
2049	-$143,000	$0	$0	-$2,380,000	$0	$0	$0	$0	-$2,523,000	$0	-$2,523,000
% Change	0 to -11%	0%	0%	0 to -11%	0%	0%	0%	0%	0 to -5%	0%	0 to -4%
High Conservation											
2020	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2025	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2030	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2040	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2049	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
% Change	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Source: Highland Economics analysis.

Table 50. Estimated Potential Change in Forage/Grain Production Value by District under the Proposed Action Compared to the No-Action Alternative, Dry Water Year

Year	DBBC Districts										
	Arnold	Central Oregon	Lone Pine	North Unit	Ochoco	Swalley	Three Sisters	Tumalo	Total, DBBC Districts	Other Irrigated Lands	All Lands
Low Conservation											
2020	-$687,000	$0	-$314,000	$0	$0	$0	$0	-$143,000	-$1,001,000	-$43,000	-$1,187,000
2025	-$472,000	$0	-$300,000	-$1,679,000	$0	$0	$0	-$29,000	-$2,451,000	-$14,000	-$2,494,000
2030	-$644,000	$0	-$471,000	-$4,373,000	$0	$0	$0	-$43,000	-$5,488,000	-$43,000	-$5,574,000
2040	-$930,000	$0	-$471,000	-$8,506,000	$0	$0	$0	-$57,000	-$9,907,000	-$43,000	-$10,007,000
2049	-$930,000	$0	-$471,000	-$7,251,000	$0	$0	$0	-$57,000	-$8,652,000	-$43,000	-$8,752,000
% Change	-54 to -100%	0%	-28 to -43%	0 to -30%	0%	0%	0%	-1 to -5%	-2 to -14%	-2 to -1%	-2 to -13%
High Conservation											
2020	-$730,000	$0	-$271,000	$0	$0	$0	$0	-$29,000	-$1,030,000	-$43,000	-$1,073,000
2025	-$587,000	$0	-$129,000	-$1,679,000	$0	$0	$0	-$43,000	-$2,438,000	-$14,000	-$2,452,000
2030	-$343,000	$0	-$171,000	-$3,081,000	$0	$0	$0	-$57,000	-$3,652,000	-$43,000	-$3,695,000
2040	-$372,000	$0	-$171,000	-$3,579,000	$0	$0	$0	-$57,000	-$4,179,000	-$43,000	-$4,222,000
2049	-$372,000	$0	-$171,000	-$1,772,000	$0	$0	$0	-$57,000	-$2,372,000	-$43,000	-$2,415,000
% Change	-23 to -80%	0%	-12 to -26%	0 to -11%	0%	0%	0%	-1 to -2%	-1 to -5%	-1 to -2%	-1 to -5%

Source: Highland Economics analysis. Note that since the no-action alternative acreage is higher in the high conservation scenario, the percent difference from the no-action alternative for the same reduction in acreage due to the proposed action is lower in the high conservation scenario than in the low conservation scenario.

Table 51. Estimated Potential Change in Forage/Grain Production Value by Subseason by District under the Proposed Action Compared to the No-Action Alternative

	Dry Water Year						Median Water Year					
	Low Conservation			High Conservation			Low Conservation			High Conservation		
District	May	June /July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept
Arnold												
2020	$0	-$458,000	-$229,000	$0	-$487,000	-$243,000	0	0	0	0	0	0
2025	$0	-$315,000	-$157,000	$0	-$372,000	-$215,000	0	0	0	0	0	0
2030	$0	-$429,000	-$215,000	$0	-$229,000	-$114,000	0	0	0	0	0	0
2040	-$286,000	-$429,000	-$215,000	$0	-$229,000	-$143,000	0	-200	0	0	0	0
2049	-$286,000	-$429,000	-$215,000	$0	-$229,000	-$143,000	0	-200	0	0	0	0
Central Oregon												
2020	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2025	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2030	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2040	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2049	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Lone Pine												
2020	$0	-$171,000	-$143,000	$0	-$171,000	-$100,000	0	0	0	0	0	0
2025	$0	-$200,000	-$100,000	$0	-$86,000	-$43,000	0	0	0	0	0	0
2030	$0	-$314,000	-$157,000	$0	-$114,000	-$57,000	0	0	0	0	0	0
2040	$0	-$314,000	-$157,000	$0	-$114,000	-$57,000	0	0	0	0	0	0
2049	$0	-$314,000	-$157,000	$0	-$114,000	-$57,000	0	0	0	0	0	0
North Unit												
2020	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2025	$0	-$849,000	-$830,000	$0	-$849,000	-$830,000	$0	$0	$0	$0	$0	$0
2030	$0	-$2,915,000	-$1,458,000	$0	-$1,734,000	-$1,347,000	$0	$0	$0	$0	$0	$0
2040	-$1,255,000	-$4,834,000	-$2,417,000	$0	-$1,808,000	-$1,771,000	-$57,000	-$57,000	-$29,000	$0	$0	$0
2049	$0	-$4,834,000	-$2,417,000	$0	-$148,000	-$1,624,000	-$57,000	-$57,000	-$29,000	$0	$0	$0

	Dry Water Year						Median Water Year					
	Low Conservation			High Conservation			Low Conservation			High Conservation		
District	May	June /July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept
Ochoco												
2020	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2025	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2030	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2040	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2049	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Tumalo												
2020	-$57,000	-$57,000	-$29,000	$0	$0	-$29,000	$0	$0	$0	$0	$0	$0
2025	$0	$0	-$29,000	$0	$0	-$43,000	$0	-$775,000	-$387,000	$0	$0	$0
2030	$0	$0	-$43,000	$0	$0	-$57,000	$0	-$1,255,000	-$627,000	$0	$0	$0
2040	$0	$0	-$57,000	$0	$0	-$57,000	$0	-$2,435,000	-$1,218,000	$0	$0	$0
2049	$0	$0	-$57,000	$0	$0	-$57,000	$0	-$1,587,000	-$793,000	$0	$0	$0
Three Sisters												
2020	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2025	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2030	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2040	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2049	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Other Irrigated Lands												
2020	$0	-$29,000	-$14,000	$0	-$29,000	-$14,000	$0	$0	$0	$0	$0	$0
2025	$0	$0	-$14,000	$0	$0	-$14,000	$0	$0	$0	$0	$0	$0
2030	$0	-$29,000	-$14,000	$0	-$29,000	-$14,000	$0	$0	$0	$0	$0	$0
2040	$0	-$29,000	-$14,000	$0	-$29,000	-$14,000	$0	$0	$0	$0	$0	$0
2049	$0	-$29,000	-$14,000	$0	-$29,000	-$14,000	$0	$0	$0	$0	$0	$0

Source: Highland Economics analysis.

Alternative 3

Table 52 presents the estimated range of potential change in annual forage/grain production value, with detail by district provided in **Tables 53**, **54, and 55**. The values in **Table 52** represent the potential changes in annual forage/grain production value, with variation across the permit years, water year types, and conservation scenarios. Across all irrigated lands over the permit term in a median water year, the change in annual forage/grain production value may vary from approximately $0 to -$1.3 million (up to 3% of forage/grain production value under the no-action alternative), while a in dry year the change in annual forage/grain production value may range from -$2.9 million to -$10.0 million (3 to 13% of dry year forage/grain production value under no-action alternative). Across all water year types, the annual average forage/grain production value may decrease by up to 5% compared to the no-action alternative. When considering the value of all agricultural production in the county (all crop and animal sales), agricultural production value may fall by up to 3% across all water year types. **Table 53** and **Table 54** present changes in estimated forage/grain production value by district and conservation scenario, for median and dry water years, respectively. **Table 55** highlights how forage/grain production value impacts vary within each irrigation subseason (May, June/July, and August/September).

Table 52. Range of Potential Change in Annual Forage/Grain Production Value across All Irrigated Lands under Alternative 3 Compared to the No-Action Alternative

Year	Water Year Type			Average, All Water Year Types[a]
	Wet	Median	Dry	
2020	0	-$461,000 to -$664,000	-$2,906,000 to -$2,963,000	-$1,155,000 to -$1,236,000
2025	0	-$111,000 to -$941,000	-$5,641,000 to -$5,684,000	-$2,008,000 to -$2,272,000
2030	0	-$683,000 to -$2,152,000	-$6,732,000 to -$10,011,000	-$2,561,000 to -$4,149,000
2040	0	-$148,000 to -$1,691,000	-$2,820,000 to -$6,667,000	-$1,031,000 to -$2,841,000
2049	0	$0 to -$1,267,000	-$2,673,000 to -$3,678,000	-$936,000 to -$1,667,000
% Change (Forage/Grain Production Value)[b]	0%	0 to -3%	-3 to -13%	-1 to -5%
% Change Agricultural Sales[c]				-1 to - 3%

Source: Highland Economics analysis.

[a] Average computed assuming that the wet year represents approximately 35% of years (water years in the 65th to 100th percentile), the median or median represents 30% of water years (water years in the 35th to 65th percentile), and the dry water year represents approximately 35% of water years (water years in the 0th to the 35th percentile).

[b] Relative to estimated forage/grain production value under existing conditions, as presented in Tables 43 and 44.

[c] Relative to total study area animal and crop sales as estimated in the 2017 Census of Agriculture.

