**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 I: CHAPTERS 1–7

**October 2019**

**Estimated lead agency & applicant total costs associated with developing and producing this EIS**
**$1,574,952**

**COVER SHEET**

| | |
|---|---|
| **Title of Proposed Action:** | Draft Environmental Impact Statement for the Deschutes Basin Habitat Conservation Plan |
| **Subject:** | Draft Environmental Impact Statement |
| **Lead Agency:** | U.S. Fish and Wildlife Service |
| **Cooperating Agencies:** | 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, Confederated Tribes of Warm Springs |
| **County/State:** | Klamath, Deschutes, Jefferson, Crook, Wasco, and Sherman Counties, Oregon |
| **Public Comments:** | We will accept comments received by or postmarked on or before November 18, 2019. See http://www.regulations.gov. |

**Abstract:**
The U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) have received applications for Incidental Take Permits (ITPs) from multiple applicants in Central Oregon in accordance with section 10(a)(1)(B) of the Endangered Species Act (ESA) of 1973, as amended. The Deschutes Basin Board of Control's eight member irrigation districts—Arnold, Central Oregon, Lone Pine, North Unit, Ochoco, Swalley, Three Sisters, and Tumalo—and the City of Prineville (collectively, the Applicants) have jointly submitted a Habitat Conservation Plan (HCP) to both FWS and NMFS to address take of species listed as threatened under ESA from their ongoing water management activities. The Applicants are requesting take of the Oregon spotted frog (*Rana pretiosa*) and and bull trout (*Salvelinus confluentus*) from FWS and take of the Middle Columbia River steelhead trout (*Oncorhynchus mykiss*), and two nonlisted species—Middle Columbia River spring Chinook salmon (*O. tshawytscha*) and sockeye salmon (*O. nerka*) from NMFS.

FWS, as the federal lead agency prepared this EIS pursuant to the requirements of the National Environmental Policy Act and its implementing regulations as well as internal agency guidance. FWS and NMFS will each make separate decisions on whether to issue ITPs to the Applicants, relying on the criteria for ITPs set forth in ESA and its implementing regulations. Key issues include the assessment of the potential for impacts associated with the different alternatives and the corresponding need to offset these impacts on the covered species.

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# DRAFT ENVIRONMENTAL IMPACT STATEMENT

## FOR THE DESCHUTES BASIN HABITAT CONSERVATION PLAN

## VOLUME I: CHAPTERS 1-7

## 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*

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**Acronyms and Abbreviations**

| | |
|---|---|
| af | acre-feet |
| AFY | acre-feet/year |
| AIAN | American Indian and Alaska Native |
| BEA | Bureau of Economic Analysis |
| BENO | Deschutes River at Benham Falls gauge |
| BiOp | Deschutes Project Biological Opinion |
| BLM | Bureau of Land Management |
| BP | before present |
| CAPO | Crooked River at Prineville gauge gauge |
| CFR | Code of Federal Regulations |
| cfs | cubic feet per second |
| CRSO | Crooked River at the Smith Rocks stream gauge |
| CULO | Deschutes River near Culver gauge |
| CV | coefficient of variation |
| DBBC | Deschutes Basin Board of Control |
| DEBO | Deschutes River below Bend gauge |
| Deschutes Basin HCP | Deschutes Basin Habitat Conservation Plan |
| EFH | essential fish habitat |
| EIS | environmental impact statement |
| ESA | Endangered Species Act |
| FEMA | Federal Emergency Management Agency |
| FR | Federal Register |
| FWS | U.S. Fish and Wildlife Service |
| ID | Irrigation District |
| ITP | incidental take permit |
| ITS | incidental take statement |
| MSAV | maximum specially assessed value |
| NEPA | National Environmental Policy Act |
| NHPA | National Historic Preservation Act |
| NMFS | National Marine Fisheries Service |
| NOAA | National Oceanic and Atmospheric Administration |
| NOI | notice of intent |
| NRHP | National Register of Historic Places |
| ODFW | Oregon Department of Fish and Wildlife |
| ORS | Oregon Revised Statutes |
| OWRD | Oregon Water Resources Department |
| Reclamation | Bureau of Reclamation |
| RM | river mile |

| | |
|---|---|
| ROD | record of decision |
| SAV | specially assessed value |
| SHPO | State Historic Preservation Office |
| SR | State Route |
| the Services | U.S. Fish and Wildlife Service and National Marine Fisheries Service |
| U.S.C. | United States Code |
| USFS | U.S. Forest Service |
| Warm Springs Tribes | Confederated Tribes of the Warm Springs Reservation of Oregon |
| WICO | Deschutes River below Wickiup Reservoir gauge |

# Executive Summary

## ES.1 Introduction

Proposed non-federal actions that are likely to cause the incidental take of endangered and threatened species must obtain an Endangered Species Act (ESA) (16 United States Code [U.S.C.] §§ 1531–1544) Section 10(a)(1)(B) incidental take permit (ITP) from the U.S. Fish and Wildlife Service (FWS) and/or the National Marine Fisheries Service (NMFS) (referred to collectively as *the Services*) authorizing such take, or they must implement measures to avoid that take of those species to avoid violating Section 9 of ESA. As defined in ESA Section 3(19), the term ***take***[1] *means to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct."*

The Deschutes Basin Board of Control (DBBC) and City of Prineville prepared the Deschutes Basin Habitat Conservation Plan (Deschutes Basin HCP) (Deschutes Basin Board of Control and City of Prineville 2019)[2] to address incidental take of ESA-listed species likely to be caused by certain water management activities. The DBBC consists of eight irrigation districts—Arnold, Central Oregon, Lone Pine, North Unit, Ochoco, Swalley, Three Sisters, and Tumalo—that distribute waters of the Deschutes River and its tributaries (Figure ES-1). All eight districts are quasi-municipal corporations formed and operated according to Oregon State law, pursuant to which they distribute water to irrigators (patrons) within designated geographic boundaries and in accordance with water rights issued by the State of Oregon. The City of Prineville operates City-owned infrastructure and provides essential services—including public safety, municipal water supply, and sewage treatment—for more than 9,000 residents.

The following terms used in the Deschutes Basin HCP are defined briefly below and described in more detail in Chapter 2, *Proposed Action and Alternatives*.

- The ***applicants***[3] include the eight irrigation districts making up the DBBC, as well as the City of Prineville. The applicants are jointly submitting one HCP and requesting one ITP covering the nine applicants from FWS and one ITP from NMFS).
- The ***covered species*** are those species for which the applicants are seeking incidental take coverage. They include three species listed as threatened under ESA—the 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. The Oregon spotted frog and bull trout are under FWS authority, and the three other species are under NMFS authority.
- The ***covered activities*** are 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

[1] Certain terms in this EIS are defined more fully in the *Glossary* (Appendix 1-A).

[2] References for cited sources in this EIS are located in the *References Cited* (Appendix 1-B).

[3] The *applicants* here are referred to as the *permittees* in the Deschutes Basin HCP. In the context of this EIS, the applicants will become permittees when the ITPs are issued.

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.

- The ***covered lands and waters*** are the specific aquatic, wetland, riparian, and floodplain habitats affected by the covered activities and where incidental take of covered species would occur (Figure ES-1).
- The ***conservation strategy*** is 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.
- The ***permit term*** is the length of time covered by the ITPs. The permit term proposed in the Deschutes Basin HCP is 30 years.

FWS is the federal lead agency responsible for preparing this environmental impact statement (EIS) (40 Code of Federal Regulations [CFR] 1501.6). FWS prepared this EIS pursuant to the requirements of the National Environmental Policy Act (NEPA) (42 U.S.C. §§ 4321–4370 et seq.), the Council on Environmental Quality NEPA-implementing regulations (40 CFR 1500–1508), the U.S. Department of the Interior's NEPA regulations (43 CFR 46), and the FWS and NMFS *2016 Habitat Conservation and Planning and Incidental Take Permit Processing Handbook*. NMFS is a cooperating agency on this EIS. Consequently, this EIS may be used by NMFS to satisfy its NEPA requirements.

The Services will each make a decision on whether to issue ITPs to the applicants, relying on the statutory and regulatory criteria for ITPs set forth in ESA and its implementing regulations. The Services' decision will also be informed by the information, analyses and findings in this EIS. The Services will each make their decision after the public has had an opportunity to comment on draft and final[4] versions of both the EIS and HCP. To support their final permit decisions, the Services will each independently prepare an ESA Section 10 findings document and an ESA Section 7 biological opinion on the proposed ITP actions prior to issuing separate record of decisions (RODs).

# ES.2 Proposed Federal Action

The proposed federal action being evaluated in this EIS is the issuance of ITPs in response to the ITP applications from the applicants. The ITPs would authorize incidental take of the covered species that could result from covered activities over the permit term.

# ES.3 Purpose and Need for Federal Action

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 incidental take of three species listed as threatened under ESA—the Oregon spotted

[4] The federal agency is not required to respond to comments on the Final HCP and EIS, but should consider them prior to making a decision.

frog, Middle Columbia River steelhead, and bull trout—and two nonlisted species—the spring Middle Columbia River Chinook salmon and sockeye salmon.

The need for the federal action is to respond to the applicants' request for ITPs for the covered species and covered activities as described in the Deschutes Basin 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.

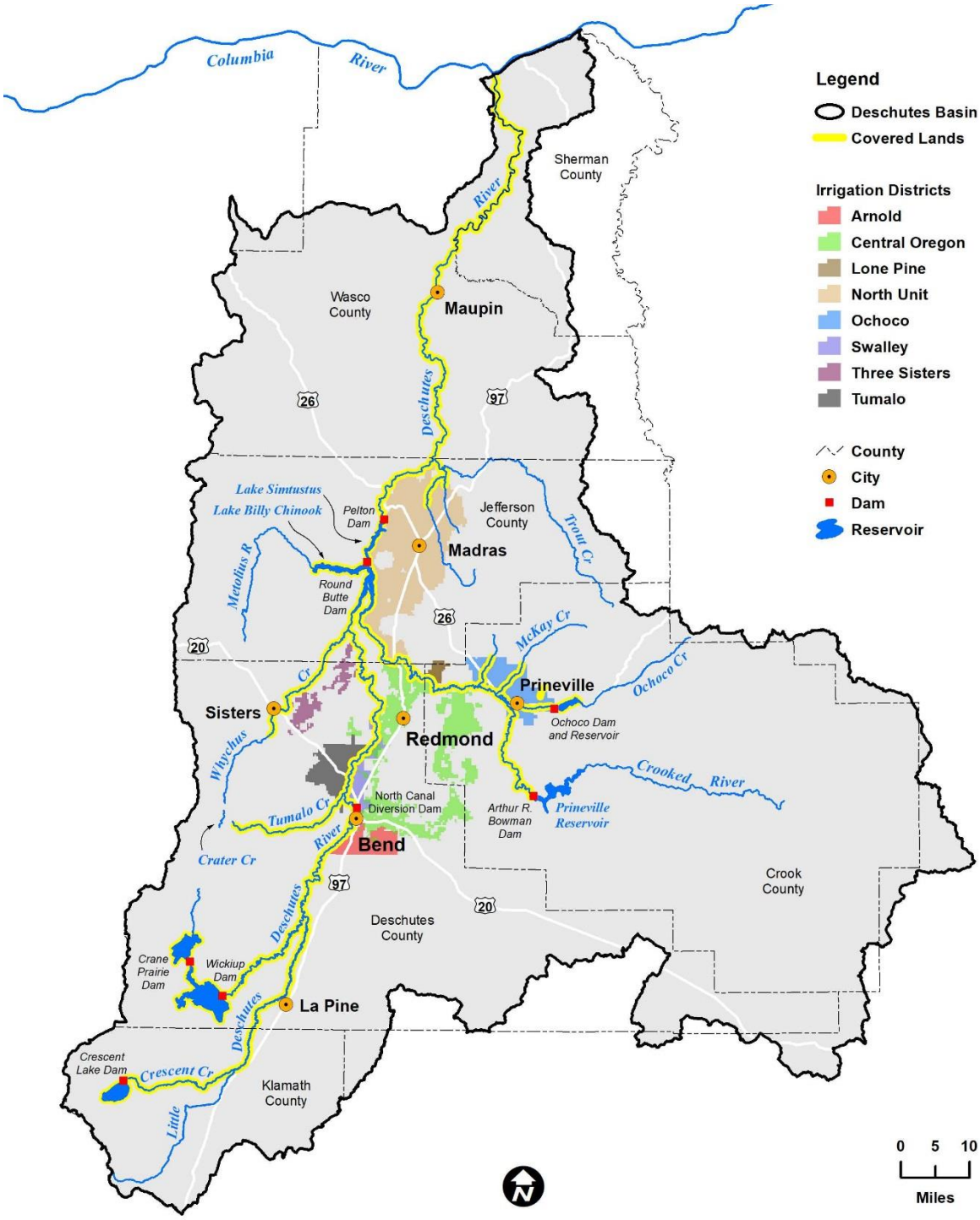
On August 30, 2019, FWS received an ITP application from the applicants for the Oregon spotted frog and the bull trout. On August 30, 2019, NMFS received an ITP application from the applicants addressing the Middle Columbia River steelhead, Middle Columbia River Chinook salmon and sockeye salmon. If the applications are approved and the Services issue ITPs, the permits would authorize the take of the covered species caused by covered activities as stipulated on the ITPs.

# ES.4 Public Involvement

FWS initiated the public scoping process for this EIS on behalf of itself and NMFS with publication of the Notice of Intent (NOI) to prepare an EIS in the *Federal Register* (FR) on July 21, 2017 (82 FR 6625). The NOI announced the FWS' intent to prepare an EIS, provided the details on four public meetings, and requested comments from all interested parties on the scope of issues and alternatives to consider in preparing the EIS. A copy of the NOI is included in Appendix 1-C, *Scoping Report.* FWS hosted two scoping meetings on August 14, 2017, in Madras, Oregon, and two scoping meetings on August 15, 2017, in Bend, Oregon. The *Scoping Report* (Appendix 1-C) summarizes comments received during the scoping period, which were considered in developing this EIS.

In addition, FWS conducted stakeholders update meetings on December 13, 2018, and September 11, 2019, to provide updates on the EIS status and development and to respond to questions related to the EIS process and content.