Table 53. Estimated Potential Change in Annual Forage/Grain Production Value by District under Alternative 3 Compared to the No-Action Alternative, Median Water Year

	DBBC Districts										
Year	Arnold	Central Oregon	Lone Pine	North Unit	Ochoco	Swalley	Three Sisters	Tumalo	Total, DBBC Districts	Other Irrigated Lands	All Lands
Low Conservation											
2020	$0	$0	$0	-$664,000	$0	$0	$0	$0	-$664,000	$0	-$664,000
2025	$0	$0	$0	-$941,000	$0	$0	$0	$0	-$941,000	$0	-$941,000
2030	-$86,000	$0	$0	-$2,066,000	$0	$0	$0	$0	-$2,152,000	$0	-$2,152,000
2040	-$86,000	$0	$0	-$1,605,000	$0	$0	$0	$0	-$1,691,000	$0	-$1,691,000
2049	-$86,000	$0	$0	-$1,181,000	$0	$0	$0	$0	-$1,267,000	$0	-$1,267,000
% Change	-0 to -6%	0%	0%	-2 to -6%	0%	0%	0%	0%	-1 to -3%	0%	-1 to -3%
High Conservation											
2020	$0	$0	$0	-$461,000	$0	$0	$0	$0	-$461,000	$0	-$461,000
2025	$0	$0	$0	-$111,000	$0	$0	$0	$0	-$111,000	$0	-$111,000
2030	$0	$0	$0	-$683,000	$0	$0	$0	$0	-$683,000	$0	-$683,000
2040	$0	$0	$0	-$148,000	$0	$0	$0	$0	-$148,000	$0	-$148,000
2049	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
% Change	0%	0%	0%	0 to -2%	0%	0%	0%	0%	0 to -1%	0%	0 to -1%

Source: Highland Economics analysis. Note that since the no-action alternative acreage is higher in the high conservation scenario, the percent difference from the no-action alternative for the same reduction in acreage due to Alternative 3 would be lower in the high conservation scenario than in the low conservation scenario.

Table 54. Estimated Potential Change in Annual Forage/Grain Production Value by District under Alternative 3 Compared to the No-Action Alternative, Dry Water Year

Year	DBBC Districts								Total, DBBC Districts	Other Irrigated Lands	All Lands
	Arnold	Central Oregon	Lone Pine	North Unit	Ochoco	Swalley	Three Sisters	Tumalo			
Low Conservation											
2020	-$472,000	$0	-$600,000	-$1,734,000	$0	$0	$0	-$143,000	-$2,949,000	-$14,000	-$2,963,000
2025	-$601,000	$0	-$514,000	-$4,483,000	$0	$0	$0	-$43,000	-$5,641,000	-$43,000	-$5,684,000
2030	-$930,000	$0	-$471,000	-$8,524,000	$0	$0	$0	-$43,000	-$9,968,000	-$43,000	-$10,011,000
2040	-$930,000	$0	-$471,000	-$5,166,000	$0	$0	$0	-$57,000	-$6,624,000	-$43,000	-$6,667,000
2049	-$930,000	$0	-$471,000	-$2,177,000	$0	$0	$0	-$57,000	-$3,635,000	-$43,000	-$3,678,000
% Change	-59 to -100%	0%	-43 to -60%	-7 to -32%	0%	0%	0%	-1 to -5%	-4 to -14%	-1 to -2%	-4 to -14%
High Conservation											
2020	-$487,000	$0	-$642,000	-$1,734,000	$0	$0	$0	-$29,000	-$2,892,000	-$14,000	-$2,906,000
2025	-$730,000	$0	-$342,000	-$4,483,000	$0	$0	$0	-$43,000	-$5,598,000	-$43,000	-$5,641,000
2030	-$372,000	$0	-$171,000	-$6,089,000	$0	$0	$0	-$57,000	-$6,689,000	-$43,000	-$6,732,000
2040	-$372,000	$0	-$171,000	-$2,177,000	$0	$0	$0	-$57,000	-$2,777,000	-$43,000	-$2,820,000
2049	-$372,000	$0	-$171,000	-$2,030,000	$0	$0	$0	-$57,000	-$2,630,000	-$43,000	-$2,673,000
% Change	-25 to -53%	0%	-16 to -61%	-6 to -19%	0%	0%	0%	-1 to -2%	-3 to -9%	-1 to -2%	-3 to -8%

Source: Highland Economics analysis.

Table 55. Estimated Potential Change in Annual Forage/Grain Production Value by Subseason by DBBC District under Alternative 3 Compared to the No-Action Alternative

	Dry Water Year						Median Water Year					
	Low Conservation			High Conservation			Low Conservation			High Conservation		
District	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept
Arnold												
2020	$0	-$315,000	-$157,000	$0	-$315,000	-$172,000	$0	$0	$0	$0	$0	$0
2025	$0	-$401,000	-$200,000	$0	-$487,000	-$243,000	$0	$0	$0	$0	$0	$0
2030	-$286,000	-$429,000	-$215,000	$0	-$229,000	-$143,000	$0	-$57,000	-$29,000	$0	$0	$0
2040	-$286,000	-$429,000	-$215,000	$0	-$229,000	-$143,000	$0	-$57,000	-$29,000	$0	$0	$0
2049	-$286,000	-$429,000	-$215,000	$0	-$229,000	-$143,000	$0	-$57,000	-$29,000	$0	$0	$0
Central Oregon												
2020	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2025	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2030	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2040	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2049	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Lone Pine												
2020	$0	-$400,000	-$200,000	$0	-$428,000	-$214,000	$0	$0	$0	$0	$0	$0
2025	$0	-$343,000	-$171,000	$0	-$228,000	-$114,000	$0	$0	$0	$0	$0	$0
2030	$0	-$314,000	-$157,000	$0	-$114,000	-$57,000	$0	$0	$0	$0	$0	$0
2040	$0	-$314,000	-$157,000	$0	-$114,000	-$57,000	$0	$0	$0	$0	$0	$0
2049	$0	-$314,000	-$157,000	0	-400	0	$0	$0	$0	$0	$0	$0
North Unit												
2020	$0	$0	-$1,734,000	$0	$0	-$1,734,000	$0	$0	-$664,000	$0	$0	-$461,000
2025	$0	-$2,989,000	-$1,494,000	$0	-$2,989,000	-$1,494,000	$0	$0	-$941,000	$0	$0	-$111,000
2030	-$886,000	-$5,092,000	-$2,546,000	$0	-$3,912,000	-$2,177,000	$0	$0	-$2,066,000	$0	$0	-$683,000
2040	$0	-$2,989,000	-$2,177,000	$0	$0	-$2,177,000	$0	$0	-$1,605,000	$0	$0	-$148,000
2049	$0	$0	-$2,177,000	$0	$0	-$2,030,000	$0	$0	-$1,181,000	$0	$0	$0

	Dry Water Year						Median Water Year					
	Low Conservation			High Conservation			Low Conservation			High Conservation		
District	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept
Ochoco												
2020	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2025	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2030	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2040	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2049	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Tumalo												
2020	-$57,000	-$57,000	-$29,000	$0	$0	-$29,000	$0	$0	$0	$0	$0	$0
2025	$0	$0	-$43,000	$0	$0	-$43,000	$0	$0	$0	$0	$0	$0
2030	$0	$0	-$43,000	$0	$0	-$57,000	$0	$0	$0	$0	$0	$0
2040	$0	$0	-$57,000	$0	$0	-$57,000	$0	$0	$0	$0	$0	$0
2049	$0	$0	-$57,000	$0	$0	-$57,000	$0	$0	$0	$0	$0	$0
Three Sisters												
2020	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2025	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2030	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2040	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2049	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Other Irrigated Lands												
2020	$0	$0	-$14,000	$0	$0	-$14,000	$0	$0	$0	$0	$0	$0
2025	$0	-$29,000	-$14,000	$0	-$29,000	-$14,000	$0	$0	$0	$0	$0	$0
2030	$0	-$29,000	-$14,000	$0	-$29,000	-$14,000	$0	$0	$0	$0	$0	$0
2040	$0	-$29,000	-$14,000	$0	-$29,000	-$14,000	$0	$0	$0	$0	$0	$0
2049	$0	-$29,000	-$14,000	$0	-$29,000	-$14,000	$0	$0	$0	$0	$0	$0

Source: Highland Economics analysis.

Alternative 4

Table 56 presents the estimated potential change in annual forage/grain production value, with detail by district provided in **Tables 57**, **58, and 59**. The values in **Table 56** represent the range of changes in annual forage/grain production value season, with variation across the permit years, water year types, and conservation scenarios. Across all irrigated lands over the permit term in a median water year, the change in annual forage/grain production value may vary from approximately -$1.3 million to -$3.9 million (up to 5% of forage/grain production value under the no-action alternative), while a in dry year the change in annual forage/grain production value may range from -$6.1 million to -$14.7 million (8 to 20% of dry year forage/grain production value under no-action alternative). Across all water year types, the annual average forage/grain production value may decrease by up to 7% compared to the no-action alternative. When considering the value of all agricultural production in the county (all crop and animal sales), agricultural production value may fall by up to 4% across all water year types.

Table 56. Range of Estimated Potential Change in Annual Forage/Grain Production Value across All Irrigated Lands under Alternative 4 Compared to the No-Action Alternative

	Water Year Type			Average, All Water Year Types[a]
Year	**Wet**	**Median**	**Dry**	
2020	$0	-$2,835,000 to -$3,882,000	-$7,992,000 to -$7,977,000	-$3,648,000 to -$3,957,000
2025	$0	-$2,583,000 to -$3,732,000	-$11,730,000 to -$14,673,000	-$4,880,000 to -$6,255,000
2030	$0	-$1,734,000 to -$3,204,000	-$7,820,000 to -$13,683,000	-$3,257,000 to -$5,750,000
2039	$0	-$1,255,000 to -$2,780,000	-$6,159,000 to -$12,369,000	-$2,532,000 to -$5,163,000
% Change (Forage/Grain Production Value)[b]	0%	-3 to -5%	-8 to -20%	-3 to -7%
% Change Agricultural Sales[c]				-2 to -4%

Source: Highland Economics analysis.

[a] Average computed assuming that the wet year represents approximately 35% of years (water years in the 65th to 100th percentile), the median represents 30% of water years (water years in the 35th to 65th percentile), and the dry water year represents approximately 35% of water years (water years in the 0th to the 35th percentile).

[b] Relative to estimated forage/grain production value under existing conditions, as presented in Tables 43 and 44.

[c] Relative to total study area animal and crop sales as estimated in the 2017 Census of Agriculture.

Table 57. Estimated Potential Change in Annual Forage/Grain Production Value by District under Alternative 4 Compared to the No-Action Alternative, Median Water Year

Year	DBBC Districts								Total, DBBC Districts	Other Irrigated Lands	All Lands
	Arnold	Central Oregon	Lone Pine	North Unit	Ochoco	Swalley	Three Sisters	Tumalo			
Low Conservation											
2020	-$215,000	$0	-$14,000	-$3,653,000	$0	$0	$0	$0	-$3,882,000	$0	-$3,882,000
2025	-$171,000	$0	$0	-$3,561,000	$0	$0	$0	$0	-$3,732,000	$0	-$3,732,000
2030	-$86,000	$0	$0	-$3,118,000	$0	$0	$0	$0	-$3,204,000	$0	-$3,204,000
2039	-$86,000	$0	$0	-$2,694,000	$0	$0	$0	$0	-$2,780,000	$0	-$2,780,000
% Change	-5 to -16%	0%	0 to -0%	-8 to -11%	0%	0%	0%	0%	-3 to -5%	0%	-3 to -5%
High Conservation											
2020	-$86,000	$0	$0	-$2,749,000	$0	$0	$0	$0	-$2,835,000	$0	-$2,835,000
2025	$0	$0	$0	-$2,583,000	$0	$0	$0	$0	-$2,583,000	$0	-$2,583,000
2030	$0	$0	$0	-$1,734,000	$0	$0	$0	$0	-$1,734,000	$0	-$1,734,000
2039	$0	$0	$0	-$1,255,000	$0	$0	$0	$0	-$1,255,000	$0	-$1,255,000
% Change	-6 to 0%	0%	0%	-4 to -8%	0%	0%	0%	0%	-2 to -3%	0%	-1 to -3%

Source: Highland Economics analysis.

Table 58. Estimated Potential Change in Annual Forage/Grain Production Value by District under Alternative 4 Compared to the No-Action Alternative, Dry Water Year

	DBBC Districts										
Year	Arnold	Central Oregon	Lone Pine	North Unit	Ochoco	Swalley	Three Sisters	Tumalo	Total, DBBC Districts	Other Irrigated Lands	All Lands
Low Conservation											
2020	-$1,087,000	$0	-$728,000	-$6,033,000	$0	$0	$0	-$86,000	-$7,934,000	-$43,000	-$7,977,000
2025	-$1,446,000	$0	-$557,000	-$12,584,000	$0	$0	$0	-$43,000	-$14,630,000	-$43,000	-$14,673,000
2030	-$1,459,000	$0	-$514,000	-$11,624,000	$0	$0	$0	-$43,000	-$13,640,000	-$43,000	-$13,683,000
2039	-$1,459,000	$0	-$514,000	-$10,296,000	$0	$0	$0	-$57,000	-$12,326,000	-$43,000	-$12,369,000
% Change	-136 to -166%[a]	0%	-47 to -73%	-25 to -50%	0%	0%	0%	-1 to -3%	-12 to -21%	-2%	-11 to -20%
High Conservation											
2020	-$1,116,000	$0	-$771,000	-$6,033,000	$0	$0	$0	-$29,000	-$7,949,000	-$43,000	-$7,992,000
2025	-$1,331,000	$0	-$386,000	-$9,927,000	$0	$0	$0	-$43,000	-$11,687,000	-$43,000	-$11,730,000
2030	-$1,159,000	$0	-$214,000	-$6,347,000	$0	$0	$0	-$57,000	-$7,777,000	-$43,000	-$7,820,000
2039	-$1,159,000	$0	-$214,000	-$4,686,000	$0	$0	$0	-$57,000	-$6,116,000	-$43,000	-$6,159,000
% Change	-74 to -88%	0%	-20 to -71%	-14 to -32%	0%	0%	0%	-1 to -2%	-8 to -15%	-2%	-8 to -15%

Source: Highland Economics analysis.

[a] This represents less than 100% reduction of the forage/grain production value in the no-action *average* water year, but it is a decrease of more than 100% of the forage/grain production value produced in a no-action dry water year (since a dry water year is projected to have much less acreage).

Table 59. Estimated Potential Change in Annual Forage/Grain Production Value by Subseason by DBBC District under Alternative 4 Compared to the No-Action Alternative

	Dry Water Year						Median Water Year					
	Low Conservation			High Conservation			Low Conservation			High Conservation		
District	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept
Arnold												
2020	-$57,000	-$687,000	-$343,000	$0	-$744,000	-$372,000	$0	-$143,000	-$72,000	$0	-$57,000	-$29,000
2025	-$372,000	-$716,000	-$358,000	$0	-$887,000	-$444,000	$0	-$114,000	-$57,000	$0	$0	$0
2030	-$343,000	-$744,000	-$372,000	$0	-$773,000	-$386,000	$0	-$57,000	-$29,000	$0	$0	$0
2039	-$343,000	-$744,000	-$372,000	$0	-$773,000	-$386,000	$0	-$57,000	-$29,000	$0	$0	$0
Central Oregon												
2020	0	0	0	0	0	0	$0	$0	$0	$0	$0	$0
2025	0	0	0	0	0	0	$0	$0	$0	$0	$0	$0
2030	0	0	0	0	0	0	$0	$0	$0	$0	$0	$0
2039	0	0	0	0	0	0	$0	$0	$0	$0	$0	$0
Lone Pine												
2020	$0	-$485,000	-$243,000	$0	-$514,000	-$257,000	$0	$0	-$14,000	$0	$0	0
2025	$0	-$371,000	-$186,000	$0	-$257,000	-$129,000	$0	$0	$0	$0	$0	0
2030	$0	-$343,000	-$171,000	$0	-$143,000	-$71,000	$0	$0	$0	$0	$0	0
2039	$0	-$343,000	-$171,000	$0	-$143,000	-$71,000	$0	$0	$0	$0	$0	0
North Unit												
2020	$0	-$4,022,000	-$2,011,000	$0	-$4,022,000	-$2,011,000	$0	-$1,144,000	-$2,509,000	$0	-$443,000	-12,500
2025	-$4,613,000	-$5,314,000	-$2,657,000	-$1,956,000	-$5,314,000	-$2,657,000	$0	-$148,000	-$3,413,000	$0	$0	-14,000
2030	-$3,653,000	-$5,314,000	-$2,657,000	$0	-$4,133,000	-$2,214,000	$0	$0	-$3,118,000	$0	$0	-9,400
2039	-$2,325,000	-$5,314,000	-$2,657,000	$0	-$2,472,000	-$2,214,000	$0	$0	-$2,694,000	$0	$0	-6,800
Ochoco												
2020	0	-1,400	-1,400	0	0	0	$0	$0	$0	$0	$0	$0
2025	0	-1,400	-1,400	0	0	0	$0	$0	$0	$0	$0	$0
2030	0	-1,400	-1,400	0	0	0	$0	$0	$0	$0	$0	$0
2039	0	-1,400	-1,400	0	0	0	$0	$0	$0	$0	$0	$0

	Dry Water Year						Median Water Year					
	Low Conservation			High Conservation			Low Conservation			High Conservation		
District	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept	May	June/ July	Aug/ Sept
Tumalo												
2020	-$57,000	$0	-$29,000	$0	$0	-$29,000	$0	$0	$0	$0	$0	$0
2025	$0	$0	-$43,000	$0	$0	-$43,000	$0	$0	$0	$0	$0	$0
2030	$0	$0	-$43,000	$0	$0	-$57,000	$0	$0	$0	$0	$0	$0
2039	$0	$0	-$57,000	$0	$0	-$57,000	$0	$0	$0	$0	$0	$0
Three Sisters												
2020	0	0	0	0	0	0	$0	$0	$0	$0	$0	$0
2025	0	0	0	0	0	0	$0	$0	$0	$0	$0	$0
2030	0	0	0	0	0	0	$0	$0	$0	$0	$0	$0
2039	0	0	0	0	0	0	$0	$0	$0	$0	$0	$0
Other Irrigated Lands												
2020	$0	-$29,000	-$14,000	$0	-$29,000	-$14,000	$0	$0	$0	$0	$0	$0
2025	$0	-$29,000	-$14,000	$0	-$29,000	-$14,000	$0	$0	$0	$0	$0	$0
2030	$0	-$29,000	-$14,000	$0	-$29,000	-$14,000	$0	$0	$0	$0	$0	$0
2039	$0	-$29,000	-$14,000	$0	-$29,000	-$14,000	$0	$0	$0	$0	$0	$0

Source: Highland Economics analysis.

Economic Contribution of Agricultural Production

This section describes the economic contribution of agricultural production in terms of the direct, indirect, and induced jobs and income supported under existing conditions and the EIS alternatives. Agricultural production spurs economic activity in the local economy through on-farm income generation and farm worker employment, as well as through farm spending at local businesses for agricultural supplies, services, and equipment (indirect impacts). Agricultural support businesses, in turn, purchase goods and services from other businesses in the local area, generating other local economic activity (more indirect impacts). Furthermore, employees and proprietors in the farm sector and all supporting industries spend their income at local businesses such as retail stores and service businesses, which further supports economic activity (induced impacts). **The sum of direct, indirect, and induced impacts represent the total economic contribution of agricultural production to the local economy.** This section presents estimates of the total economic contribution under existing conditions and the EIS alternatives.