**Figure ES-1. Covered Lands and Waters and Irrigation District Service Areas**



# ES.5 Alternatives

## ES.5.1 Alternative 1 – No Action

Guidance from the Services' HCP Handbook provides that the no-action alternative for an HCP EIS would be a condition in which no-take of covered species occurs. As explained in Appendix 2-A, *EIS Alternatives Screening Process,* a no-take approach for the no-action alternative is not feasible for this EIS because no-take of covered species in the context of ongoing water facility operations does not appear to be physically possible given the highly degraded baseline condition where historical flows can no longer inundate wetland habitats for the covered species consistent with their full life history needs. Further, attempts to achieve as close to no-take as possible would likely involve substantial reduction or perhaps near elimination of Deschutes Basin water supply operations. Such a future condition is not considered feasible because of the probable economic and legal implications of such an action.

The no-action alternative considered in this EIS assumes continuation of the actions covered in the current ESA Section 7 Biological Opinion for the Upper Deschutes River to address take of Oregon spotted frog (U.S. Fish and Wildlife Service 2017, 2019), referred to in this EIS as the *Deschutes Project BiOp*; the actions covered in the current BiOp for the Deschutes River Basin Projects to address take of Middle Columbia River steelhead trout (National Marine Fisheries Service 2005); and other predictable current and future conditions described below.

The no-action alternative, as defined in this EIS, is considered the most predictable condition to assume for purposes of NEPA analysis given considerable uncertainty about what actions the applicants would take in the absence of the proposed action over the next 30 years.

For example, under the no-action alternative analyzed in this EIS, the Services would take no action. No ITPs for the Deschutes Basin HCP would be issued, and the applicants would remain subject to the take prohibition for listed species under the ESA. Ongoing applicant activities or future actions that may result in the incidental take of federally listed species would need to be authorized through ESA Section 7 or through separate project-by-project ITP applications submitted by each applicant under Section 10.

The assumptions of the no-action alternative are described in more detail in Chapter 2, *Proposed Action and Alternatives*; water management operations assumed under the no-action alternative are summarized in Table 2-1.

## ES.5.2 Alternative 2 – Proposed Action

Under the proposed action, the Services would each issue a 30-year ITP to the applicants for incidental take of each agency's respective covered species likely to be caused by the covered activities in the Deschutes Basin. The applicants would implement the Deschutes Basin HCP.

The Deschutes River Basin (or Deschutes Basin) is a 10,700-square-mile area that encompasses the Deschutes River and its tributary watersheds to its confluence with the Columbia River. The specific area in which the ITPs would apply and the proposed action would be implemented is limited to narrow corridors of covered river and stream segments and covered reservoirs and diversion structures, and connected floodplains and wetlands that could be affected by changes in operation and maintenance of covered facilities (Figure ES-1).

### ES.5.2.1 Covered Activities

The 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; and groundwater withdrawals and effluent discharges.[5] The applicants operate and maintain four covered dams and reservoirs: two owned by the federal government and administered by Reclamation and two owned by applicants. Figure ES-1 shows the locations of the covered dams and reservoirs in the Deschutes Basin. The applicants own, operate, and maintain 25 covered water supply diversion structures, pumps, and intakes used for diversion of irrigation water by the applicants and their patrons. Water diversion by the applicants is a covered activity. Most of the applicants divert a combination of in-channel reservoir storage and live streamflow, but one relies on out-of-channel storage and live streamflow, and one relies entirely on live streamflow. The amount of water diverted by each of the applicants is determined by the amount of water available for irrigation, the applicants' water rights, operations constraints of the conveyance system, and local demands. Return flow, or water delivered from covered facilities that is allowed to flow back into a river or creek, is a covered activity. Return flow can be either tailwater or spill return flow. Current and projected future groundwater withdrawals and effluent discharges by the City of Prineville are covered activities.

### ES.5.2.2 Covered Species

The ITPs that would be issued to the applicants apply to three species listed as threatened under the ESA and two species that currently have no formal ESA status. These five species, listed above, are collectively referred to as the covered species. The FWS ITP would cover Oregon spotted frog and bull trout; the NMFS ITP would cover steelhead, Chinook salmon, and sockeye salmon.

### ES.5.2.3 Conservation Strategy

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 and mitigate (i.e., offset) the adverse effects of covered activities that can result in the take of the covered species. The conservation measures are also intended to address the effects of take on covered species. Proposed conservation measures include actions that would change the timing and volume of water released from covered reservoirs and streamflow in covered rivers and creeks. The conservation strategy also provides an adaptive management and monitoring program to ensure that it is achieving the intended benefits to the covered species.

## ES.5.3 Alternative 3 – Enhanced Variable Streamflows

Under Alternative 3, the Services would each issue a 30-year ITP to applicants for incidental take of each agency's respective covered species likely to be caused by the covered activities in the Deschutes Basin. The applicants would implement the Deschutes Basin HCP with modifications to the conservation strategy. These modifications would increase fall and winter flows in the Deschutes River below Wickiup Dam sooner than under the proposed action, target higher minimum flows during above-normal and wet years, add an Upper Deschutes River Conservation Fund, provide improved certainty of flows at North Unit ID's Crooked River pumping plant, and protect uncontracted (fish and wildlife) storage releases on the Crooked River instream to Lake Billy

[5] The ITPs also authorize any take that may result from implementation of the HCP conservation strategy.

Chinook. All other conservation measures and the adaptive management and monitoring program would be the same as under the proposed action.

### ES.5.4 Alternative 4 – Enhanced and Accelerated Variable Streamflows

Under Alternative 4, the Services would each issue a 20-year ITP to applicants for incidental take of each agency's respective covered species likely to be caused by the covered activities in the Deschutes Basin. The applicants would implement the Deschutes Basin HCP for a shortened permit term and with the following modifications to the conservation strategy. Alternative 4 is similar to Alternative 3 in that it increases fall and winter flows on the Deschutes River sooner than under the proposed action, requires implementation of the Upper Deschutes River Conservation Fund, provides improved flow certainty at North Unit ID's Crooked River pumping plant, and protects releases of uncontracted storage on the Crooked River instream to Lake Billy Chinook. Alternative 4 also accelerates the timing of fall and winter flow increases on the Deschutes River and achieves a higher minimum flow compared to the proposed action and Alternative 3. Alternative 4 also increases releases of uncontracted storage on the Crooked River. All other conservation measures and the adaptive management and monitoring program are the same in Alternative 4 as under the proposed action.

## ES.6 Environmental Consequences

### ES.6.1 Scope of Analysis

The analysis in this EIS is focused primarily on the direct, indirect, and cumulative impacts of the covered activities likely to cause incidental take of the covered species and the impacts associated with implementing the conservation strategy defined under the Deschutes Basin HCP. Because the covered activities consist mainly of storage and release of water that would adversely affect the covered species, and the conservation strategy consists mainly of modifications to these activities to reduce these adverse effects, the analysis focuses on resources that would be affected by changes in surface water, groundwater, and water supply. These affected resources are water quality, aquatic and terrestrial species and their habitats, land use and agricultural resources, recreation, aesthetics, cultural resources, tribal resources, and socioeconomics and environmental justice. These analyses are presented in Chapter 3, *Affected Environment and Environmental Consequences*. As discussed in Section 3.1, *Introduction*, the following elements of the human environment were excluded from detailed analysis in this EIS: transportation; air quality and greenhouse gases; noise; hazards and hazardous materials; geology, seismicity, and soils; and public services and utilities.

### ES.6.2 General Approach to Analysis

This EIS, in Chapter 3, *Affected Environment and Environmental Consequences*, evaluates the covered activities' potential impacts on the natural and human environment at the level of detail possible, based on the level of detail provided for the proposed action and developed for the alternatives. Because of the nature of the covered activities and conservation strategy, emphasis is provided for resources that could be affected by changes in water resource management and on covered species effects. Much of the analysis is focused on the covered lands and waters, but direct and indirect

effects of the covered activities and conservation strategy are addressed where they occur, especially for land use and agricultural resources and socioeconomics and environmental justice. Resource analyses address the proposed action, two action alternatives (Alternatives 3 and 4), and the no-action alternative. The no-action alternative effects are judged against existing conditions. The proposed action and Alternatives 3 and 4 effects are judged against the no-action alternative, and effect thresholds are provided to determine effect conclusions for each impact addressed and considering the context and intensity of the effect. Based on the effects thresholds, impacts are determined to be adverse, not adverse, beneficial, or having no effect.

Cumulative impacts of the proposed action and action alternatives are addressed in Chapter 4, *Cumulative Analysis*, considering past, present, and reasonably foreseeable future projects that, when combined with the proposed action and alternatives, could result in greater or more intense effects than the proposed action or each action alternative considered alone. The emphasis for the cumulative analysis is to provide the level of information needed to meet NEPA requirements and support the Services' ITP decisions.

## ES.6.3 Summary of Impact Analysis

Table ES-1 summarizes the impacts that could occur under the proposed action and alternatives for all environmental issues analyzed in the EIS. Chapter 3 provides a detailed analysis of potential effects and describes the approach to characterizing and evaluating each resource and the assessment methods used, the potentially affected environment for the resource, and an assessment of the environmental consequences. Chapter 4 describes the cumulative impacts, and Appendix 3.1-A provides the regulatory context for each resource.

**Table ES-1. Summary of Potential Impacts**

| Alternative 1-No Action | Alternative 2 – Proposed Action | Alternative 3 – Enhanced Variable Streamflows | Alternative 4 – Enhanced and Accelerated Variable Streamflows |
|---|---|---|---|
| **Water Resources**<br>**WR-1: Change Reservoir Storage** | | | |
| Continuation of current water management operations would have no effect on reservoir storage compared to existing conditions. However, climate change is expected to reduce reservoir storage over the analysis period. | Changes in reservoir storage under the proposed action compared to the no-action alternative would result in slight increases during the storage season and slight decreases during the irrigation season in Crane Prairie, progressive decreases in normal and dry years over the permit term in in Wickiup Reservoir, increases during dry years in Crescent Lake Reservoir, decreases in Prineville Reservoir, and slight decreases in Ochoco Reservoir. These changes are used to inform the analysis of effects on water supply, groundwater and reservoir recreation. | Changes in reservoir storage under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action, but would occur earlier in the permit term. | Changes in reservoir storage under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all reservoirs except Wickiup Reservoir, where storage in normal and dry years would be up to 16% greater. Changes in Wickiup, Crescent Lake and Prineville Reservoirs would occur earlier in the permit term than the proposed action or Alternative 3 but would end sooner due to the shorter permit term. |
| **Water Resources**<br>**WR-2: Change Water Supply for Irrigation Districts and Other Surface Water Users** | | | |
| Continuation of current water management operations would have no effect on water supply compared to existing conditions. Climate change is expected to reduce water supply over the analysis period, while planned water conservation projects could result in increased water supply for irrigation districts compared to existing conditions. | Changes in reservoir storage under the proposed action compared to the no-action alternative would result in varying degrees of water supply reductions for irrigation districts and other live flow diverters, primarily during dry and very dry years. North Unit, Arnold, Lone Pine, and Ochoco IDs would experience the largest water supply reductions. Central Oregon, Tumalo, and Three Sisters IDs would experience relatively minor water supply reductions. Swalley ID would not be affected. The effects of these changes are addressed under land use and agricultural resources and socioeconomics and environmental justice. | Changes in water supply under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all users. Changes for North Unit, Central Oregon, Arnold, Lone Pine, Ochoco, and Tumalo IDs, and other Deschutes and Crooked River water users would occur earlier in the permit term and therefore be of longer duration. | Changes in water supply under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all users except North Unit ID, which would experience up to 20% greater in magnitude during a dry water year. Changes would occur earlier in the permit term than the proposed action or Alternative 3 but would end sooner due to the shorter permit term. |

| Alternative 1-No Action | Alternative 2 – Proposed Action | Alternative 3 – Enhanced Variable Streamflows | Alternative 4 – Enhanced and Accelerated Variable Streamflows |
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| **Water Resources**<br>**WR-3: Change Reservoir Water Surface Elevations and Flood Storage Capacity** | | | |
| Continuation of current water management operations would have no effect on reservoir water surface elevations and flood storage capacity compared to existing conditions. | Changes in reservoir flood storage capacity under the proposed action compared to the no-action alternative would not result in an increase in median or maximum reservoir water surface elevations exceeding 90% of reservoir storage capacity. Therefore, effects on flood storage capacity would be not adverse.<br>Changes in reservoir water surface elevations would vary across the study area reservoirs; effects of these changes are addressed under impacts on water quality, biological resources, aesthetics and visual resources, and recreation. | Changes in flood storage capacity and reservoir water surface elevations would under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action. | Changes in flood storage capacity under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action.<br>Changes in reservoir water surface elevations would be the same or nearly the same as described for the proposed action except in Wickiup Reservoir where elevations would be considerably lower. |
| **Water Resources**<br>**WR-4: Change Seasonal River and Creek Flows** | | | |
| Continuation of current water management operations would have no effect on seasonal river and creek flows compared to existing conditions.<br>Climate change is expected to result in higher peak flows and lower summer low flows, while planned water conservation projects would result in increased instream flows below Bend during the irrigation season compared to existing conditions. | Changes in seasonal rivers and creek flows under the proposed action compared to the no-action alternative would occur in the study area, especially in dry years. On the Deschutes River, seasonal flow changes would be most pronounced from Wickiup Dam downstream to the Deschutes River near Culver, where fall and winter flow would be higher. During the irrigation season, flows between Wickiup and Bend would generally be lower. On the Crooked River, flows below Bowman Dam would become less variable, especially during dry years. Streamflow changes in the remainder of study area would be minor, although seasonally important differences may affect water users and other resources. Effects of the changes are addressed under water | Changes in seasonal river and creek flows under Alternative 3 compared to the no-action alternative are the same or nearly the same as described for the proposed action in all reaches, except the Crooked River between the North Unit ID pumps and Osborne Canyon where changes would be of slightly lower magnitude. Additionally, flow changes described under the proposed action for the Upper Deschutes River below Wickiup Dam and the Middle Deschutes River would occur earlier in the permit term and therefore be of longer duration.<br>Changes in flood flows under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action. | Changes in seasonal river and creek flows under Alternative 4 compared to the no-action alternative would be the same or nearly the same in all reaches except the Upper and Middle Deschutes River and the Crooked River, where winter storage flows would generally be higher and irrigation season flows lower.<br>Changes in flood flows under Alternative 4 compared to the no-action alternative would be nearly the same as described for the proposed action. |

| Alternative 1-No Action | Alternative 2 – Proposed Action | Alternative 3 – Enhanced Variable Streamflows | Alternative 4 – Enhanced and Accelerated Variable Streamflows |
|---|---|---|---|
| | quality, biological resources, aesthetics and visual resources, recreation, and tribal resources.<br>The proposed action would result in little change in the magnitude and frequency of 100-year and 500-year flood events. Reduced irrigation season flows on the Upper Deschutes River associated with the proposed action are anticipated to reduce the frequency of irrigation season lower magnitude flooding. The proposed action is not anticipated to affect the frequency of lower-magnitude flood events on the Crooked River. Therefore, effects of the proposed action on flood flows would be not adverse. | | |
| **Water Resources**<br>**WR-5: Affect Groundwater Recharge** | | | |
| Continuation of current water management operations would have no effect on groundwater recharge compared to existing conditions.<br><br>Climate change could have an adverse effect on groundwater resources. Planned water conservation projects would result in minor local-scale declines in the groundwater levels that would be attenuated and absorbed by the regional groundwater system and would not affect the overall regional groundwater system compared to existing conditions. | Effects on groundwater recharge under the proposed action compared to the no-action alternative in the study area would be minor. These minor changes would likely be *de minimis* compared to the average annual groundwater recharge and likely masked by the naturally occurring basin-scale groundwater level fluctuations associated 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, effects compared to the no-action alternative would be not adverse. | Effects on groundwater recharge 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 seepage associated with the Deschutes River segment downstream of Sunriver would occur earlier in the permit term. Effects compared to the no-action alternative would be not adverse. | Effects on groundwater recharge under Alternative 4 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 seepage associated with the Deschutes River segment downstream of Sunriver would occur earlier in the permit term. Effects compared to the no-action alternative would be not adverse. |
| **Water Quality**<br>**WQ-1: Affect Water Quality in Deschutes River Subbasin** | | | |
| Continuation of current water management operation and maintenance of covered facilities is expected to | Effects on water quality in the Deschutes River Subbasin under the proposed action compared | Effects of Alternative 3 on water quality in the Deschutes River Subbasin compared to the | Effects of Alternative 4 on water quality in the Deschutes River Subbasin compared to |

| Alternative 1-No Action | Alternative 2 – Proposed Action | Alternative 3 – Enhanced Variable Streamflows | Alternative 4 – Enhanced and Accelerated Variable Streamflows |
|---|---|---|---|
| have little effect on water quality in the study area compared to existing conditions. Existing water quality impairments would continue in basin waterbodies. Potential negative effects on water quality associated with climate change and ongoing development in the basin would likely be offset somewhat by beneficial effects associated with water conservation and river restoration projects assumed under the no-action alternative over the analysis period. Overall, the effect on water quality would be adverse compared to existing conditions because water quality impairments would not improve appreciably, and potential effects from climate change and land development would continue. | to the no-action alternative would not be detectable on Whychus Creek, the Little Deschutes River, Tumalo Creek, and Crescent Lake Reservoir. Crane Prairie Reservoir could experience increases in daytime temperature, dissolved oxygen, pH, chlorophyll, turbidity, and nuisance algae. In Wickiup Reservoir, the surface waters are expected to exhibit daytime increases in pH, dissolved oxygen, chlorophyll, turbidity, and nuisance algae, and the bottom waters decreases in dissolved oxygen and pH. In the Upper Deschutes River, changes in temperature, pH, dissolved oxygen, nitrate or phytoplankton (from Wickiup Reservoir) would be minor and reduced peak flows would reduce streambank erosion. On the Middle Deschutes River changes would be minor. Cyanobacteria blooms could increase in Crane Prairie Reservoir, but are more likely in Wickiup Reservoir. If blooms in Wickiup Reservoir were discharged to the Upper Deschutes River, they could affect these reaches, but this likelihood is undetermined. Overall, effects on water quality under the proposed action compared to the no-action alternative in the Upper Deschutes Subbasin would be adverse. | no-action alternative would be the same or nearly the same as described for the proposed action, except that effects on water quality in the Upper Deschutes River could be offset by restoration actions funded through Conservation Measure DR-2. Effects on Wickiup Reservoir and the Upper Deschutes River would occur earlier in the permit term and therefore be of longer duration. Overall, effects compared to the no-action alternative would be adverse. | the no-action alternative would be the same or nearly the same as described for the proposed action for Crane Prairie Reservoir, Crescent Creek, the Little Deschutes River, Tumalo Creek, and Whychus Creek. Effects in Wickiup Reservoir and the Upper and Middle Deschutes River under Alternative 4 would be similar to the proposed action but would be more likely and of greater magnitude, though adverse effects in the Upper Deschutes River could be offset by restoration actions funded through Conservation Measure DR-2. These effects would occur earlier in the permit term than the proposed action or Alternative 3 but would end sooner due to the shorter permit term. Overall, effects compared to the no-action alternative would be adverse. |
| **Water Quality**<br>**WQ-2: Affect Water Quality in the Crooked River Subbasin** | | | |
| See WQ-1. | There would be no discernable effects on water quality in the in Prineville and Ochoco Reservoirs under the proposed action compared to the no-action alternative. Small increases in flow in Ochoco and McKay Creeks would likely have a small beneficial effect on water quality. Decreased irrigation season | Effects of Alternative 3 on water quality in the Crooked River Subbasin compared to the no-action alternative would be the same or nearly the same as described for the proposed action, except on the Crooked River, where a combination of slight increases and decreases in flows between the North Unit ID | Effects of Alternative 4 on water quality in the Crooked River Subbasin compared to the no-action alternative would be the same or nearly the same as described for the proposed action, except for in the Crooked River, where irrigation season flows would decrease in all reaches over the permit term, |

| Alternative 1-No Action | Alternative 2 – Proposed Action | Alternative 3 – Enhanced Variable Streamflows | Alternative 4 – Enhanced and Accelerated Variable Streamflows |
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| | flows below Bowman Dam in years 1 through 5 and between the North Unit ID pumps and Smith Rock State Park in years 21 through 30 would have an adverse effect on water quality in those reaches during those stages of the permit term. Overall, effects of the proposed action on water quality in the Crooked River Subbasin would be not adverse. | pumps and Smith Rock State Park, depending on the water year type and stage of the permit term, would result in no net effect on water quality. Overall, effects compared to the no-action alternative would be slightly beneficial. | resulting in adverse effects on water quality. Overall, effects compared to the no-action alternative would be adverse. |
| **Biological Resources**<br>**BIO-1: Change Vegetation Communities** | | | |
| Although continuation of current water management operations under the no-action alternative would have small beneficial effects on vegetation in some reaches along the Upper Deschutes River downstream of Wickiup Reservoir over the analysis period, climate change is anticipated to result in generally adverse effects on vegetation throughout the study area when compared to existing conditions. Overall, due to the effects of climate change over the analysis period, effects on vegetation would be adverse compared to existing conditions. | Changes in vegetation communities (riparian and wetland) under the proposed action would be not adverse in most river reaches compared to the no-action alternative. The proposed action would provide clear benefits in other reaches (primarily along the Upper Deschutes River) and result in a mix of beneficial and adverse (primarily Wickiup Reservoir) effects in a few reaches. Overall, effects compared to the no-action alternative would be beneficial. | Changes in vegetation communities under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action, except beneficial effects on the Upper Deschutes River would be greater due to Conservation Measures DR-2. Both adverse and beneficial effects would occur earlier in the permit term and, therefore, be of longer duration under Alternative 3 than the proposed action. Overall, effects compared to the no-action alternative would be beneficial. | Changes in vegetation communities under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action, except that adverse and beneficial effects on the Upper Deschutes would be of greater magnitude. Effects would occur earlier in the permit term but end sooner than under the proposed action or Alternative 3; the duration of these full implementation effects would be between the proposed action and Alternative 3. Overall, effects compared to the no-action alternative would be beneficial. |
| **Biological Resources**<br>**BIO-2: Change Habitat for Wildlife Species** | | | |
| Although the continuation of current water management operations would have little to no effect on wildlife in the study area over the analysis period, compared to existing conditions, climate change could cause adverse effects on wildlife by permanently reducing the quality and function of existing habitats for special-status species (potentially, all wildlife species addressed in this analysis). Therefore, effects | Changes to habitat for wildlife species under the proposed action would be not adverse in most river reaches compared to the no-action alternative. The proposed action would provide clear benefits in other reaches and result in a mix of beneficial and adverse effects in a few reaches. Overall, the effect of the proposed action compared to the no-action alternative would be beneficial. | Changes to habitat for wildlife species under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action. Both adverse effects in Wickiup Reservoir and beneficial effects in the Upper Deschutes River would occur earlier in the permit term and, therefore, be of longer duration under Alternative 3 than the proposed action. Overall, the effect | Changes to habitat for wildlife species under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action but of greater magnitude in of the Upper Deschutes River and some reaches of the Crooked River. The duration of both beneficial and adverse effects would be between the proposed action and Alternative 3. Overall, the effect |

| Alternative 1-No Action | Alternative 2 – Proposed Action | Alternative 3 – Enhanced Variable Streamflows | Alternative 4 – Enhanced and Accelerated Variable Streamflows |
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| on wildlife habitat in the study area would be adverse compared to existing conditions. | | compared to the no-action alternative would be beneficial. | compared to the no-action alternative would be beneficial. |
| **Biological Resources**<br>**BIO-3: Affect Oregon Spotted Frog Habitat** | | | |
| Although the continuation of current water management operations could result in slight improvements to Oregon spotted frog habitat, compared to existing conditions, it is likely to perpetuate degraded habitat conditions for Oregon spotted frog in the basin. Moreover, climate change could result in adverse effects on the distribution and quality of habitat available in the study area. Other adverse impacts would continue unabated (e.g., negative impacts from nonnative predators, and habitat degradation from reed canarygrass). Overall, effects on Oregon spotted frog in the study area would be adverse compared to existing conditions because of the perpetuation of degraded habitat conditions in the basin and effects of climate change. | During most life history periods and in most reaches considered in this analysis, the proposed action at full implementation (years 21–30) would have a beneficial effect on the Oregon spotted frog and its habitat compared to the no-action alternative. Prior to reaching full implementation, the proposed action would perpetuate degraded habitat conditions for Oregon spotted frog in the basin. The proposed action would have an adverse effect in Wickiup Reservoir during all life history periods and in other reaches during rearing. Adverse effects on the frog that stem from threats other than flow (e.g., invasive and predatory species) could perpetuate throughout the permit term. Overall, compared to the no-action alternative, effects would be beneficial. | Hydrology-related effects on Oregon spotted frog and its habitat (both beneficial and adverse) under Alternative 3 at full implementation compared to the no-action alternative are the same as described for the proposed action but would occur earlier in the permit term. In addition, actions implemented through Conservation Measure DR-2 funding would address ongoing threats to Oregon spotted frogs that would persist concurrent despite with improvements in hydrology. Overall, compared to the no-action alternative, effects would be beneficial. | Hydrology-related effects on Oregon spotted frog and its habitat (both beneficial and adverse) under Alternative 4 at full implementation compared to the no-action alternative would be the same as described for the proposed action except that both beneficial and adverse effects would be of greater magnitude and would occur earlier in the permit term and end earlier than under the proposed action or Alternative 3. In addition, actions implemented through Conservation Measure DR-2 funding would address ongoing threats to Oregon spotted frogs that would persist concurrent despite with improvements in hydrology. Overall, compared to the no-action alternative, effects would be beneficial. |
| **Biological Resources**<br>**BIO-4: Affect Bull Trout Habitat** | | | |
| Continuation of current 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 would result in unquantifiable improvements to fish and mollusk habitat. Continuation of current 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 | The proposed action would have no effect on bull trout habitat conditions in the Crooked River in wet water years compared to the no-action alternative, but would have an adverse effect on habitat in some reaches during critical life stages in dry and normal water years at full implementation, depending on annual water management practices. Habitat improve on the Middle Deschutes River and Ochoco and McKay Creeks, and would be unchanged in other areas occupied by bull | Effects on bull trout habitat under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all reaches except the Crooked River reach between the North Unit ID pumps and Osborne Canyon, where adverse effects would be of slightly lesser magnitude due to instream protection of uncontracted releases under this alternative. In addition, effects in the Middle Deschutes River and Crooked River would occur earlier in the permit term | Effects on bull trout habitat under Alternative 4 compared to the no-action alternative 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. Increased storage season flows and associated beneficial effects on bull trout habitat in the Middle Deschutes River and Crooked River would be the same as described for the proposed action but of greater magnitude at full implementation. |

| Alternative 1-No Action | Alternative 2 – Proposed Action | Alternative 3 – Enhanced Variable Streamflows | Alternative 4 – Enhanced and Accelerated Variable Streamflows |
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| potential to adversely affect the distribution and quality of the covered fish species habitat available in the study area. Therefore, effects under the no-action alternative are expected to be adverse compared to existing conditions. Effects would likely be greatest in the Crooked River because of relatively less influence of groundwater inflow to portions of the river. | trout. Overall, compared to the no-action alternative, effects would be not adverse. | and, therefore, be of longer duration under Alternative 3 than the proposed action. Overall, effects compared to the no-action alternative would be not adverse. | Adverse irrigation season effects in reaches of the Crooked River would also be of slightly greater magnitude. Beneficial effects in the Middle Deschutes River and beneficial and adverse seasonal effects on the Crooked River would occur earlier in the permit term but end sooner than under the proposed action or Alternative 3. Overall, effects compared to the no-action alternative would be not adverse. |
| **Biological Resources**<br>**BIO-5: Affect Bull Trout Migratory Life Stages** | | | |
| See BIO-4. | Effects on bull trout migratory life stages under the proposed action in the Middle Deschutes River would be beneficial compared to the no-action alternative. In the Crooked River, migratory life stages would not be affected. In Ochoco and McKay Creeks, increased flows would have small beneficial effects. Overall, compared to the no-action alternative, effects would be beneficial. | Effects on bull trout migratory life stages under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all reaches. Beneficial effects in the Middle Deschutes River would occur earlier in the permit term and, therefore, have a longer duration than under the proposed action. Overall, effects compared to the no-action alternative would be beneficial. | Effects on bull trout migratory life stages under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all reaches except for the Middle Deschutes River, where effects would be of greater magnitude at full implementation. The duration of these beneficial effects would be between the proposed action and Alternative 3. Overall, effects compared to the no-action alternative would be beneficial. |
| **Biological Resources**<br>**BIO-6: Affect Steelhead Trout Habitat** | | | |
| See BIO-4. | In the Crooked River, Conservation Measures CR-4, CR-5, and CR-6 would result in beneficial effects on steelhead habitat under the proposed action compared to the no-action alternative. However, Conservation Measures WR-1 would have an adverse effect on water temperatures and juvenile habitat in all water years at full implementation (years 21–30), depending on annual water management | Effects on steelhead trout habitat under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all reaches, except in the Crooked River between the North Unit ID pumps and Osborne Canyon where adverse effects would be of slightly lesser magnitude. In addition, effects in the Middle Deschutes River and | Effects on steelhead trout habitat under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all reaches, except the Middle Deschutes River and Crooked River. Beneficial effects in the Middle Deschutes River and Crooked River and adverse effects in summer in all water year types on the Crooked River |