If agricultural production declines, as projected in the proposed action and Alternatives 3 and 4, the total economic contribution of agriculture (i.e., the regional jobs and income supported by agriculture) also would decline. However, it is important to note that the economic contribution of agricultural production *does not* equal the economic impact (i.e., the change in jobs and income in the local economy) that would result from reduced agricultural production. The actual economic impact, particularly in the long-term, would be smaller as at least some portion of the affected workers and businesses would likely find alternative sources of income generation and employment.

Existing Conditions

Agricultural Economy

This section summarizes published data from the Bureau of Economic Analysis (BEA), the Oregon Department of Employment, and the U.S. Census of Agriculture on total employment and income in the farm sector in the study area. These data include employment and income from both crop and animal production. The various data sources indicate different levels of farm worker employment (with BEA indicating higher farm worker employment, particularly in Deschutes County than Oregon Department of Employment), and different levels of net farm income to proprietors (with BEA indicating lower net income than the U.S. Census of Agriculture). The following tables and figures summarize these data.

BEA data provide a consistent basis for comparing the farm sector with other economic sectors, as these data include income and employment data for both workers and proprietors. Including farm proprietors (many of whom may be part-time farmers), BEA data indicate that farm-related employment may account for up to approximately 12 to 13% of total employment in Crook and Jefferson Counties, and up to approximately 1% of total labor income. In Deschutes County, farm sector employment and income represent up to approximately 2% of the county economy.

Following this overview of published data, this section provides estimates of the economic contribution of existing forage and grain production under median and dry water years.

Table 60. 2017 Farm and Other Sector Employment and Income, Bureau of Economic Analysis

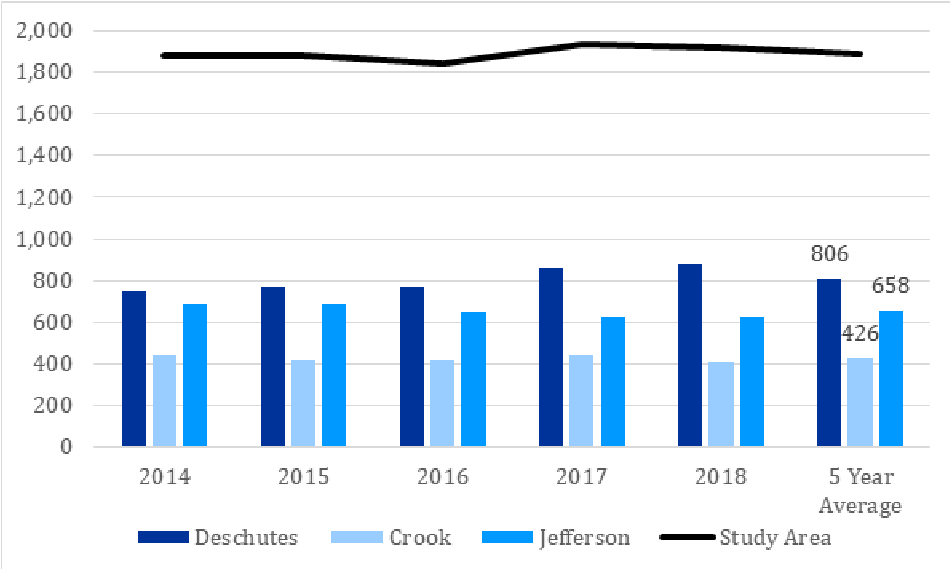
Sector	Jobs	Income[a]
Crook		
Farm workers	700	$5,375,000
Farm proprietors	519	-$1,277,000
Total farm-related	1,219	$4,098,000
All other sectors, workers and proprietors	8,607	$452,606,000
Total	9,826	$456,704,000
% farm-related	12%	1%
Deschutes		
Farm workers	1,206	$8,390,000
Farm proprietors	1206	-$17,511,000
Total farm-related	2,412	-$9,121,000
All other sectors, workers and proprietors	115,747	$6,191,292,000
Total	118159	$6,182,171,000
% farm-related	2%	N/A
Jefferson		
Farm workers	774	$12,438,000
Farm proprietors	424	-$16,191,000
Total farm-related	1,198	-$3,753,000
All other sectors, workers and proprietors	8,081	$277,405,000
Total	9279	$273,652,000
% farm-related	13%	N/A

Source: Bureau of Economic Analysis 2019: Tables CAINC5N Personal Income by Major Component and Earnings by NAICS Industry and CAEMP25N Total Full-Time and Part-Time Employment by NAICS Industry for Crook, Deschutes, and Jefferson Counties.

[a] Including supplements to wages and salaries.

Farm worker data from the Oregon Department of Employment (2014, 2015, 2016, 2017, 2018) indicate that the number of farm workers in the study area may be lower than reported by the Bureau of Economic Analysis (2019) in **Table 60**. **Figure 12** shows Oregon Department of Employment data for farm workers for the period 2014 to 2018. The 5-year average for this time period indicates that there were approximately 1,900 farm workers employed throughout the study area in crop and animal production, with approximately 800 farm workers in Deschutes County, 430 farm workers in Crook County, and approximately 660 farm workers in Jefferson County.

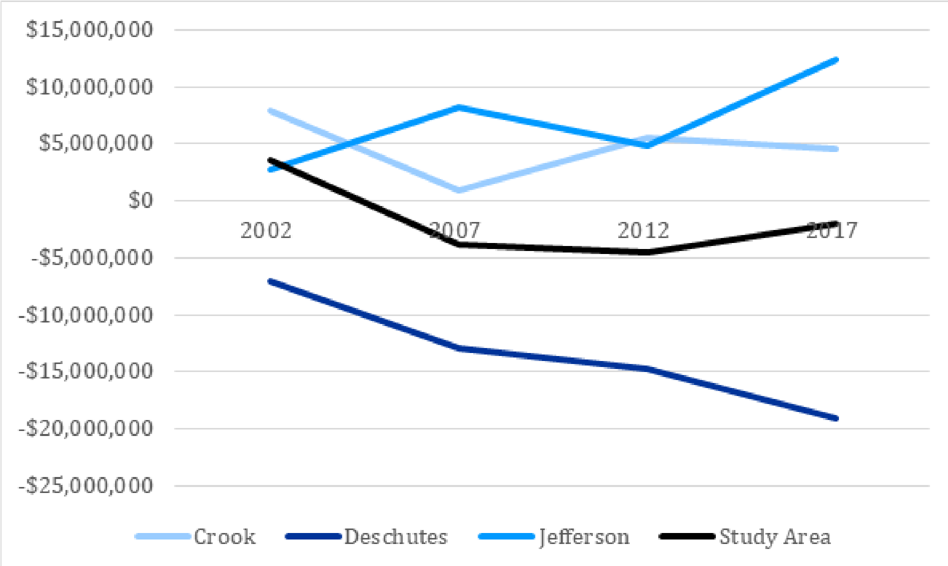
Figure 12. Study Area Farm Worker (Crop and Animal Production) Employment from 2014 to 2018



Source: Oregon Department of Employment 2014–2018.

While the data from the Bureau of Economic Analysis (2019) indicate that total net cash farm income (a measure of farm profit that does not include such non-cash items as depreciation) is negative across all farms in the three counties, data from the 2017 Census of Agriculture (2019) indicate that net cash farm income in Jefferson and Crook is positive. Only in Deschutes County, which has many smaller lifestyle farms, shows a negative net cash farm income across all farms (although some farms will be positive and some negative). It is important to note that a negative net cash farm income does not necessarily mean a negative economic value to the proprietor. Many farm proprietors derive enjoyment from a rural, agricultural lifestyle and also benefit through being able to support their livestock animals through on-farm forage production.

Figure 13. Net Cash Farm Income (to Proprietors) by County (2017)



Source: 2017 Census of Agriculture (2019).

Economic Contribution of Forage and Grain Production

To provide a baseline for the change in the economic contribution under the EIS alternatives, this section presents estimates of the economic contribution of existing forage and grain production under median and dry water years. **Table 61** summarizes by county the value of forage and grain production presented in the section above for a median water year under existing conditions. For this level of production, **Table 62** presents the estimated direct, indirect, and induced economic contribution in each county and the study area as a whole**.** Indirect and induced effects in sectors supporting agriculture and agricultural workers include those arising from agricultural production within the county, as well as those arising from agricultural production in the other two study area counties (e.g., if a farm in Crook County purchased supplies from a Deschutes County farm supplier, or vice versa). **Tables 63 and 64** present the same data for a dry water year.

Table 61. Forage and Grain Production Value by County under Existing Conditions, Median Water Year

District	County: Crook	County: Deschutes	County: Jefferson	Study Area
Arnold	$0	$1,342,000	$0	$1,342,000
Central Oregon	$13,664,000	$13,664,000	$0	$27,328,000
Lone Pine	$1,144,000	$0	$0	$1,144,000
North Unit	$0	$0	$32,383,000	$32,383,000
Ochoco	$10,300,000	$0	$0	$10,300,000
Swalley	$0	$1,910,000	$0	$1,910,000
Three Sisters	$0	$4,794,000	$0	$4,794,000
Tumalo	$0	$3,578,000	$0	$3,578,000
Other Irrigated Lands	$2,407,000	$0	$0	$2,407,000
Total	**$27,515,000**	**$25,287,000**	**$32,383,000**	**$85,186,000**

Source: Highland Economics analysis of District Acreage data and U.S. Department of Agriculture, National Agricultural Statistics Service yield and price data. Study area totals may not sum due to rounding.