| Alternative 1-No Action | Alternative 2 – Proposed Action | Alternative 3 – Enhanced Variable Streamflows | Alternative 4 – Enhanced and Accelerated Variable Streamflows |
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| | practices. Effects would be not adverse in the remainder of the Crooked River, beneficial in the Middle Deschutes River and Ochoco and McKay Creeks, and unchanged in other areas occupied by steelhead trout. Overall, compared to the no-action alternative, effects would be not adverse. | Crooked River would occur earlier in the permit term and, therefore, be of longer duration. Overall, compared to the no-action alternative, effects would be not adverse. | would be of greater magnitude than described for the proposed action. The duration of these beneficial and adverse effects would be between the proposed action and Alternative 3. Overall, compared to the no-action alternative, effects would be not adverse. |
| **Biological Resources**<br>**BIO-7: Affect Steelhead Trout Migratory Life Stages** | | | |
| See BIO-4. | The proposed action would have no effect on steelhead trout migratory life stages compared to the no-action alternative. | Same as the proposed action. | Same as the proposed action. |
| **Biological Resources**<br>**BIO-8: Affect Spring Chinook Salmon Habitat** | | | |
| See BIO-4. | In the Crooked River, Conservation Measures CR-4, CR-5, and CR-6 would result in beneficial effects on spring Chinook salmon habitat under the proposed action compared to the no-action alternative in the Crooked River would be beneficial. However, Conservation Measure WR-1 would result in adverse effects on habitat quantity and quality during juvenile Chinook salmon summer rearing and adult holding in some reaches in dry and average water years at full implementation, , and to a lesser extent in earlier years (11–20), depending on annual water management practices. Effects would be not adverse in the remainder of the Crooked River, beneficial in Ochoco Creek, and unchanged in other areas occupied by spring Chinook salmon. Overall, compared to the no-action alternative, effects would be not adverse. | Effects on spring Chinook salmon habitat under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all reaches. Effects in the Crooked River would occur earlier in the permit term and therefore be of longer duration under Alternative 3 than the proposed action. Overall, compared to the no-action alternative, effects would be not adverse. | Effects on spring Chinook salmon habitat under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all reaches except for the Crooked River. Beneficial storage season effects and adverse summer effects on the Crooked River would be of greater magnitude than described for the proposed action. The duration of these beneficial and adverse effects would be between the proposed action and Alternative 3. Overall, compared to the no-action alternative, effects would be not adverse. |

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| **Biological Resources<br>BIO-9: Affect Spring Chinook Salmon Migratory Life Stages** | | | |
| See BIO-4. | Effects on spring Chinook salmon migratory life stages under the proposed action compared to the no-action alternative would have no effect on migrating adult spring Chinook salmon from March to May and migrating spring Chinook salmon smolts in the Crooked River. However, depending on water management practices, the proposed action could result in a decline in habitat for adult spring Chinook salmon migrating in July and August. There would be no effects in other areas occupied by migrating spring Chinook salmon. Overall, compared to the no-action alternative, effects would be not adverse. | Effects on spring Chinook salmon migratory life stages under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all reaches, but effects in the Crooked River would occur earlier in the permit term and, therefore, have a longer duration. Overall, compared to the no-action alternative, effects would be not adverse. | Effects on spring Chinook salmon habitat under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action. The duration of effects on the Crooked River would be between the proposed action and Alternative 3. Overall, compared to the no-action alternative, effects would be not adverse. |
| **Biological Resources<br>BIO-10: Affect Sockeye Salmon Habitat** | | | |
| See BIO-4. | The proposed action would have no effect on sockeye salmon habitat compared to the no-action alternative. | Same as the proposed action. | Same as the proposed action. |
| **Biological Resources<br>BIO-11: Affect Sockeye Salmon Migratory Life Stages** | | | |
| See BIO-4. | There would be no effect on sockeye salmon migratory life stages under the proposed action compared to the no-action alternative in any of the modeled water year types. | Effects on sockeye salmon migratory life stages under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all reaches. Alternative 3 would have no effect on sockeye salmon migratory life stages. | Effects on sockeye salmon migratory life stages under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all reaches. Alternative 4 would have no effect on sockeye salmon migratory life stages. |
| **Biological Resources<br>BIO-12: Affect Redband Trout Habitat** | | | |
| See BIO-4. | There would be no effect on redband trout habitat in Crescent Lake Reservoir, Crescent Creek, the Little Deschutes River, Whychus | Effects on redband trout under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described | Effects on redband trout habitat under Alternative 4 compared to the no-action alternative would be the same or nearly the |

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| | and Tumalo Creeks, and the Lower Deschutes, Lake Billy Chinook, Lake Simtustus, and Prineville Reservoir under the proposed action compared to the no-action alternative. There would be a beneficial effect on redband trout in Crane Prairie Reservoir, the Upper Deschutes River between Crane Prairie and Wickiup Reservoirs, the Middle Deschutes River, and Ochoco and McKay Creeks. Adverse effects in the Crooked River would be limited to specific reaches at full implementation (years 21–30) and would be not adverse in the Crooked River reaches downstream of Osborne Canyon. Adverse effects on habitat quantity and quality would also occur in Wickiup Reservoir and the Upper Deschutes River between Wickiup Reservoir and the city of Bend. Overall, compared to the no-action alternative, effects under the proposed action would be adverse. | 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. Beneficial effects in the Upper Deschutes 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. 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 than the proposed action. Overall, compared to the no-action alternative, effects would be adverse. | same as described for the proposed action, except that beneficial storage season effects in the Middle Deschutes River and Crooked River and adverse irrigation season effects in Wickiup Reservoir, the Upper Deschutes River, and the Crooked River would be of greater magnitude. Implementation of habitat restoration activities funded through Conservation Measure DR-2 could offset adverse effects in the Upper Deschutes River. The duration of these beneficial and adverse effects would be between the proposed action and Alternative 3. Overall, compared to the no-action alternative, effects would be adverse. |
| **Biological Resources**<br>**BIO-13: Affect Nonnative Resident Trout Habitat** | | | |
| See BIO-4. | The proposed action would have no effect on nonnative resident trout habitat in several reaches and small beneficial effects in the Upper Deschutes River, Middle Deschutes River, and Ochoco and McKay Creeks, and an adverse effect in Wickiup Reservoir compared to the no-action alternative. Overall, compared to the no-action alternative, effects would be not adverse. | Effects on nonnative resident trout under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action in all reaches. Effects in Wickiup Reservoir and the Upper and Middle Deschutes River and Crooked River would be of longer duration. Overall, compared to the no-action alternative, effects would be not adverse. | Effects on nonnative resident trout habitat under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action in all reaches. Effects in Wickiup Reservoir, the Upper and Middle Deschutes River, and the Crooked River would occur earlier in the permit term but end sooner than under the proposed action or Alternative 3. Overall, compared to the no-action alternative, effects would be not adverse. |

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| **Biological Resources<br>BIO-14: Affect Summer/Fall Chinook Salmon Habitat** | | | |
| See BIO-4. | There would be no effect on summer/fall Chinook salmon habitat under the proposed action compared to the no-action alternative. | Same as the proposed action. | Same as the proposed action. |
| **Biological Resources<br>BIO-15: Affect Kokanee Salmon Habitat and Migratory Life Stages** | | | |
| See BIO-4. | Effects of the proposed action on kokanee salmon habitat and migratory life stages would be adverse in Wickiup Reservoir compared to the no-action alternative. There would be no effect in the remaining reaches occupied by the species. Overall, compared to the no-action alternative, effects would be adverse. | Effects on kokanee salmon habitat and migratory life stages under Alternative 3 compared to the no-action alternative would be the same or nearly the same 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, compared to the no-action alternative, effects would be adverse. | Effects on kokanee salmon habitat and migratory life stages under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action in all reaches except Wickiup Reservoir, where adverse effects would be of greater magnitude. The duration of these adverse effects would be between the proposed action and Alternative 3. Overall, compared to the no-action alternative, effects would be adverse. |
| **Biological Resources<br>BIO-16: Affect Native Non-Trout and Non-Game Fish Habitat** | | | |
| See BIO-4. | The effect on native non-trout and non-game species under the proposed action compared to the no-action alternative would be adverse in Wickiup Reservoir, not adverse in the Upper Deschutes River, beneficial in the Middle Deschutes River and Ochoco and McKay Creeks, and would have no effect in other areas occupied by these species. Overall, compared to the no-action alternative, effects would be not adverse. | Effects on non-game native fish habitat 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 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 Deschutes River, 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. | Effects on non-game native fish habitat under Alternative 4 compared to the no-action alternative would be the same or nearly the same 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 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 |

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| | | Overall, compared to the no-action alternative, effects would be not adverse. | reach. Adverse effects in Wickiup Reservoir and in the Crooked River would be of slightly greater magnitude. The duration of these adverse effects would be between the proposed action and Alternative 3. Overall, compared to the no-action alternative, effects would be not adverse. |
| **Biological Resources**<br>**BIO-17: Affect Freshwater Mollusk Habitat** | | | |
| See BIO-4. | There would be no effect on freshwater mollusk habitat in Whychus Creek, the Lower Deschutes River, and Crane Prairie Reservoir under the proposed action compared to the no-action alternative. Effects would be not adverse in Crescent Lake Reservoir and the Upper Deschutes River; beneficial, not adverse, or adverse in Crescent Creek, the Little Deschutes River and the Middle Deschutes River depending on the species; and adverse in Wickiup Reservoir. Overall, compared to the no-action alternative, effects would be not adverse. | Effects on freshwater mollusk habitat under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action except for floater species mussels and western pearlshell mussels in the Crooked River, where there would be an adverse effect. 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 under the proposed action. Overall, compared to the no-action alternative, effects would be not adverse. | Effects on freshwater mollusk habitat under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action except for floater species mussels and western pearlshell mussels in the Crooked River. There would be no adverse effect on these species. The duration of these effects in Wickiup Reservoir, the Upper and Middle Deschutes River, and the Crooked River would be between the proposed action and Alternative 3. Overall, compared to the no-action alternative, effects would be not adverse. |
| **Land Use and Agricultural Resources**<br>**LUAG-1: Change Irrigated Agricultural Acreage** | | | |
| Under the no-action alternative, the water available to crops in dry water years is anticipated to increase over time compared to existing conditions because of on-farm and district water conservation through the piping of canals and increased irrigation efficiency. This would result in a net benefit to agricultural lands by increasing the amount of water available for irrigation and would not result in a conversion of agricultural lands to other land uses. Therefore, | Changes in irrigated agricultural acreage due to reduced water supply under the proposed action would consist of increased fallowing or deficit irrigation of irrigated lands compared to the no-action alternative. These changes are not expected to result in a conversion of agricultural lands to other land uses; therefore, compared to the no-action alternative, effects would be not adverse. Impacts under socioeconomics and environmental justice address how increased | Changes in irrigated agricultural acreage due to reduced water supply under Alternative 3 would consist of increased fallowing or deficit irrigation of irrigated lands in the compared to the no-action alternative. Increased fallowing or deficit irrigation would be similar to but greater than that described for the proposed action. These changes are not expected to result in a conversion of agricultural lands to other land uses. | Changes in irrigated agricultural acreage due to reduced water supply under Alternative 4 would consist of increased fallowing or deficit irrigation of irrigated lands compared to the no-action alternative. Increased fallowing or deficit irrigation would be similar to but greater than that described under the proposed action and Alternative 3. These changes are not expected to result in a conversion of agricultural lands to other land uses. Therefore, compared to the no- |

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| effects would be not adverse compared to existing conditions. | fallowing or deficit irrigation of irrigated lands could affect the local economy. | Therefore, compared to the no-action alternative, effects 3 would be not adverse. | action alternative, effects would be not adverse. |
| **Aesthetics and Visual Resources**<br>**AES-1: Change Visual Character and Quality of Lands and Waters in the Direct Effects Study Area** | | | |
| Although the continuation of current water management operations could have slightly beneficial effects on visual quality in portions of the Upper Deschutes, changes in precipitation related to forecasted climate change could result in adverse effects on visual quality related to reduced quality and extent of vegetation, reduced recreation access and opportunity, and reduced irrigation. Elevated risk of extreme weather events could affect water management operations and cause extended periods of consecutive very dry or wet years that could result in substantial alteration of viewsheds, visual quality, and access to visual resources. However, the visual character and quality of the Deschutes Basin would continue to provide an abundance of high-quality views and dynamic visual environments that would be enjoyed by viewers in the study area. Overall, effects on visual character and quality in the study area would be not adverse over the analysis period compared to existing conditions. | Changes in visual character and quality of lands and waters in the direct effects study area under the proposed action compared to the no-action alternative would be limited to the Deschutes River upstream of Bend. Improved wetland and riparian vegetation would have beneficial effects on visual quality along the Deschutes River reaches and, to a lesser degree, at Crane Prairie Reservoir and adverse effects at Wickiup Reservoir. Reduced access to boat ramps and recreational use areas at Wickiup Reservoir related to lower water levels during the summer months would also be an adverse effect. Overall, compared to the no-action alternative, effects would be not adverse. | Changes in visual character and quality of lands and waters in the direct effects study area 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 beneficial effects on the Upper Deschutes River would be further increased. In addition, restoration and/or habitat maintenance activities under Conservation Measure DR-2, included under Alternative 3, would increase visual diversity in the Upper Deschutes River; therefore, beneficial effects in this reach would be greater than under the proposed action. Both beneficial and adverse effects under Alternative 3 would occur earlier in the permit term than the proposed action, so the duration of these effects would be greater. Overall, compared to the no-action alternative, effects would be not adverse. | Changes in visual character and quality of lands and waters in the direct effects study area under Alternative 4 compared to the no-action alternative would be the same or nearly the same as those described for the proposed action, but the changes would be of greater magnitude. These effects would occur earlier in the permit term than under the proposed action or Alternative 3 but would end sooner. Conservation Measure DR-2, included under Alternative 4 (as under Alternative 3), would also increase visual diversity and thereby have beneficial visual effects in the Upper Deschutes River. Both beneficial and adverse effects under Alternative 4 would be of greater magnitude and would occur earlier in the permit term but end sooner than under the proposed action and Alternative 3. Overall, compared to the no-action alternative, effects would be not adverse. |
| **Aesthetics and Visual Resources**<br>**AES-2: Change Visual Character and Quality of Irrigated Lands** | | | |
| See AES-1. | Changes in visual character and quality of irrigated lands under the proposed action compared to the no-action alternative would only occur in normal and dry years and would not be notable, and other water users, including residential developments and golf courses, would not be affected. Therefore, | Changes in visual character and quality of irrigated lands under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action but would occur earlier in the permit term and would, therefore, have a longer duration under Alternative 3 | Changes in visual character and quality of irrigated lands under Alternative 4 compared to the no-action alternative would be the same or nearly the same as those described for the proposed action. However, both beneficial and adverse effects under Alternative 4 would be of greater magnitude |

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| | compared to the no-action alternative, effects would be not adverse. | compared to the no-action alternative. Compared to the no-action alternative, effects would be not adverse. | and would occur earlier in the permit term and end sooner than under the proposed action and Alternative 3. Compared to the no-action alternative, effects would be not adverse. |
| **Recreation**<br>**REC-1: Change Recreational Opportunities or Quality of Experiences in and along Rivers, Creeks, and Reservoirs** | | | |
| Continuation of existing water management operations would not affect recreation, but climate change would likely reduce recreational opportunities, and future development and population growth may displace some areas currently used for recreation and create increased demand for and use of existing recreational areas. Overall, the study area is expected to continue to provide plentiful, high-quality recreational opportunities, and effects on recreation in the study area compared to existing conditions would be not adverse. | Changes in recreational opportunity or quality of experiences in and along rivers, creeks, and reservoirs under the proposed action compared the no-action alternative would consist of more natural and consistent flows and improved aesthetics. In the Upper Deschutes River Basin, recreational opportunities and experiences are likely to benefit from more stable flows and river levels and increased native shoreline vegetation and potential benefits to recreationally important fish populations. Most reservoirs would have little noticeable changes in water levels or associated recreational opportunities and experiences. Wickiup Reservoir is the one exception, where low water events may occur more frequently or with more severity; this could result in adverse effects related to additional days of poor or eliminated access to boat ramps and shoreline campgrounds and reduced aesthetic values and fishing opportunities and experiences. Some adverse effects would occur on the recreationally popular redband trout in Wickiup Reservoir and in areas of the Upper Deschutes and Crooked Rivers. Overall, compared to the no-action alternative, effects would be not adverse. | Changes in recreational opportunity or quality of experiences in and along rivers, creeks, and reservoirs under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action. Although the effects and the intensity of those effects—both adverse effects in Wickiup Reservoir and adverse and beneficial effects in the Upper Deschutes River—would be the same as under the proposed action, the duration of these effects would be greater because they would occur earlier in the permit term. Overall, compared to the no-action alternative, effects would be not adverse. | Changes in recreational opportunity or quality of experiences in and along rivers, creeks, and reservoirs under Alternative 4 compared to the no-action alternative would be the same or nearly the same as those described for the proposed action but would be of greater magnitude. Adverse effects in Wickiup Reservoir would be more adverse and beneficial effects in the Upper Deschutes River would be more beneficial than described under the proposed action. These effects would also occur earlier in the permit term. However, the duration of effects would be shorter. Therefore, although associated effects on recreational opportunities and experiences would be the same as described for the proposed action, they would be of greater intensity and shorter duration than under the proposed action or Alternative 3. Overall, compared to the no-action alternative, effects would be not adverse. |

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| **Recreation**<br>**REC-2: Conflict with Existing and Future Wild and Scenic River Designations** | | | |
| See REC-1. | Overall, compared to the no-action alternative, effects would be beneficial. | Effects on existing and future Wild and Scenic River designations under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action, with more natural and consistent flows and enhanced ecological function on the Upper Deschutes River. Although the effects and the intensity of those effects would be the same as under the proposed action, the duration of these effects would be greater because they would occur earlier in the permit term under Alternative 3 than under the proposed action. Overall, compared to the no-action alternative, effects would be beneficial. | Effects on existing and future Wild and Scenic River designations under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action, with more natural and consistent flows and enhanced ecological function in the Upper Deschutes, but the improvements would be of greater intensity than under the proposed action and Alternative 3. They would also occur earlier in the permit term than under the proposed action or Alternative 3 but would end sooner. Therefore, although associated effects on Wild and Scenic Rivers be the same as described for the proposed action, they would be of greater intensity and shorter duration than under the proposed action or Alternative 3. Overall, compared to the no-action alternative, effects would be beneficial. |
| **Tribal Resources**<br>**TR-1: Affect Fish Populations Harvested by Tribes** | | | |
| Climate change is anticipated to result in generally adverse effects on vegetation throughout the study area when compared to existing conditions. Overall, due to the effects of climate change over the analysis period, effects on vegetation under the no-action alternative would be adverse compared to existing conditions. Although the continuation of current water management and other ongoing projects and programs assumed under the no-action alternative to restore habitats for fish and wildlife with small beneficial effects in some parts of the study area, climate change is anticipated to have an overall | There would be no effects on fish populations harvested by tribes in the Lower Deschutes River (fish habitat) and Lower Deschutes River (salmon and steelhead) compared to the no-action alternative. The proposed action would have beneficial effects on redband trout habitat and redband trout in the Middle Deschutes River. On the Crooked River, beneficial storage season effects would be outweighed by adverse irrigation season effects in some reaches on habitat for bull trout, steelhead trout, and spring Chinook | Effects on fish populations harvested and potentially harvested by tribal members 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 beneficial effects in the Upper Deschutes River would be greater with implementation of habitat restoration activities funded through Conservation Measure DR-2. Effects in Wickiup Reservoir, the Upper and Middle Deschutes River, and the Crooked River | Effects on fish populations harvested and potentially harvested by tribal members under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all reaches except for Wickiup Reservoir and in the Upper and Middle Deschutes River where both beneficial and adverse effects would be of greater magnitude. The duration of these beneficial and adverse effects would be between the proposed action and |

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| adverse effect on fish and wildlife by permanently reducing the quality and function of existing habitats of many of the species that are considered a tribal resource. Similarly, throughout the study area, climate change is anticipated to have generally adverse effects on vegetation. Overall, due to the effects of climate change over the analysis period, effects on fish, wildlife, and vegetation tribal resources under the no-action alternative would be adverse compared to existing conditions because they would permanently reduce the quality and function of existing habitats. | salmon. In the Upper Deschutes River downstream of Wickiup Reservoir, the proposed action would have beneficial effects on redband trout habitat during storage season but adverse effects during spawning, egg incubation, and fry emergence that could affect abundance of redband trout. Extreme changes in Wickiup Reservoir elevation and volume at full implementation would result in adverse effects on kokanee and trout habitat and populations in Wickiup Reservoir. Overall, compared to the no-action alternative, effects would be not adverse. | would occur earlier in the permit term and, therefore, be of longer duration under Alternative 3 than under the proposed action. Overall, compared to the no-action alternative, effects would be not adverse. | Alternative 3. Overall, compared to the no-action alternative, effects would be not adverse. |
| **Tribal Resources**<br>**TR-2: Affect Reintroduction of Salmon and Steelhead into Habitats Upstream of the Pelton-Round Butte Complex** | | | |
| See TR-1. | Effects of reintroducing salmon and steelhead into habitats upstream of the Pelton-Round Butte Complex under the proposed action would consist of beneficial storage season effects on the Crooked River compared to the no-action alternative, but these beneficial effects would be outweighed by adverse irrigation season effects that would impede reintroduction success and potentially result in reintroduction failure by reducing brood year success during critical early stages of reintroduction. Overall, compared to the no-action alternative, effects would be adverse. | Effects of reintroducing salmon and steelhead into habitats upstream of the Pelton-Round Butte Complex 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 adverse effects in the Crooked River reach between the North Unit ID pumps and Osborne Canyon would be of slightly lesser magnitude due to instream protection of uncontracted releases under Alternative 3 in Conservation Measure CR-1. Adverse effects would occur earlier in the permit term under Alternative 3 and, therefore, be of longer duration under Alternative 3 than under the proposed action. Overall, compared to the no-action alternative, effects would be adverse. | Effects of reintroducing salmon and steelhead into habitats upstream of the Pelton-Round Butte Complex under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action, except that beneficial and adverse effects on the Crooked River would be of slightly greater magnitude, as described under Impacts BIO-6 through BIO-9. Effects would occur earlier in the permit term under Alternative 4. The duration of these beneficial and adverse effects would be between the proposed action and Alternative 3. Overall, compared to the no-action alternative, effects would be adverse. |
| **Tribal Resources**<br>**TR-3: Affect Wildlife and Plant Species Harvested by Tribes** | | | |
| See TR-1. | There would be no effect on wildlife and plant species harvested by tribes under the | Effects on wildlife and plant species harvested and potentially harvested by tribal | Effects on wildlife and plant species harvested and potentially harvested by |

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| | proposed action compared to the no-action alternative over most of the study area. Beneficial effects would be expected in Crane Prairie Reservoir and the Deschutes River between Wickiup Reservoir and Bend. An adverse effect would be expected in Wickiup Reservoir; however, wildlife and plant species are impaired under current water management operations. Overall, compared to the no-action alternative, effects would be not adverse. | members 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 beneficial effects in the Upper Deschutes River would be greater with implementation of habitat restoration activities funded through Conservation Measure DR-2. Beneficial effects in the Upper Deschutes River and adverse effects in Wickiup Reservoir would occur earlier in the permit term and would, therefore, be longer in duration than the proposed action. Overall, compared to the no-action alternative, effects would be not adverse. | tribal members under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action, except for Wickiup Reservoir and in the Upper and Middle Deschutes River where both beneficial and adverse effects would be of greater magnitude. The duration of these beneficial and adverse effects would be between the proposed action and Alternative 3. Overall, compared to the no-action alternative, effects would be not adverse. |
| **Tribal Resources**<br>**TR-4: Affect Warm Springs Tribes' Off-Reservation Reserved Water Right** | | | |
| See TR-1. | There would be no effect on the Warm Springs Tribes' ability to exercise their reserved off-reservation water right under the proposed action compared to no-action alternative. | Same as the proposed action. | Same as the proposed action. |
| **Socioeconomics and Environmental Justice**<br>**SOC-1: Affect Economic Opportunity (Employment and Income)** | | | |
| Adverse effects related to increased electricity costs are expected through time under the no-action alternative. Adverse effects on fish, vegetation, and wildlife resources may result in adverse effects on socioeconomic values related to species and habitat conservation, as well as potential adverse effects on tribal environmental justice populations for whom fish and wildlife species are important resources. Possible beneficial to adverse effects are expected on social, cultural, and economic values related to economic opportunity, suburban/urban irrigation water costs, community way of life, and farmworker environmental justice populations. Effects on local | Effects on economic opportunity (employment and income) under the proposed action compared to the no-action alternative would consist of reductions in irrigation water availability that would result in reductions in agricultural production and associated economic contribution. These reductions could represent an adverse effect on economic opportunity in Jefferson County in dry water years. Decreased employment and income opportunities in other counties would be less than 1% of total economic activity. Compared | Effects on economic opportunity (employment and income) under Alternative 3 compared to the no-action alternative would consist of reductions in irrigation water availability that would result in reductions in agricultural production and associated economic contribution. These reductions could represent an adverse effect on economic opportunity in Jefferson County in dry water years. Effects in other counties would be less than 1% of total economic activity and are therefore considered not | Effects on economic opportunity (employment and income) under Alternative 4 compared to the no-action alternative would consist of reductions in irrigation water availability that would result in reductions in agricultural production and associated economic contribution. In all counties, effects would be larger than under the proposed action and Alternative 3. These reductions could represent an adverse effect on economic opportunity in Jefferson County in dry water years. Effects in other counties would be less than 1% of total economic |