Table 62. Forage/Grain Production Economic Contribution: Employment and Income under Existing Conditions, Median Water Year

Type of Economic Impact	County: Crook	County: Deschutes	County: Jefferson	Study Area
Employment (Full and Part-Time Jobs)				
Direct	230	520	400	1,150
Indirect & Induced (from County Production)	100	170	100	370
Indirect & Induced (from Elsewhere Study Area Production)	0	70	0	80
Total	**330**	**760**	**500**	**1,590**
Income (Employee Compensation and Proprietor Income)				
Direct	$11,589,000	$9,024,000	$7,322,000	$27,935,000
Indirect & Induced (from County Production)	$3,669,000	$6,826,000	$5,097,000	$15,592,000
Indirect & Induced (from Elsewhere Study Area Production)	$227,000	$3,002,000	$225,000	$3,454,000
Total	**$15,485,000**	**$18,852,000**	**$12,644,000**	**$46,981,000**

Source: Highland Economics analysis using 2017 IMPLAN data and models of Crook, Deschutes, and Jefferson Counties. Study area totals may not sum due to rounding.

Table 63. Forage and Grain Production Value by County under Existing Conditions, Dry Water Year

	County			
District	**Crook**	**Deschutes**	**Jefferson**	**Study Area**
Arnold	$0	$801,000	$0	$801,000
Central Oregon	$13,400,000	$13,400,000	$0	$26,800,000
Lone Pine	$915,000	$0	$0	$915,000
North Unit	$0	$0	$23,528,000	$23,528,000
Ochoco	$10,300,000	$0	$0	$10,300,000
Swalley	$0	$1,910,000	$0	$1,910,000
Three Sisters	$0	$3,672,000	$0	$3,672,000
Tumalo	$0	$2,841,000	$0	$2,841,000
Other Irrigated Lands	$2,382,000	$0	$0	$2,382,000
Total	**$26,997,000**	**$22,624,000**	**$23,528,000**	**$73,149,000**

Source: Highland Economics analysis of District Acreage data and U.S. Department of Agriculture, National Agricultural Statistics Service yield and price data. Study area totals may not sum due to rounding.

Table 64. Forage/Grain Production Economic Contribution: Employment and Income under Existing Conditions, Dry Water Year

	County			
Type of Economic Impact	**Crook**	**Deschutes**	**Jefferson**	**Study Area**
Employment (Full and Part-Time Jobs)				
Direct	220	460	290	980
Indirect & Induced (from County Production)	100	150	70	320
Indirect & Induced (from Elsewhere Study Area Production)	0	60	0	70
Total	**330**	**680**	**370**	**1,370**
Income (Employee Compensation and Proprietor Income)				
Direct	$11,371,000	$8,074,000	$5,320,000	$24,765,000
Indirect & Induced (from County Production)	$3,600,000	$6,107,000	$3,704,000	$13,411,000
Indirect & Induced (from Elsewhere Study Area Production)	$180,000	$2,597,000	$216,000	$2,993,000
Total	**$15,151,000**	**$16,778,000**	**$9,239,000**	**$41,168,000**

Source: Highland Economics analysis using 2017 IMPLAN data and models of Crook, Deschutes, and Jefferson Counties. Study area totals may not sum due to rounding.

No-Action Alternative

In wet and median water year types, the total economic contribution under the no-action alternative would be similar to existing conditions. In the initial years of the analysis period, the no-action alternative dry year economic contribution also would be similar to existing conditions. However, due to water conservation over the analysis period, under the no-action alternative, water available to crops in dry water years may increase over time compared to existing conditions, which may lead to increased acreage and/or yields and associated economic activity in dry water years over the analysis period. **Table 65** summarizes the effect on the total economic contribution of forage and grain production in terms of annual jobs and income supported under the no-action alternative in dry water years throughout the analysis period and provides a comparison to existing conditions. **Tables 66 and 67** provide detail by year and low and high conservation scenarios.

Table 65. Forage/Grain Production Economic Contribution: Annual Total Employment and Income from Forage/Grain Production under No-Action Alternative Compared to Existing Conditions, Dry Water Year

	County			
Type of Economic Impact	**Crook**	**Deschutes**	**Jefferson**	**Study Area**
Employment (Full and Part-Time Jobs)				
Jobs	330	680 to 720	380 to 500	1,380 to 1,570
Change from existing conditions	0 to 5	0 to 40	10 to 130	10 to 200
% Change	0 to 1%	0 to 7%	2 to 36%	1 to 15%
Income (Employee Compensation and Proprietor Income)				
Income (Millions $)	$15.2	$16.9 to $18.0	$9.4 to $12.7	$41.5 to $45.9
Change from existing conditions (Millions $)	$0.1	$0.9 to $1.2	$0.2 to $3.5	$0.3 to $4.7
% Change	0%	1 to 7%	2 to 37%	1 to 12%

Source: Highland Economics analysis using IMPLAN. Study area totals may not sum due to rounding. Total employment and income includes direct, indirect, and induced effects.

Table 66. Estimated Annual Total Employment (Direct, Indirect, Induced Effects of Forage/Grain Production) under No-Action Alternative, Dry Water Year

	County			
Year	**Crook**	**Deschutes**	**Jefferson**	**Study Area**
Low Conservation				
2020	330	680	380	1,380
2025	330	700	390	1,410
2030	330	700	410	1,440
2040	330	710	450	1,480
2049	330	710	480	1,520
High Conservation				
2020	330	680	390	1,400
2025	330	720	450	1,500
2030	330	720	490	1,550
2040	330	720	500	1,560
2049	330	720	500	1,570

Source: Highland Economics analysis using 2017 IMPLAN data and models of Crook, Deschutes, and Jefferson Counties. Study area totals may not sum due to rounding.

Table 67. Estimated Annual Total Income (Direct, Indirect, Induced Effects of Forage/Grain Production) under No-Action Alternative, Dry Water Year

Year	County			Study Area
	Crook	Deschutes	Jefferson	
Low Conservation				
2020	$15,201,000	$16,865,900	$9,423,800	$41,490,700
2025	$15,249,000	$17,269,000	$9,909,000	$42,427,000
2030	$15,249,000	$17,387,000	$10,416,000	$43,052,000
2040	$15,249,000	$17,535,000	$11,234,000	$44,018,000
2049	$15,249,000	$17,535,000	$11,980,000	$44,764,000
High Conservation				
2020	$15,233,000	$17,004,000	$9,757,000	$41,994,000
2025	$15,249,000	$17,822,000	$11,350,000	$44,421,000
2030	$15,249,000	$17,970,000	$12,364,000	$45,583,000
2040	$15,249,000	$17,970,000	$12,567,000	$45,786,000
2049	$15,249,000	$17,970,000	$12,697,000	$45,916,000

Source: Highland Economics analysis using 2017 IMPLAN data and models of Crook, Deschutes, and Jefferson Counties. Study area totals may not sum due to rounding.

Proposed Action

Table 68 summarizes the estimated potential change in annual total economic contribution in terms of jobs and income (direct, indirect, and induced) supported by forage/grain production under the proposed action relative to the no-action alternative for the same water year type, conservation scenario, and permit year. The greatest potential impacts would be experienced in dry water years. In dry water years, economic contribution declines in all counties, with Jefferson County potentially experiencing the greatest reduction in forage/grain-related employment and income (up to 30% in the low conservation scenario, though high water conservation measures, as modeled in the high conservation scenario, would fully mitigate this impact). In a median water year, Crook and Deschutes counties are expected to experience minor impacts (less than 1% of the economic contribution of grain/forage production under the no-action alternative), while Jefferson County may experience a decline of to 11% relative to the jobs and income supported by grain/forage production. Across all water year types, total jobs and income supported by grain/forage production are expected to decrease by 1 to 2% in Crook and Deschutes Counties, and by up to 14% in Jefferson County.

Tables 69, 70, 71, and 72 provide detailed data on estimated potential change in annual employment and income by county by permit year and conservation scenario for median and dry water years.

Table 68. Range of Potential Change in Annual Total Economic Contribution from Forage and Grain Production by County, Proposed Action Compared to the No-Action Alternative

County	Water Year Type			Average, All Water Year Types[a]
	Wet	Median	Dry	
Crook				
Employment (Full- and part-time jobs)	0	0	-10 to 0	0 to 0
Income (Millions)	$0	$0	-$0.3 to -$0.1	-$0.1 to 0
% Change (Forage Production Contribution)	0%	0%	-2 to -1%	-1 to 0%
Deschutes				
Employment (Full- and part-time jobs)	0	0	-30 to -10	-10 to 0
Income (Millions)	$0	-$0.1 to $0	-$0.7 to -$0.3	-$0.3 to $0
% Change (Forage Production Contribution)	0%	0%	-4 to -2%	-2 to 0%
Jefferson				
Employment (Full- and part-time jobs)	0	-60 to 0	-130 to 0	-60 to 0
Income (Millions)	$0	-$1.4 to $0	-$3.3 to $0	-$1.2 to $0
% Change (Forage Production Contribution)	0%	-11 to 0%	-30 to 0%	-14 to 0%
Study Area				
Employment	0	-70 to 0	-190 to -20	-90 to -10
Income (Millions)	$0	-$1.5 to $0	-$4.4 to -$0.7	-$1.5 to -$0.3
% Change (Forage Production Contribution)	0%	-3 to 0%	-10 to -2%	-4 to -1%

Source: Highland Economics analysis using 2017 IMPLAN data and models of Crook, Deschutes, and Jefferson Counties. Study area totals may not sum due to rounding. Total economic contribution includes direct, indirect, and induced effects.

[a] Average computed assuming that the wet year represents approximately 35% of years (water years in the 65th to 100th percentile), the median represents 30% of water years (water years in the 35th to 65th percentile), and the dry water year represents approximately 35% of water years (water years in the 0th to the 35th percentile).

Table 69. Estimated Potential Change in Annual Total Employment (Direct, Indirect, Induced Effects) by County under Proposed Action Compared to the No-Action Alternative, Median Water Year

	County			
Year	Crook	Deschutes	Jefferson	Study Area
Low Conservation				
2020	0	0	0	0
2025	0	0	-20	-20
2030	0	0	-30	-40
2040	0	0	-60	-70
2049	0	0	-40	-50
High Conservation				
2020	0	0	0	0
2025	0	0	0	0
2030	0	0	0	0
2040	0	0	0	0
2049	0	0	0	0

Source: Highland Economics analysis using 2017 IMPLAN data and models of Crook, Deschutes, and Jefferson Counties. Study area totals may not sum due to rounding.

Table 70. Estimated Potential Change in Annual Total Income (Direct, Indirect, Induced Effects) by County in a under Proposed Action Compared to the No-Action Alternative, Median Water Year

	County			
Year	Crook	Deschutes	Jefferson	Study Area
Low Conservation				
2020	$0	$0	$0	$0
2025	$0	$0	-$456,000	-$456,000
2030	$0	$0	-$739,000	-$739,000
2040	$0	-$106,000	-$1,434,000	-$1,540,000
2049	$0	-$106,000	-$934,000	-$1,040,000
High Conservation				
2020	$0	$0	$0	$0
2025	$0	$0	$0	$0
2030	$0	$0	$0	$0
2040	$0	$0	$0	$0
2049	$0	$0	$0	$0

Source: Highland Economics analysis using 2017 IMPLAN data and models of Crook, Deschutes, and Jefferson Counties. Study area totals may not sum due to rounding.

Table 71. Estimated Potential Change in Annual Total Employment (Direct, Indirect, Induced Effects) by County under Proposed Action Compared to the No-Action Alternative, Dry Water Year

	County			
Year	Crook	Deschutes	Jefferson	Study Area
Low Conservation				
2020	0	-20	0	-20
2025	0	-10	-30	-50
2030	-10	-20	-70	-100
2040	-10	-30	-130	-190
2049	-10	-30	-110	-160
High Conservation				
2020	0	-20	0	-20
2025	0	-20	-30	-50
2030	0	-10	-50	-70
2040	0	-10	-60	-80
2049	0	-10	-30	-50

Source: Highland Economics analysis using 2017 IMPLAN data and models of Crook, Deschutes, and Jefferson Counties. Study area totals may not sum due to rounding.

Table 72. Estimated Potential Change in Annual Total Income (Direct, Indirect, Induced Effects) by County under Proposed Action Compared to the No-Action Alternative, Dry Water Year

	County			
Year	Crook	Deschutes	Jefferson	Study Area
Low Conservation				
2020	-$200,000	-$616,000	$0	-$816,000
2025	-$176,000	-$372,000	-$659,000	-$1,207,000
2030	-$288,000	-$510,000	-$1,717,000	-$2,515,000
2040	-$288,000	-$733,000	-$3,339,000	-$4,360,000
2049	-$288,000	-$733,000	-$2,846,000	-$3,867,000
High Conservation				
2020	-$176,000	-$563,000	$0	-$739,000
2025	-$80,000	-$468,000	-$659,000	-$1,207,000
2030	-$120,000	-$297,000	-$1,209,000	-$1,626,000
2040	-$120,000	-$318,000	-$1,405,000	-$1,843,000
2049	-$120,000	-$318,000	-$696,000	-$1,134,000

Source: Highland Economics analysis using 2017 IMPLAN data and models of Crook, Deschutes, and Jefferson Counties. Study area totals may not sum due to rounding.

Alternative 3

Table 73 summarizes the estimated potential change in annual total economic contribution in terms of jobs and income (direct, indirect, and induced) supported by forage/grain production under Alternative 3 relative to the no-action alternative for the same water year type, conservation scenario, and permit year. The greatest potential impacts would be experienced in dry water years. In dry water years, economic contribution declines in all counties, with Jefferson County potentially experiencing the greatest reduction in forage/grain- related employment and income (up to 32% in the low conservation scenario, though high water conservation measures, as modeled in the high conservation scenario, would reduce this impact to 6% compared to the no-action alternative). In a median water year, Crook and Deschutes Counties are expected to experience minor impacts (less than 1% of the economic contribution of grain/forage production under the no-action alternative), while Jefferson County may experience a decline of to 6% relative to the jobs and income supported by grain/forage production. Across all water year types, total jobs and income supported by grain/forage production are expected to decrease by 1 to 2% in Crook and Deschutes counties, and by up to 13% in Jefferson County. **Tables 74, 75, 76, and 77** provide detailed data on the estimated potential change in annual employment and income by county by permit year and conservation scenario for median and dry water years.

Table 73. Range of Potential Change in Annual Total Economic Contribution from Forage and Grain Production by County, Alternative 3 Compared to the No-Action Alternative

	Water Year Type			Average, All Water Year Types[a]
County	**Wet**	**Median**	**Dry**	
Crook				
Employment (Full- and part-time jobs)	0	0	-10 to 0	0 to 0
Income (Millions)	$0	$0	-$0.4 to -$0.1	-$0.1 to 0
% Change (Forage Production Contribution)	0%	0%	-2 to -1%	-1 to 0%
Deschutes				
Employment (Full- and part-time jobs)	0	0	-30 to -10	-10 to 0
Income (Millions)	$0	-$0.1 to $0	-$0.7 to -$0.3	-$0.3 to $0.1
% Change (Forage Production Contribution)	0%	0%	-4 to -2%	-2 to -1%
Jefferson				
Employment (Full- and part-time jobs)	0	-30 to 0	-130 to -30	-50 to -10
Income (Millions)	$0	-$0.8 to $0	-$3.3 to -$0.7	-$1.2 to -$0.2
% Change (Forage Production Contribution)	0%	-6 to 0%	-32 to -6%	-13 to -2%
Study Area				
Employment (Full- and part-time jobs)	0	-40 to 0	-190 to -50	-80 to -20
Income (Millions)	$0	-$0.9 to $0	-$4.4 to -$1.2	-$1.5 to -$0.4
% Change (Forage Production Contribution)	0%	-2 to 0%	-10 to -3%	-4 to -1%

Source: Highland Economics analysis using 2017 IMPLAN data and models of Crook, Deschutes, and Jefferson Counties. Study area totals may not sum due to rounding. Total economic contribution includes direct, indirect, and induced effects.

[a] Average computed assuming that the wet year represents approximately 35% of years (water years in the 65th to 100th percentile), the median represents 30% of water years (water years in the 35th to 65th percentile), and the dry water year represents approximately 35% of water years (water years in the 0th to the 35th percentile).

Table 74. Estimated Potential Change in Annual Total Employment (Direct, Indirect, Induced Effects) by County under Alternative 3 Compared to the No-Action Alternative, Median Water Year

	County			
Year	**Crook**	**Deschutes**	**Jefferson**	**Study Area**
Low Conservation				
2020	0	0	-10	-10
2025	0	0	-10	-20
2030	0	0	-30	-40
2040	0	0	-30	-30
2049	0	0	-20	-20
High Conservation				
2020	0	0	-10	-10
2025	0	0	0	0
2030	0	0	-10	-10
2040	0	0	0	0
2049	0	0	0	0

Source: Highland Economics analysis using 2017 IMPLAN data and models of Crook, Deschutes, and Jefferson Counties. Study area totals may not sum due to rounding.

Table 75. Estimated Potential Change in Annual Total Income (Direct, Indirect, Induced Effects) by County under Alternative 3 Compared to the No-Action Alternative, Median Water Year

	County			
Year	**Crook**	**Deschutes**	**Jefferson**	**Study Area**
Low Conservation				
2020	$0	$0	-$261,000	-$261,000
2025	$0	$0	-$369,000	-$369,000
2030	$0	-$64,000	-$811,000	-$875,000
2040	$0	-$64,000	-$630,000	-$694,000
2049	$0	-$64,000	-$464,000	-$528,000
High Conservation				
2020	$0	$0	-$181,000	-$181,000
2025	$0	$0	-$44,000	-$44,000
2030	$0	$0	-$268,000	-$268,000
2040	$0	$0	-$58,000	-$58,000
2049	$0	$0	$0	$0

Source: Highland Economics analysis using 2017 IMPLAN data and models of Crook, Deschutes, and Jefferson Counties. Study area totals may not sum due to rounding.

Table 76. Estimated Potential Change in Annual Total Employment (Direct, Indirect, Induced Effects) by County under Alternative 3 Compared to the No-Action Alternative, Dry Water Year

	County			
Year	Crook	Deschutes	Jefferson	Study Area
Low Conservation				
2020	-10	-20	-30	-60
2025	-10	-20	-70	-110
2030	-10	-30	-130	-190
2040	-10	-30	-80	-120
2049	-10	-30	-30	-70
High Conservation				
2020	-10	-20	-30	-50
2025	0	-20	-70	-110
2030	0	-10	-90	-130
2040	0	-10	-30	-50
2049	0	-10	-30	-50

Source: Highland Economics analysis using 2017 IMPLAN data and models of Crook, Deschutes, and Jefferson Counties. Study area totals may not sum due to rounding.