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| government fiscal stability, aesthetic values (and associated property values), and recreation values are anticipated to be not adverse. Overall, depending on the severity of climate change impacts on fish and wildlife species and availability of water supplies, the socioeconomics effects would be adverse to not adverse compared to existing conditions. | to the no-action alternative, effects would be not adverse. | adverse. Overall, compared to the no-action alternative, effects would be not adverse. | activity and are therefore considered not adverse. Overall, compared to the no-action alternative, effects would be not adverse. |
| **Socioeconomics and Environmental Justice<br>SOC-2: Affect Recreation Value** | | | |
| See SOC-1. | Effects on recreation value under the proposed action compared to the no-action alternative would be not adverse. | Effects on recreation value under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action but would occur earlier in the permit term. Compared to the no-action alternative, effects would be not adverse. | Effects on recreation value under Alternative 4 compared to the no-action alternative would be the same or nearly the same as those described for the proposed action but would occur earlier in the permit term than under the proposed action or Alternative 3. Compared to the no-action alternative, effects would be not adverse. |
| **Socioeconomics and Environmental Justice<br>SOC-3: Affect Habitat and Species-Related Cultural and Economic Values** | | | |
| See SOC-1. | Effects on habitat and species-related cultural and economic values under the proposed action would be beneficial or adverse compared to the no-action alternative, depending on the species and habitat type. Overall, effects on socioeconomic value associated with species and habitat conservation under the proposed action cannot be forecast reliably. | Same as the proposed action. | Same as the proposed action. |
| **Socioeconomics and Environmental Justice<br>SOC-4: Result in Aesthetic Changes Affecting Property Values** | | | |
| See SOC-1. | Aesthetic changes at Wickiup Reservoir under the proposed action would have little to no effect on property values under the proposed action compared to the no-action alternative due to lack of adjacent private properties. | Aesthetic changes at Wickiup Reservoir under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action and would have little to no | Aesthetic changes at Wickiup Reservoir under Alternative 4 compared to the no-action alternative would be the same or nearly the same as, but of slightly greater magnitude than, those described for the |

| Alternative 1-No Action | Alternative 2 – Proposed Action | Alternative 3 – Enhanced Variable Streamflows | Alternative 4 – Enhanced and Accelerated Variable Streamflows |
|---|---|---|---|
| | Possible beneficial effects on scenic resources in other parts of the study area could result in a slight beneficial effect on adjacent private properties, as reflected in potential increases in property value. Overall, compared to the no-action alternative, effects would be slightly beneficial. | effect on property values. Possible beneficial effects on scenic resources in other parts of the study area under Alternative 3 compared to the no-action alternative would also be the same as described for the proposed action with slight beneficial effects on adjacent private property value. Overall, compared to the no-action alternative, effects would be slightly beneficial. | proposed action. However, these effects would have little to no effect on property values. Possible beneficial effects on scenic resources in other parts of the study area under Alternative 4 compared to the no-action alternative also would be similar to but of slightly greater magnitude than those described for the proposed action, with slight beneficial effects on adjacent private property values. Although beneficial effects would occur earlier under Alternative 4 than the proposed action or Alternative 3, they would end sooner. Overall, compared to the no-action alternative, effects would be slightly beneficial. |
| **Socioeconomics and Environmental Justice<br>SOC-5: Affect Urban/Suburban Water Supply Availability and Costs** | | | |
| See SOC-1. | Effects on urban/suburban water supply availability and costs under the proposed action would consist of reduced irrigation diversions compared to the no-action alternative, particularly in dry water years. Compared to the no-action alternative, effects would be adverse. | Effects on urban/suburban water supply availability and costs under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action. However, because these effects would occur earlier in the permit term than under the proposed action, they may be of greater magnitude on average due to reduced time available to implement water conservation projects. Compared to the no-action alternative, effects would be adverse. | Effects on urban/suburban water supply availability and costs under Alternative 4 compared to the no-action alternative would be the same or nearly the same as, but of greater magnitude than, those described for the proposed action, in part due to reduced time to implement water conservation projects. Compared to the no-action alternative, effects would be adverse. |
| **Socioeconomics and Environmental Justice<br>SOC-6: Affect Hydropower Production and Energy Costs** | | | |
| See SOC-1. | Effects of hydropower production and energy costs under the proposed action compared to the no-action alternative would result from shifts in timing of hydropower production at Pelton-Round Butte and Opal Springs Dam but | Effects of hydropower production and energy costs under Alternative 3 compared to the no-action alternative would result from shifts in timing of hydropower production at Pelton-Round Butte and Opal Springs Dam and small | Effects of hydropower production and energy costs under Alternative 4 compared to the no-action alternative would result from shifts in timing of hydropower production at Pelton-Round Butte and Opal |

| Alternative 1-No Action | Alternative 2 – Proposed Action | Alternative 3 – Enhanced Variable Streamflows | Alternative 4 – Enhanced and Accelerated Variable Streamflows |
|---|---|---|---|
| | would be small and have no substantial effect on energy costs or reliability. Compared to the no-action alternative, effects would be not adverse. | effects on district hydropower generation under Alternative 3 compared to the no-action alternative would be the same or nearly the same as those described for the proposed action but would occur earlier in the permit term. Compared to the no-action alternative, effects would be not adverse. | Springs Dam and small effects on district hydropower generation under Alternative 4 compared to the no-action alternative would be the same or nearly the same, but of slightly greater magnitude than, described for the proposed action. These effects would occur earlier but for a shorter duration under Alternative 4 than under the proposed action or Alternative 3. Compared to the no-action alternative, effects would be not adverse. |
| **Socioeconomics and Environmental Justice<br>SOC-7: Change Local Government Fiscal Conditions** | | | |
| See SOC-1. | Changes in local government fiscal conditions under the proposed action would consist of decreased agricultural production value compared to the no-action alternative and may decrease agricultural property values, which may decrease agricultural property taxes. However, compared to the no-action alternative, effects would be not adverse. | Changes in local government fiscal conditions under the Alternative 3 compared to the no-action alternative would consist of decreased agricultural production value and potential associated decreases agricultural property value and property taxes would be the same as or nearly the same as those described for the proposed action. However, these effects would occur earlier in the permit term and be larger on average through the permit term due to reduced time to implement conservation measures. Compared to the no-action alternative, effects would be not adverse. | Changes in local government fiscal conditions under Alternative 4 compared to the no-action alternative would consist of decreased agricultural production value and potential associated decreases agricultural property value and property taxes under Alternative 4 compared to the no-action alternative would be the same as or nearly the same as, but slightly greater than, described for the proposed action due to reduced time to implement water conservation projects. These effects would occur earlier in the permit term than under the proposed action or Alternative 3. Compared to the no-action alternative, effects would be not adverse compared to the no-action alternative. |
| **Socioeconomics and Environmental Justice<br>SOC-8: Affect Social Values Associated with Community Character and Way of Life** | | | |
| See SOC-1. | Effects on social values associated with community character and way of life under the | Recreation-related effects on community way of life under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the | Recreation-related effects on community way of life under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the |

| Alternative 1-No Action | Alternative 2 – Proposed Action | Alternative 3 – Enhanced Variable Streamflows | Alternative 4 – Enhanced and Accelerated Variable Streamflows |
|---|---|---|---|
| | proposed action compared to the no-action alternative would be not adverse.<br>If some ranches and farms are no longer economically viable in the study area or if farms can support fewer livestock, effects on way of life of farmers and ranchers and community character under the proposed action compared to the no-action alternative could be adverse. | proposed action. Effects are considered not adverse.<br>Effects on the way of life of farmers and ranchers and community character under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action, but the potential for adverse effect is slightly greater due to the reduced time to implement conservation projects. Compared to the no-action alternative, effects could be adverse. | proposed action. Effects are considered not adverse.<br>Effects on the way of life of farmers and ranchers and community character under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action, but the potential for adverse effect is slightly greater than under the proposed action or Alternative 3 due to the reduced time to implement conservation projects. Compared to the no-action alternative, effects could be adverse. |
| **Socioeconomics and Environmental Justice**<br>**SOC-9: Affect Environmental Justice Populations** | | | |
| See SOC-1. | Due to expected adverse effects on some fishery resources (which may be partially offset by expected beneficial effects on wildlife and vegetation), an adverse effect on cultural and economic values associated with species and habitat conservation may be experienced by the tribal members (an AIAN environmental justice population) of the Confederated Tribes of the Warm Springs (and other tribes outside the study area) compared to the no-action alternative. Reduced agricultural income and employment opportunities would result in negative economic impacts on minority and low-income farmworkers, which could appreciably exceed those experienced by the general population. Therefore, effects on environmental justice populations could be disproportionally high and adverse. | Adverse effects on cultural and economic values associated with species and habitat conservation experienced by tribal members (an AIAN environmental justice population) of the Confederated Tribes of the Warm Springs (and other tribes outside the study area) under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action but would occur earlier in the permit term.<br>Effects on minority and low-income farmworkers under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action but of greater magnitude. Therefore, effects on environmental justice populations could be disproportionally high and adverse. | Adverse effects on cultural and economic values associated with species and habitat conservation experienced by tribal members (an AIAN environmental justice population) of the Confederated Tribes of the Warm Springs (and other tribes outside the study area) under Alternative 4 compared to the no-action alternative would be the same or nearly the same as those described for the proposed action but would occur earlier in the permit term than under the proposed action or Alternative 3.<br>Effects on minority and low-income farmworkers under Alternative 4 compared to the no-action alternative would be the same or nearly the same, but of greater magnitude, than those described for the proposed action or Alternative 3 due to reduced time to implement water conservation projects. Therefore, effects on environmental justice populations could be disproportionally high and adverse. |

| Alternative 1-No Action | Alternative 2 – Proposed Action | Alternative 3 – Enhanced Variable Streamflows | Alternative 4 – Enhanced and Accelerated Variable Streamflows |
|---|---|---|---|
| **Cultural Resources**<br>**CUL-1: Naturally Transport and Disturb Archaeological Materials** | | | |
| Continuation of current water management operations of Wickiup Reservoir under the no-action alternative is likely to result in continued and movement of artifacts from water level fluctuations over the analysis period. These effects could be adverse compared to existing conditions and could be intensified by more extreme water fluctuations anticipated with climate change. | Increased natural transport and disturbance of Previously recorded archaeological resources, including NRHP-eligible sites, under the proposed action compared to the no-action alternative could result in an adverse effect. | Same as the proposed action. | Same as the proposed action but any adverse effects may be of greater intensity. |
| **Cultural Resources**<br>**CUL-2: Disturb Archaeological Materials through Human Access** | | | |
| Continuation of current water management operations of Wickiup Reservoir under the no-action alternative is likely to result in continued exposure of and increased access to archaeological sites during low water that could lead to looting and disturbance over the analysis period. These effects could be adverse compared to existing conditions and could be intensified by more frequent and longer periods of low water with climate change. | Increased human access to previously recorded archaeological resources, including NRHP-eligible sites, under the proposed action compared to the no-action alternative could result in an adverse effect. | Same as the proposed action. | Same as the proposed action but any adverse effects would likely be of greater intensity. |

Chapter 1
# Purpose and Need

## 1.1 Introduction

Proposed non-federal actions that are likely to cause the incidental take of endangered and threatened species must obtain an Endangered Species Act (ESA) (16 United States Code [U.S.C.] §§ 1531–1544) Section 10(a)(1)(B) incidental take permit (ITP) from the U.S. Fish and Wildlife Service (FWS) and/or the National Marine Fisheries Service (NMFS) (referred to collectively as *the Services*) authorizing such take, or they must implement measures to avoid that take of those species to avoid violating Section 9 of ESA. As defined in ESA Section 3(19), the term ***take***[1] *means to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct."*

The Deschutes Basin Board of Control (DBBC) and City of Prineville prepared the Deschutes Basin Habitat Conservation Plan (Deschutes Basin HCP) (Deschutes Basin Board of Control and City of Prineville 2019)[2] to address incidental take of ESA-listed species likely to be caused by certain water management activities. The DBBC consists of eight irrigation districts—Arnold, Central Oregon, Lone Pine, North Unit, Ochoco, Swalley, Three Sisters, and Tumalo—that distribute waters of the Deschutes River and its tributaries (Figure 1-1). All eight districts are quasi-municipal corporations formed and operated according to Oregon State law, pursuant to which they distribute water to irrigators (patrons) within designated geographic boundaries and in accordance with water rights issued by the State of Oregon. The City of Prineville operates City-owned infrastructure and provides essential services—including public safety, municipal water supply, and sewage treatment—for more than 9,000 residents.

The following terms used in the Deschutes Basin HCP are defined briefly below and described in more detail in Chapter 2, *Proposed Action and Alternatives*.

- The ***applicants***[3] include the eight irrigation districts making up the DBBC, as well as the City of Prineville. The applicants are jointly submitting one HCP and requesting ITPs covering the nine applicants from both FWS and NMFS.
- The ***covered species*** are those species for which the applicants are seeking incidental take coverage. They include three species listed as threatened under ESA—the 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. The Oregon spotted frog and bull trout are under FWS authority, and the three other species are under NMFS authority.
- The ***covered activities*** are 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

[1] Certain terms in this EIS are defined more fully in the *Glossary* (Appendix 1-A).

[2] References for cited sources in this EIS are located in the *References Cited* (Appendix 1-B).

[3] The *applicants* here are referred to as the *permittees* in the Deschutes Basin HCP. In the context of this EIS, the applicants will become permittees when the ITPs are issued.

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.

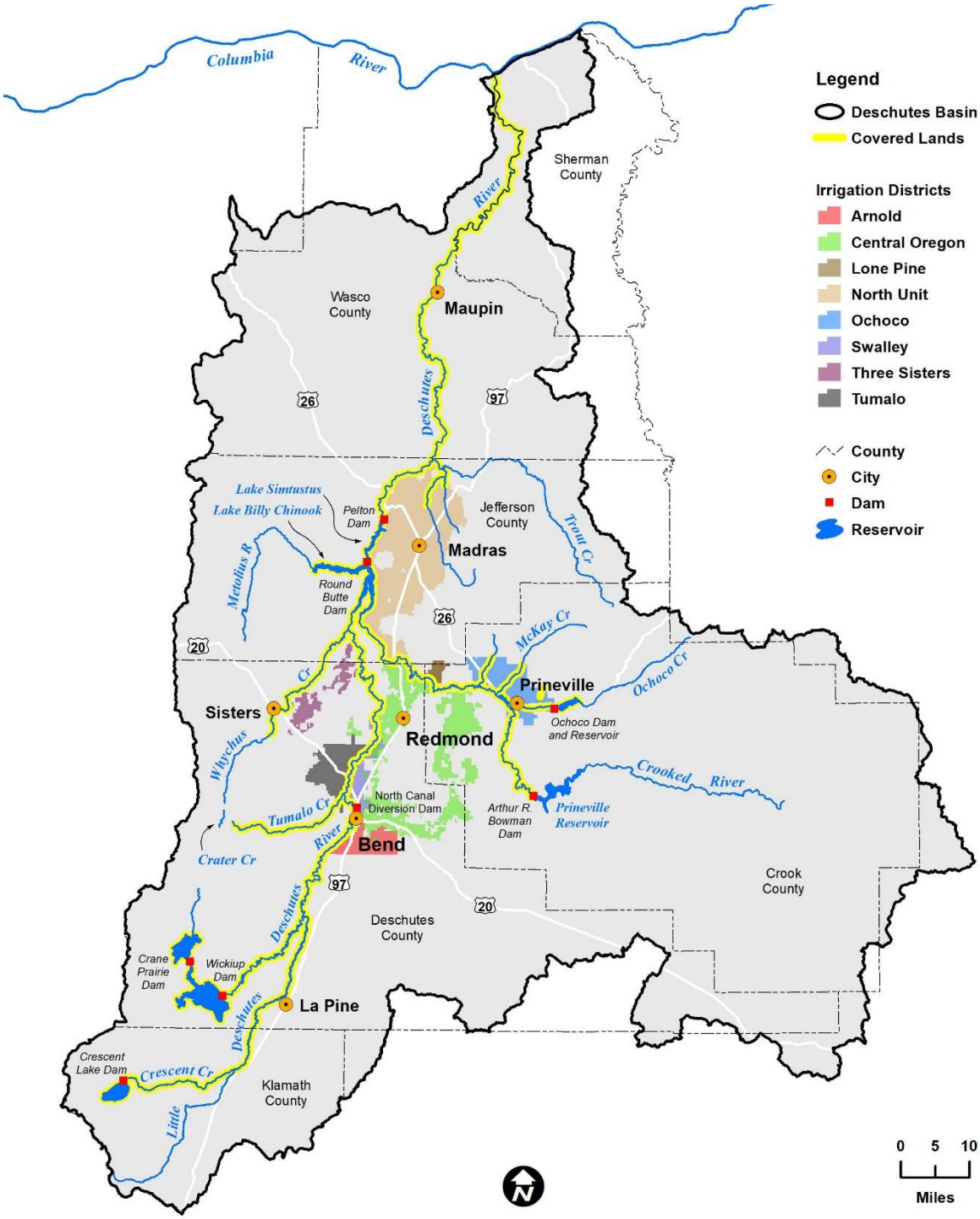
- The ***covered lands and waters*** are the specific aquatic, wetland, riparian, and floodplain habitats affected by the covered activities and where incidental take of covered species would occur (Figure 1-1).
- The ***conservation strategy*** is a series of conservation measures implemented by the 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.
- The ***permit term*** is the length of time covered by the ITPs. The permit term proposed in the Deschutes Basin HCP is 30 years.

FWS is the federal ***lead agency*** responsible for preparing this ***environmental impact statement (EIS)*** (40 Code of Federal Regulations [CFR] 1501.6). FWS prepared this EIS pursuant to the requirements of the ***National Environmental Policy Act (NEPA)*** (42 U.S.C. §§ 4321–4370 et seq.), the ***Council on Environmental Quality*** NEPA-implementing regulations (40 CFR 1500–1508), the U.S. Department of the Interior's NEPA regulations (43 CFR 46), and the FWS and NMFS *2016 Habitat Conservation and Planning and Incidental Take Permit Processing Handbook*. NMFS is a ***cooperating agency*** on this EIS. Consequently, this EIS may be used by NMFS to satisfy its NEPA requirements.

The Services will each make a decision on whether to issue ITPs to the applicants, relying on the statutory and regulatory criteria for ITPs set forth in ESA and its implementing regulations. The Services' decision will also be informed by the information, analyses and findings in this EIS. The Services will each make their decision after the public has had an opportunity to comment on draft and final[4] versions of both the EIS and HCP. To support their final permit decisions, the Services will each independently prepare an ESA Section 10 findings document and an ESA Section 7 biological opinion on the proposed ITP actions prior to issuing separate ***record of decisions (RODs)***.

[4] The federal agency is not required to respond to comments on the final HCP and EIS, but should consider them prior to making a decision.

**Figure 1-1. Covered Lands and Waters and Irrigation District Service Areas**



# 1.2 Proposed Federal Action

The proposed federal action being evaluated in this EIS is the issuance of ITPs in response to the ITP applications from the applicants. The ITPs would authorize incidental take of the covered species that could result from covered activities over the permit term.

## 1.2.1 Purpose and Need for Federal Action

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 incidental take of three species listed as threatened under ESA—the Oregon spotted frog, Middle Columbia River steelhead, and bull trout—and two nonlisted species—the spring Middle Columbia River Chinook salmon and sockeye salmon.

The need for the federal action is to respond to the applicants' request for ITPs for the covered species and covered activities as described in the Deschutes Basin HCP. The Services will review the ITP applications to determine if they meet ITP 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.

On August 30, 2019, FWS received an ITP application from the applicants for the Oregon spotted frog and the bull trout. On August 30, 2019, NMFS received an ITP application from the applicants addressing the Middle Columbia River steelhead, Middle Columbia River Chinook salmon and sockeye salmon. If the applications are approved and the Services issue ITPs, the permits would authorize the take of the covered species caused by covered activities as stipulated on the ITPs.

# 1.3 National Environmental Policy Act

NEPA serves as the nation's basic charter for determining how federal decisions affect the ***human environment***. NEPA requires that any federal agency undertaking a "major federal action" likely to "significantly affect the quality of the human environment" to prepare an EIS (42 U.S.C. § 4332). An EIS must provide a "detailed statement" of the environmental ***impacts*** of the action and reasonable ***alternatives***.

Although NEPA does not mandate a particular result, it requires the federal agency to follow specific procedures in its decision-making process. The NEPA procedures ensure that high-quality environmental information is available to public officials and citizens before decisions are made and actions are taken. The NEPA process is intended to help public officials make decisions that are based on understanding of ***environmental consequences*** and take actions that protect, restore, and enhance the environment.

The EIS process culminates in a ROD. As described above, FWS will issue a ROD documenting the agency's decision on the project; identify all alternatives considered and the environmentally preferable alternative; explain whether practicable means to avoid or minimize environmental harm from the alternative selected have been adopted and, if not, why they were not adopted; summarize monitoring requirements; and describe the mitigation program under the selected alternative that will offset the adverse impacts of the alternative on the human environment. NMFS will issue a separate ROD documenting its decision in the same manner. The issuance of ITPs by the Services is a

major federal actions subject to NEPA compliance. This EIS evaluates the potential environmental consequences associated with the issuance of the proposed ITPs, as well as the effects of alternatives, including a ***no-action alternative***, on the human environment.

# 1.4 Scope of Analysis

The analysis in this EIS is focused primarily on the direct, indirect, and ***cumulative impacts*** of the covered activities likely to cause incidental take of the covered species and the impacts associated with implementing the conservation strategy defined under the Deschutes Basin HCP. Because the covered activities consist mainly of storage and release of water that would adversely affect the covered species, and the conservation strategy consists mainly of modifications to these activities to reduce these adverse effects, the analysis focuses on resources that would be affected by changes in surface water, groundwater, and water supply. These affected resources are water quality, aquatic and terrestrial species and their habitats, land use and agricultural resources, recreation, aesthetics, cultural and tribal resources, and socioeconomics. These analyses are presented in Chapter 3, *Affected Environment and Environmental Consequences*. As discussed in Section 3.1, *Introduction*, the following elements of the human environment were excluded from detailed analysis in this EIS: transportation; air quality and greenhouse gases; noise; hazards and hazardous materials; geology, seismicity, and soils; and public services and utilities.

# 1.5 Scoping and Public Engagement

FWS initiated the public ***scoping*** process for this EIS on behalf of itself and NMFS with publication of the ***Notice of Intent (NOI)*** to prepare an EIS in the *Federal Register* (FR) on July 21, 2017 (82 FR 6625). The NOI announced the FWS' intent to prepare an EIS, provided the details on four public meetings, and requested comments from all interested parties on the ***scope*** of issues and alternatives to consider in preparing the EIS. A copy of the NOI is included in Appendix 1-C, *Scoping Report.* FWS hosted two scoping meetings on August 14, 2017, in Madras, Oregon, and two scoping meetings on August 15, 2017, in Bend, Oregon. The *Scoping Report* (Appendix 1-C) summarizes comments received during the scoping period, which were considered in developing this EIS.

In addition, FWS conducted stakeholders update meetings on December 13, 2018, and September 11, 2019, to provide updates on the EIS status and development and to respond to questions related to the EIS process and content.

# 1.6 NEPA Cooperating Agencies

The following entities are NEPA cooperating agencies for this EIS. Each signed a memorandum of understanding identifying the terms of their cooperation with FWS.

- 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
- Confederated Tribes of Warm Springs

FWS conducted cooperating agencies meetings on November 1, 2018, and September 11, 2019, to facilitate input for and understanding of the EIS contents.

# 1.7 Tribal Consultation

FWS initiated government-to-government consultation with the Confederated Tribes of the Warm Springs prior to the NEPA scoping process. Through monthly government-to-government meetings FWS requested tribal involvement, information, and review of materials. These meetings commenced in May 2016 and are ongoing.

# 1.8 Draft EIS Public Comment Period

On October 4, 2019, the notice of availability of Draft EIS was published in the *Federal Register* for public review in accordance with requirements set forth in NEPA (42 U.S.C. 4321 et seq.) and its implementing regulations (40 CFR 1500–1508). The HCP was concurrently released for public review and comment. Public comments will be accepted during a 45-day period following publication of the Federal Register Notice of Availability. Two public meetings will be held—one in Bend and one in Prineville—during the comment period. Comments received will be considered and addressed in the Final EIS.

# Chapter 2
# Proposed Action and Alternatives

This chapter describes the alternatives that are analyzed in this EIS. NEPA requires a comparative evaluation of a reasonable range of alternatives that provides a clear basis for choice of an alternative (40 Code of Federal Regulations [CFR] 1502.14). For this EIS, the Services initially considered 15 alternatives in a structured screening process, in addition to the no-action alternative and the proposed Deschutes Basin HCP (***proposed action***). This screening process resulted in four alternatives being selected for evaluation in the EIS.

Water management in the Deschutes Basin is performed by federal and non-federal entities. On the federal side, the Bureau of Reclamation (Reclamation) approves water management contracts, performs dam safety inspections, and implements the Crooked River Act of 2014 and other related actions. On the non-federal side, the eight applicant irrigation districts manage the storage, delivery, diversion and return of irrigation water. Portions of Reclamation's underlying federal actions are identified in this chapter for the purpose of explaining how the federal and non-federal water management activities complement one another to provide the public with the full description of water management activities in the Deschutes Basin. Reclamation's federal actions will be analyzed through the ESA Section 7 interagency consultation process, resulting in both of the Services issuing biological opinions (BiOps) prior to making final incidental take permit (ITP) decisions.

## 2.1 Alternatives Analyzed in the EIS

This section provides a description of the four alternatives considered in detail in this EIS.

- Alternative 1: No Action
- Alternative 2: Proposed Action
- Alternative 3: Enhanced Variable Streamflows
- Alternative 4: Enhanced and Accelerated Variable Streamflows

Objective evaluation of these alternatives satisfies the requirements of NEPA to consider a reasonable range of alternatives that are technically and economically practicable and feasible, that avoid or reduce environmental effects, and that meet the purpose and need for the federal action as described in Chapter 1, *Purpose and Need*. The alternatives evaluated in this EIS were informed by discussions with the applicants, public comments received during the scoping period, and discussions with and comments from the cooperating agencies. Appendix 1-C, *Scoping Report*, provides a summary of the EIS scoping process and comments received. Section 2.3, *Alternatives Considered but Eliminated from Further Consideration*, and Appendix 2-A, *EIS Alternatives Screening Process,* provide further information on the alternatives screening process and results.

### 2.1.1 Alternative 1: No Action

Council on Environmental Quality regulations for implementing NEPA require that an EIS include evaluation of a no-action alternative (40 CFR 1502.14). The no-action alternative may be described as the future circumstances without the proposed action. It can include predictable actions by

persons or entities other than the federal agencies involved in a project action acting in accordance with current management direction or level of management intensity. When a proposed action involves updating an adopted management plan or program, the no-action alternative assumes the continuation of the existing management plan or program. The no-action alternative considered in this EIS assumes continuation of the actions covered in the current ESA Section 7 Biological Opinion for the Upper Deschutes River to address take of Oregon spotted frog (U.S. Fish and Wildlife Service 2017, 2019), referred to in this EIS as the *Deschutes Project BiOp*; the actions covered in the current BiOp for the Deschutes River Basin Projects to address take of Middle Columbia River steelhead trout (National Marine Fisheries Service 2005); and other predictable current and future conditions described below.

Guidance from the Services' HCP Handbook provides that the no-action alternative for an HCP EIS should be a condition in which no-take of covered species occurs. As explained in Appendix 2-A, *EIS Alternatives Screening Process,* a no-take approach for the no-action alternative is not feasible for this EIS because no take of covered species in the context of ongoing water facility operations does not appear to be physically possible given the highly degraded baseline condition where historical flows can no longer inundate wetland habitats for the covered species consistent with their full life history needs. Further, attempts to achieve as close to no take as possible would likely involve substantial reduction, or perhaps near elimination, of Deschutes Basin water supply operations. Such a future condition is not considered feasible because of the probable economic and legal implications of such an action, as described further in Appendix 2-A.

It is important to recognize that the no-action alternative is a point of comparison for the purposes of determining impacts of the federal action on the human environment under NEPA (46 FR 18026 [March 23, 1981]). It is not intended to dictate to applicants what they should do if an ITP is not approved. The no-action alternative, as defined in this EIS, is considered the most predictable condition to assume, for purposes of NEPA analysis, given considerable uncertainty about what actions the applicants would take in the absence of the proposed action over the next 30 years.

For example, under the no-action alternative analyzed in this EIS, the Services would take no action. No ITPs for the Deschutes Basin HCP would be issued, and the applicants would remain subject to the take prohibition for listed species under the Endangered Species Act (ESA). Ongoing applicant activities or future actions that may result in the incidental take of federally listed species would need to be authorized through ESA Section 7 where possible, as is the case now where a subset of the applicants are operating under a BiOp for ESA coverage, or through separate project-by-project ITP applications submitted by each applicant under Section 10. Specific potential actions that could be taken by the applicants under separate ITP applications are unknown, and a no-action alternative that assumes no take of covered species is not considered feasible (see Section 2.3, *Alternatives Considered but Eliminated from Further Consideration*, and Appendix 2-A).

It should be noted that defining a no-action alternative for ongoing actions can be very difficult. As discussed above, crafting a no-take alternative for water management in the ***Upper Deschutes Basin*** as the no-action alternative is not feasible; also, the applicants' current water management operations do not represent no take. FWS has no evidence that the applicants plan or intend to operate differently from the actions covered by the Deschutes Project BiOp. Although no party intends for these actions to continue for the 30-year period of analysis that this EIS covers and the BiOp expires on December 31, 2019, FWS considers it reasonable to assume continuation of the BiOp under the no-action alternative because the applicants are currently operating under these conditions and they provide a known and reasonable baseline against which to compare the

proposed action and alternatives for purposes of the NEPA analyses. This conclusion is supported by the following.