Table 77. Estimated Potential Change in Annual Total Income (Direct, Indirect, Induced Effects) by County under Alternative 3 Compared to the No-Action Alternative, Dry Water Year

	County			
Year	Crook	Deschutes	Jefferson	Study Area
Low Conservation				
2020	-$345,000	-$456,000	-$681,000	-$1,482,000
2025	-$313,000	-$478,000	-$1,760,000	-$2,551,000
2030	-$288,000	-$722,000	-$3,346,000	-$4,356,000
2040	-$288,000	-$733,000	-$2,028,000	-$3,049,000
2049	-$288,000	-$733,000	-$855,000	-$1,876,000
High Conservation				
2020	-$368,000	-$383,000	-$681,000	-$1,432,000
2025	-$216,000	-$574,000	-$1,760,000	-$2,550,000
2030	-$120,000	-$318,000	-$2,390,000	-$2,828,000
2040	-$120,000	-$318,000	-$855,000	-$1,293,000
2049	-$120,000	-$318,000	-$797,000	-$1,235,000

Source: Highland Economics analysis using 2017 IMPLAN data and models of Crook, Deschutes, and Jefferson Counties. Study area totals may not sum due to rounding.

Alternative 4

Table 78 summarizes the estimated potential change in annual total economic contribution in terms of annual jobs and income (direct, indirect, and induced) supported by forage/grain production under Alternative 4 relative to the no-action alternative for the same water year type, conservation scenario, and permit year. The greatest potential impacts would be experienced in dry water years. In dry water years, economic contribution declines in all counties, with Jefferson County potentially experiencing the greatest reduction in forage/grain- related employment and income (up to 50% in the low conservation scenario, though high water conservation measures, as modeled in the high conservation scenario, would reduce this impact to 15% compared to the no-action alternative.) In a median water year, Crook and Deschutes counties are expected to experience minor impacts (less than 1% of the economic contribution of grain/forage production under the no-action alternative), while Jefferson County may experience a decline of to 11% relative to the jobs and income supported by grain/forage production. Across all water year types, total jobs and income supported by grain/forage production are expected to decrease by 1 to 3% in Crook and Deschutes counties, and by up to 21% in Jefferson County.

Table 78. Range of Potential Change in Annual Total Economic Contribution from Forage and Grain Production by County, Alternative 4 Compared to the No-Action Alternative

County	Water Year Type			Average, All Water Year Types[a]
	Wet	Median	Dry	
Crook				
Employment (Full- and part-time jobs)	0	0	-10 to 0	0 to 0
Income (Millions)	$0	$0	-$0.5 to -$0.1	-$0.2 to -$0.1
% Change (Forage Production Contribution)	0%	0%	-3 to -1%	-1 to 0%
Deschutes				
Employment (Full- and part-time jobs)	0	-10 to 0	-50 to -30	-20 to -10
Income (Millions)	$0	-$0.2 to $0	-$1.1 to -$0.9	-$0.4 to -$0.3
% Change (Forage Production Contribution)	0%	-1 to 0%	-6 to -5%	-3 to -2%
Jefferson				
Employment (Full- and part-time jobs)	0	-60 to -20	-200 to -70	-90 to -30
Income (Millions)	$0	-$1.4 to -$0.5	-$4.9 to -$1.8	-$1.7 to -$0.6
% Change (Forage Production Contribution)	0%	-11 to -4%	-50 to -15%	-21 to -6%
Study Area				
Employment (Full- and part-time jobs)	0	-70 to -20	-270 to -120	-120 to -40
Income (Millions)	$0	-$1.6 to -$0.5	-$6.4 to -$2.9	-$2.2 to -$1.0
% Change (Forage Production Contribution)	0%	-3 to -1%	-15 to -6%	-6 to -3%

Source: Highland Economics analysis using 2017 IMPLAN data and models of Crook, Deschutes, and Jefferson Counties. Study area totals may not sum due to rounding. Total economic contribution includes direct, indirect, and induced effects.

[a] Average computed assuming that the wet year represents approximately 35% of years (water years in the 65th to 100th percentile), the median represents 30% of water years (water years in the 35th to 65th percentile), and the dry water year represents approximately 35% of water years (water years in the 0th to the 35th percentile).

Tables 79, 80, 81, and 82 provide detailed data on the estimated potential change in annual employment and income by county by permit year and conservation scenario for median and dry water years.

Table 79. Estimated Potential Change in Annual Total Employment (Direct, Indirect, Induced Effects) by County under Alternative 4 Compared to the No-Action Alternative, Median Water Year

	County			
Year	**Crook**	**Deschutes**	**Jefferson**	**Study Area**
Low Conservation				
2020	0	-10	-60	-70
2025	0	-10	-60	-70
2030	0	0	-50	-60
2039	0	0	-40	-50
High Conservation				
2020	0	0	-40	-50
2025	0	0	-40	-50
2030	0	0	-30	-30
2039	0	0	-20	-20

Source: Highland Economics analysis using 2017 IMPLAN data and models of Crook, Deschutes, and Jefferson Counties. Study area totals may not sum due to rounding.

Table 80. Estimated Potential Change in Annual Total Income (Direct, Indirect, Induced Effects) by County under Alternative 4 Compared to the No-Action Alternative, Median Water Year

	County			
Year	**Crook**	**Deschutes**	**Jefferson**	**Study Area**
Low Conservation				
2020	-$8,000	-$160,000	-$1,434,000	-$1,602,000
2025	$0	-$127,000	-$1,398,000	-$1,525,000
2030	$0	-$64,000	-$1,224,000	-$1,288,000
2039	$0	-$64,000	-$1,057,000	-$1,121,000
High Conservation				
2020	$0	-$64,000	-$1,079,000	-$1,143,000
2025	$0	$0	-$1,014,000	-$1,014,000
2030	$0	$0	-$681,000	-$681,000
2039	$0	$0	-$493,000	-$493,000

Source: Highland Economics analysis using 2017 IMPLAN data and models of Crook, Deschutes, and Jefferson Counties. Study area totals may not sum due to rounding.

Table 81. Estimated Potential Change in Annual Total Employment (Direct, Indirect, Induced Effects) by County under Alternative 4 Compared to the No-Action Alternative, Dry Water Year

	County			
Year	Crook	Deschutes	Jefferson	Study Area
Low Conservation				
2020	-10	-40	-90	-150
2025	-10	-40	-200	-270
2030	-10	-40	-180	-260
2039	-10	-50	-160	-230
High Conservation				
2020	-10	-30	-90	-150
2025	-10	-40	-150	-220
2030	0	-40	-100	-150
2039	0	-40	-70	-120

Source: Highland Economics analysis using 2017 IMPLAN data and models of Crook, Deschutes, and Jefferson Counties. Study area totals may not sum due to rounding.

Table 82. Estimated Potential Change in Annual Total Income (Direct, Indirect, Induced Effects) by County under Alternative 4 Compared to the No-Action Alternative, Dry Water Year

	County			
Year	Crook	Deschutes	Jefferson	Study Area
Low Conservation				
2020	-$433,000	-$871,000	-$2,368,000	-$3,672,000
2025	-$337,000	-$1,105,000	-$4,940,000	-$6,382,000
2030	-$313,000	-$1,115,000	-$4,563,000	-$5,991,000
2039	-$313,000	-$1,125,000	-$4,041,000	-$5,479,000
High Conservation				
2020	-$457,000	-$850,000	-$2,368,000	-$3,675,000
2025	-$241,000	-$1,020,000	-$3,897,000	-$5,158,000
2030	-$144,000	-$903,000	-$2,491,000	-$3,538,000
2039	-$144,000	-$903,000	-$1,839,000	-$2,886,000

Source: Highland Economics analysis using 2017 IMPLAN data and models of Crook, Deschutes, and Jefferson Counties. Study area totals may not sum due to rounding.

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Appendix 3.10-A
Literature Review

Existing Data and Background Data

ICF archaeologist Kainoa Little performed a record search on using the Archaeological Inventory Database managed by the Oregon State Historic Preservation Office (SHPO) to identify previously documented archaeological, ethnographic, and historic period resources within a 0.25-mile radius of the Wickiup Reservoir. The database contains all records and reports on file with the Oregon SHPO, including completed cultural resources survey reports, properties listed in or determined eligible for listing in the National Register of Historic Places (NRHP), archaeological sites, cemeteries, and inventoried built environment resources. Other agencies (e.g., U.S. Forest Service) and Tribes retain records that are not available on the Oregon SHPO database, and these likely contain information about archaeological resources. These other data sources were not reviewed for this EIS but should be part of a Section 106 compliance effort. Archaeological resources that were recorded as submerged or partially submerged are specifically considered in this analysis. Additionally, some archaeological sites with poorly defined boundaries may extend into the area that would typically be submerged.

Previous Cultural Resource Studies

A total of 30 cultural resource studies have been conducted within 0.25 mile of the Wickiup Reservoir Affected Environment (Table 1). The studies vary greatly in size and intensity. Several of the studies are large-scale landscape surveys (e.g., Davis 1983; Dudley et al. 1979; Appleby 1984a) while some were very small projects covering a specific activity (e.g., Fowler 1981; Lipscomb 2007; Purdy and Byram 2009). On the north bank, the studies are generally timber sale surveys.

Archaeological resources will be cited for given cultural resources studies within the Wickiup Reservoir Affected Environment if the resource is within approximately 100 meters of the high-water line of the reservoir.

Table 1. Previously Conducted Cultural Resources Surveys within 0.25 Mile of Wickiup Reservoir

Author/Date	Investigation Type/NADB #	Title	Archaeological Resources
Appleby 1984a	Survey Report; #1295814	*West Wickiup, Cultural Resources Report, Deschutes National Forest, Bend Ranger District*	Sites: 35DS288, 35DS291, 35DS292,35DS293, 35DS294, 35DS295, 35DS296, 35DS297 35DS299
Carlson 1984	Survey Report; #1295821	*Wampus, Cultural Resources Report, Deschutes National Forest, Bend Ranger District*	Two possible rockshelters mentioned north and west of Eaton Butte – no site numbers

Author/Date	Investigation Type/NADB #	Title	Archaeological Resources
Cassidy 1994	Survey Report; Biblio #14814	*Cultural Resource Survey Report: Unclaimed Lavas Project, Crescent Ranger District, Deschutes National Forest, USDA, Forest Service*	None
Cressman 1937	Site report	*The Wickiup Dam Site No. 1 Knives*	Wickiup Dam Site No. 1
Davis 1983	Inventory Plan; #1293250	*Deschutes National Forest Cultural Resources Inventory Plan*	None
Dudley et al. 1979	Cultural Resources Overview; #1291758	*Cultural Resources Overview: Deschutes National Forest*	None
Ertle 1986	Survey Report; #1297496	*Browns Mountain Project Cultural Resource Report, Deschutes National Forest, Bend Ranger District*	Site: 35DS421
Fowler 1979	Survey Report; #1294618	*Deschutes National Forest, Bend Ranger District, Environmental Analysis Report for the Proposed Brown's Mountain Salvage Sale*	None
Fowler 1981	Survey Report; # 1291586	*Cultural Resource Report Wickiup Reservoir Powerhouse Project*	None
Fowler 1983a	Survey Report; #1295100	*Twin-Gull Timber Sale, Cultural Resource Report, Deschutes National Forest, Bend Ranger District*	Sites: 35DS227, 35DS228
Hatfield and Stellmacher 1988	Survey Report; Biblio #11530	*Twin Lakes Timber Sale. Cultural Resources Report, Bend Ranger District, Deschutes National Forest*	Site: 35DS619 Isolates: 14-BRD-87, 15-BRD-87, 17-BRD-87
Hickerson 2006	Survey Report; Biblio #23941	*Five Buttes Interface Project*	None
Hickerson 2004a	Survey Report; Biblio #18999	*Davis Fire Recovery Projects*	Sites: 35DS1640, 35DS389
Hickerson 2001	Survey Report; Biblio #23932	*Seven Buttes Return Analysis Area*	None
Hickerson 1997	Survey Report Biblio #23929	*Cultural Resource Survey Report for Eagle Rock and Seven Buttes, Crescent Ranger District, Deschutes National Forest, USDA, Forest Service*	None
Johnson 1982	Survey Report; #1292999	*Dilman-Table L.P. Timber Sales, Cultural Resource Report, Deschutes National Forest, Bend Ranger District*	None
Lipscomb 1989	Survey Report; Biblio #11527	*Caretaker Timber Sale, Cultural Resource Report, Bend Ranger District, Deschutes National Forest*	Site: 35DS586 Isolate: 81-BRD-89

Author/Date	Investigation Type/NADB #	Title	Archaeological Resources
Lipscomb 1990	Survey Report; Biblio #11777	*Dillwick Salvage Sale, Cultural Resource Report, Bend Ranger District, Deschutes National Forest*	None
Lipscomb 1992a	Survey Report; Biblio #13095	*Jingle Salvage Sale, Cultural Resource Inventory Report*	None
Lipscomb 2007	Survey Report; Biblio #21354	*Gull Point Boat Ramps Improvement*	None
Mawhirter 2015	Survey Report; Biblio #28337	*Browns Creek Burned Area Replanting*	None
McFarland and Stellmacher 1988	Survey Report; Biblio #11765	*End Table Timber Sale, Cultural Resource Report, Bend Ranger District, Deschutes National Forest*	None
McFarland 1985a	Survey Report; #1296488	*Cultural Resource Survey Report Short Form for South Twin Campground Hazard Tree Removal*	None
Menefee and Spencer 1992	Survey Report; Biblio #13333	*Mechanical Slash Project, Cultural Resource Inventory Report*	None
Mulligan 1991	Survey Report; Biblio #13276	*1990 Small Sales Project Timber Sale Cultural Resource Inventory Report, Crescent Ranger District, Deschutes National Forest*	None
Purdy and Byram 2009	Survey Report; Biblio #23177	*Archaeological Survey of the Wickiup Dam Hydroelectric*	None
Walker and Lipscomb 1989	Data Recovery Program; #1297078	*Caretaker Timber Sale Cultural Resource Report, Bend Ranger District, Deschutes National Forest*	None

Previously Recorded Archaeological Resources

There have been 21 sites and 9 isolates identified within 0.25 mile of Wickiup Reservoir. Two "possible rockshelters" were identified but not given number designations and do not appear to have been revisited for confirmation (Carlson 1984). The possible rockshelters are located near the southeast bank of Wickiup Reservoir. One, just west of Eaton Butte, is shown on the Oregon SHPO database without accompanying data, while the other, north of Eaton Butte, was not shown on the SHPO database but is noted in Carlson (1984).

Site types within the 0.25-mile search radius include precontact lithic materials, a multicomponent site consisting of a lithic scatter and notched logs that appear to be remnants of a trapper's cabin (Hickerson 2004b), and one isolate (80-BRD-89), which was considered multicomponent with both lithic debitage and a ceramic sherd with floral patterns. Seven of these sites have been formally determined eligible for listing in the NRHP. The remainder of the sites and isolates are yet unevaluated for NRHP eligibility.

Doncaster and Horting-Jones (2013) discuss a substantial camp used by the Civilian Conservation Corps (CCC Camp Wickiup) and later by World War II Conscientious Objectors during construction of the dam and nearby tree clearing. This site is not identified in the Oregon SHPO database and lacks a formal archaeological site Smithsonian Trinomial. The site is submerged, can be seen during low water periods, but has not been formally evaluated for NRHP eligibility.

Notably, the site designated 35DS619 (FS 13-BRD-87) has artifacts that are visible when Wickiup Reservoir is at low pool in the late summer and early fall, then is inundated again when the reservoir fills (Hatfield and Stellmacher 1988). Hatfield and Stellmacher noted that the artifacts within the scatter might vary in visibility or location year to year.

Thirteen archaeological resources appeared on the Oregon SHPO database without accompanying data. Based on their locations, all were identified using the survey reports from the same areas and all but one had SHPO trinomials associated with them.

Table 2. Previously Recorded Archaeological and Historic Resources within 0.25 Mile of Wickiup Reservoir

Citation	Trinomial/ Forest Service Site Number	Site Type	Description	NRHP Eligibility Status
Fowler 1983b	35DS227	Precontact lithic material	Debitage	Unevaluated
Fowler 1983c	35DS228	Precontact lithic material	Debitage	Unevaluated
Appleby 1984b	35DS288	Precontact lithic material	Projectile point fragment, flaked tool, debitage	Unevaluated
Appleby 1984c	35DS291	Precontact lithic material	Projectile point and debitage	Unevaluated
Appleby 1984d	35DS292	Precontact lithic material	Projectile point fragment and debitage	Determined eligible (Lipscomb 1996)
Appleby 1984e	35DS293	Precontact lithic material	Debitage	Unevaluated
Appleby 1984f	35DS294	Precontact lithic material	Projectile point fragment and debitage	Unevaluated
Appleby 1984g	35DS295	Precontact lithic material	Projectile point and debitage	Determined eligible (Mulligan 1991)
Appleby 1984h	35DS296	Precontact lithic material	Debitage	Determined eligible (Lipscomb 1996)
Appleby 1984i	35DS297	Precontact lithic material	Projectile point fragment, flaked tool, debitage	Unevaluated
Appleby 1984j	35DS299	Precontact lithic material	Debitage	Unevaluated
McFarland 1985b	35DS380	Precontact lithic material	Debitage	Unevaluated
McFarland 1985c	35DS389	Precontact lithic material	Debitage	Determined eligible

Citation	Trinomial/ Forest Service Site Number	Site Type	Description	NRHP Eligibility Status
Ertle 1986	35DS420	Precontact lithic material	Debitage	Determined eligible
Ertle 1986	35DS421	Precontact lithic material	Debitage	Determined eligible
Hatfield 1988	35DS619	Precontact lithic material	Debitage	Unevaluated
Lipscomb 1992b	35DS990	Precontact lithic material	Debitage	Unevaluated
Hickerson 1997	35DS1135	Precontact feature	Peeled tree	Unevaluated
Hickerson 2004a	35DS1640	Precontact lithic material and historic-period structure	Debitage, log cabin wall remnants, tin can	Unevaluated
Mawhirter 2014	35DS2946	Precontact lithic material	Debitage	Determined eligible
Hatfield and Stellmacher 1988	13-BRD-87	Precontact lithic material	Debitage	Unevaluated
Doncaster and Horting-Jones 2013	Unknown	CCC Camp	Historic features and artifacts	Unevaluated
Hatfield and Stellmacher 1988	14-BRD-87	Precontact isolate	Debitage	Unevaluated
Hatfield and Stellmacher 1988	15-BRD-87	Precontact isolate	Debitage	Unevaluated
Hatfield and Stellmacher 1988	17-BRD-87	Precontact isolate	Debitage	Unevaluated
McFarland and Stellmacher 1988	51-BRD-88	Historic-period isolate	Can dump, stove pipe, and car body	Unevaluated
Lipscomb 1989	77-BRD-89	Precontact isolate	Debitage	Unevaluated
Lipscomb 1989	80-BRD-89	Precontact and historic-period isolates	Debitage and ceramic fragment	Unevaluated
Lipscomb 1989	81-BRD-89	Precontact isolate	Debitage	Unevaluated
Hickerson 2004b	2141-09P	Precontact isolate	Debitage	Unevaluated
Carlson 1984	N/A	Possible rockshelter	Not confirmed	Unevaluated
Carlson 1984	N/A	Possible rockshelter	Not confirmed	Unevaluated

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