- The proposed action described in the Deschutes Project BiOp for Crane Prairie, Wickiup, and Crescent Lake Reservoirs and instream flows downstream of the reservoirs are currently being implemented as an interim step to implementing the Deschutes Basin HCP. Thus, the proposed action described in the Deschutes Project BiOp represents what is actually and currently happening on the ground.
- The proposed action described in the Deschutes Project BiOp was designed based on the *Oregon Spotted Frog Settlement Agreement* (filed November 9, 2016), which requires enhanced instream winter flows, compared to historical flows.
- The proposed action described in the Deschutes Project BiOp is an existing management approach that has been approved and that is based on a rigorous formal consultation under ESA Section 7, and the resulting take of those actions are lawfully exempted by the incidental take statement (ITS) that accompanies the Deschutes Project BiOp.
- Alternatives 3 and 4 provide were designed to provide further reduction of take (greater covered species conservation) than achieved under the proposed action.
- Other potential assumptions for long-term water management operations are considered speculative if they have not been formally proposed or implemented prior to this EIS.

For the purpose of analysis, the no-action alternative considered the following:

- Existing water management operations as of the date of the Notice of Intent (July 21, 2017) as described in Table 2-1.
- Ongoing programs adopted before or during the early stages of development of the EIS.
- Relevant projects that were permitted or under construction during the early stages of development of the EIS.
- Relevant projects and programs that have been completed or for which environmental review has been completed and that therefore are assumed to be implemented during the 30-year permit term for the proposed Deschutes Basin HCP.[1]

Specific no-action alternative assumptions are as follows.

- Continuation of the federal action (inclusive of interrelated and interdependent activities) addressed in the Deschutes Project BiOp.
    - Continuation of the principal components of the proposed action described in the Deschutes Project BiOp, which include changes to water management operations associated with the Crane Prairie, Wickiup, and Crescent Lake Reservoirs. Specifically, two actions are aimed at benefiting the Oregon spotted frog: (1) increase minimum instream flows in the Deschutes River, Crescent Creek, and portions of the Little Deschutes River and (2) increase the period of inundation of wetlands adjoining Crane Prairie Reservoir (Table 2-1).
    - Continued implementation of the reasonable and prudent measures and the terms and conditions identified in the ITS accompanying the Deschutes Project BiOp. These measures

[1] Projects for which draft NEPA or other review has been completed or which are currently being permitted were considered to be reasonably certain to be implemented.

involve conducting hydrological and biological monitoring, implementing adaptive management, increasing winter flows in the Deschutes River where feasible, coordinating with the Oregon Water Resources Department and FWS during certain operating periods, and preparing and submitting annual reports.

  - Contractual changes needed to implement the ITS requirements, including federal contracting actions needed to implement reservoir operation changes and monitoring conducted by Reclamation or the irrigation districts to evaluate the efficacy of the ITS requirements at achieving its conservation goals.

- Continuation of the February 17, 2005, BiOp between Reclamation and National Marine Fisheries Service (NMFS) to address incidental take of steelhead from the activities covered by the 2005 BiOp.
- Reclamation's continued release of uncontracted fish and wildlife water storage from Prineville Reservoir and from City of Prineville mitigation storage into the Crooked River as directed under the Crooked River Collaborative Water Security and Jobs Act of 2014 (Table 2-1).
- Continuation of the Deschutes River Conservancy/North Unit Water Supply Program on the Crooked River (Table 2-1).
- For all other water supply operations not stated in Table 2-1, continuation of current operations and maintenance of storage reservoirs, diversions, pumps, and conveyance facilities in the Deschutes Basin.
- Physical inspections, tests, and maintenance of dams that require short-term changes in dam operations administered under Reclamation's Review of Operations and Maintenance and Safety Evaluations of Existing Dams programs. Activities are coordinated to minimize adverse effects on the Oregon spotted frog and ESA-listed fish.
- District water conservation projects (i.e., canal piping) that have been completed or for which NEPA review has been completed (refer to Appendix 2-B, *No-Action and Cumulative Scenarios,* for details).
  - Tumalo Irrigation District (ID) Irrigation Modernization Project
  - Swalley ID Irrigation Modernization Project
- Operation of fish passage facilities at Opal Springs Dam on the Crooked River (Appendix 2-B).
- River restoration projects including physical habitat restoration, streamflow augmentation, and water leasing actions (refer to Appendix 2-B for list of projects considered).
- Climate change and related effects.
- Continued population growth and development in the basin (refer to Appendix 2-B for assumptions).

The water management operations assumed under the no-action alternative are summarized in Table 2-1. The water management operations described in the Deschutes Project BiOp identify minimum and maximum reservoir volumes, seasonal minimum instream flows, and ramping rates for storage and flow increases or decreases.

**Table 2-1. Water Management Operations Assumptions for No-Action Alternative**

| Reservoir or Stream | Operations Assumptions for No-Action Alternative |
|---|---|
| **Deschutes Project Biological Opinion** | |
| Crane Prairie Reservoir | • Maintain reservoir storage generally between 35,000 af (elevation 4,440.6 af msl) and 50,000 af (elevation 4,443.9 feet msl).<br>• Stop release of stored water during the irrigation season when volume drops to 35,000 af except when inflow is less than the combination of evaporation, seepage, and minimum instream flow targets downstream of Crane Prairie Dam.<br>• Store up to 50,000 af except for short durations to address flood events.<br>• Operate reservoir to attain at least 45,000 af by March 15 (of each year) and minimize reservoir fluctuation between March 15 and May 1. Between May 1 and May 15, if Wickiup Reservoir holds 180,000 af or more, store additional water in Crane Prairie Reservoir up to 50,000 af.<br>• Operate reservoir to minimize fluctuations in water depth between May 15 and July 15 with no stored water released before July 15.<br>• Operate reservoir from July 16 to July 31 to release water stored in excess of 35,000 af at a rate of no more than 0.5 foot per day.<br>• Operate reservoir after July 31 to release storage at a rate of no more than 0.1 foot per day until irrigation demand is met or reservoir volume reaches 35,000 af, whichever occurs first. |
| Deschutes River downstream of Crane Prairie Dam to Wickiup Reservoir | • When consistent with management above, maintain minimum instream flows of 100 cfs in the Deschutes River downstream of Crane Prairie dam from January through August, 75 cfs from September through December, and maximum flows of 400 cfs year-round. |
| Wickiup Reservoir and Deschutes River downstream of Wickiup Dam | • Operate reservoir to provide minimum instream flows of 600 cfs (WICO gauge) from March 31 through September 15 and 100 cfs from September 16 through March 30.<br>• Operate reservoir to provide maximum instream flow (WICO gauge) of 800 cfs until April 15; from March 31 through April 30 flow can increase but not decrease.<br>• When flow is at or below 800 cfs, increase flow no more than 0.1 foot per 4-hour period and decrease flow no more than 0.2 foot per 12-hour period. |
| Crescent Lake Reservoir and Crescent Creek | • Operate reservoir to provide minimum instream flow in Crescent Creek of 30 cfs (CREO gauge) from March 15 through November 30 and 20 cfs from December 1 through March 14.<br>• Increase ramping rates to no more than 30 cfs per day (+/- 2 cfs) and decrease rates to no more than 20 cfs per 2-day period (+/- 2 cfs).<br>• Ramp down releases no earlier than September 1 and no later than October 31. |

| Reservoir or Stream | Operations Assumptions for No-Action Alternative |
|---|---|
| **Crooked River Act Actions Carried out by Reclamation** | |
| Crooked River | Release of uncontracted fish and wildlife water storage and City of Prineville mitigation storage in Prineville Reservoir for flow into the Crooked River when such storage is available, per the Crooked River Act, summarized below.<br>• Releases uncontracted, stored water to benefit downstream fish and wildlife. All such releases pursuant to an annual release schedule to be developed by the Reclamation in coordination with the Services.<br>• The first fill protection is subject to compliance with the U.S. Army Corps of Engineers' flood curve requirements and the prior 10 cubic foot per second release to benefit fish and wildlife. The annual first fill protection extends to:<br>○ 68,273 af of water to fulfill 16 existing Reclamation water supply contracts;<br>○ 2,740 af of water to supply certain McKay Creek lands;<br>○ 10,000 af of water made available to North Unit ID (or certain other Reclamation contractors) under temporary water service contracts; and<br>○ 5,100 af of water made available to the City of Prineville via Reclamation water service contract. |
| **Deschutes River Conservancy/North Unit Water Supply Program on the Crooked River** | |
| Crooked River | • Continuation of the Deschutes River Conservancy/North Unit Water Supply Program to maintain specified minimum flows immediately downstream of the North Unit ID pumps on the Crooked River whenever the pumps are operating and water is being diverted. This agreement was certificated by OWRD in 2012. The goal of this program is to restore streamflow in the low flow section below RM 28 that runs through Smith Rock State Park. |

Sources: Deschutes Project Biological Opinion (U.S. Fish and Wildlife Service 2017, 2019); Crooked River Collaborative Water Security and Jobs Act of 2014; North Unit Irrigation District and Deschutes River Conservancy 2012.

af = acre-feet; msl = mean sea level; cfs = cubic feet per second; Reclamation = Bureau of Reclamation; ID = irrigation district; OWRD = Oregon Water Resources Department; RM = river mile.

## 2.1.2 Alternative 2: Proposed Action

Under the proposed action, each of the Services would issue a 30-year ITP to the applicants for incidental take of each agency's respective covered species likely to be caused by covered activities in the Deschutes Basin. The applicants would implement the Deschutes Basin HCP,[2] summarized in this section.

### 2.1.2.1 Deschutes River Basin and Covered Lands and Waters

The Deschutes River Basin (or Deschutes Basin) is a 10,700-square-mile area that encompasses the Deschutes River and its tributary watersheds to its confluence with the Columbia River. The specific area in which the ITPs would apply and the proposed action would be implemented is limited to narrow corridors of covered river and stream segments and covered reservoirs and diversion structures, and connected floodplains and wetlands that could be affected by changes in operation and maintenance of covered facilities (Figure 1-1). See Chapter 3 of the Draft Deschutes Basin HCP, *Scope of the HCP,* for details on the covered lands and waters.

[2] Available: https://www.fws.gov/Oregonfwo/articles.cfm?id=149489716.

### 2.1.2.2 Covered Activities

The covered activities, summarized in this section and described in detail in Chapter 3 of the Draft Deschutes Basin HCP, 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; and groundwater withdrawals and effluent discharges.[3] Post-diversion 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.

#### Operation and Maintenance of Storage Dams and Reservoirs

The applicants operate and maintain four covered dams and reservoirs: two owned by the federal government and administered by Reclamation and two owned by applicants (Table 2-2). The Deschutes Basin HCP does not cover Bowman Dam and Prineville Reservoir on the Crooked River because they are reserved federal facilities.[4] As such, the operation and maintenance of Bowman Dam will receive incidental take coverage through ESA Section 7 consultation between Reclamation and the Services. However, potential effects of the covered activities and conservation measures on Prineville Reservoir are still addressed in this EIS. Figure 1-1 shows the locations of the covered dams and reservoirs in the Deschutes Basin as well as Prineville Reservoir and Bowman Dam. These dams and reservoirs are generally operated to store irrigation water during the winter months for agricultural use in the applicants' service areas during the spring and summer. In some cases, reservoirs are also authorized for flood protection.

**Table 2-2. Covered Storage Reservoirs and Dams**

| Facility | Surface Water | Ownership | Operation and Maintenance | Description |
|---|---|---|---|---|
| Crane Prairie Dam and Reservoir | Deschutes River | Reclamation | Central Oregon ID (transferred work)[a] | In-channel facility to store water for Central Oregon, Arnold, Lone Pine, and North Unit IDs |
| Wickiup Dam, East Dike, South Dike, and Reservoir | Deschutes River | Reclamation | North Unit ID (transferred work)[a] | In-channel facility to store water for North Unit ID |
| Ochoco Dam and Reservoir | Ochoco Creek | Ochoco ID | Ochoco ID | In-channel facility to store irrigation water for Ochoco ID and provide flood control |
| Crescent Lake Dam and Reservoir | Crescent Creek | Tumalo ID | Tumalo ID | In-channel facility to store water for Tumalo ID |

Reclamation = Bureau of Reclamation; ID = Irrigation District.

[a] Transferred works are facilities for which daily responsibilities for operation and maintenance activities have been transferred to and are financed by the irrigation district.

[3] The ITPs also authorize any take that may result from implementation of the HCP conservation strategy (see Section 2.1.2.4, *Conservation Strategy*).

[4] Reclamation retains responsibility for operation and maintenance of Bowman Dam/Prineville Reservoir as a reserved federal facility. Ochoco ID operates Bowman Dam under contract with Reclamation, but Reclamation retains administrative and financial responsibility for the facility.

## Operation and Maintenance of Diversions, Pumps, and Intakes

The applicants own, operate, and maintain 25 covered water supply diversion structures, pumps, and intakes used for diversion of irrigation water by the applicants and their patrons. The covered activities associated with these facilities are described by the applicants as follows:

- Arnold ID diverts live flow and Crane Prairie Reservoir storage water at the Arnold Diversion and Headworks and six patron diversions on the Deschutes River.
- Central Oregon ID diverts live flow and Crane Prairie Reservoir storage water at the Central Oregon Canal Headworks, Pilot Butte Canal Headworks, and 10 patron diversions on the Deschutes River.
- North Unit ID diverts live flow and Wickiup Reservoir storage water at North Unit Headworks (at North Canal Diversion Dam) and Crooked River Pumping Plant on the Deschutes River and Crooked River, respectively.
- Ochoco ID diverts Crooked River live flow and Prineville Reservoir storage at Crooked River Diversion and 34 patron diversions. The ID diverts Ochoco Creek live flow and Ochoco Reservoir storage at Ochoco Main Canal, Red Granary Diversion, Breese Diversion, North and South Infiltration Galleries, Ryegrass Diversion and 33 patron pumps on Ochoco Creek. The district also diverts water at multiple locations on Johnson Creek, Dry Creek, McKay Creek, and Lytle Creek.
- Swalley ID diverts live flow at Swalley Headworks and 19 patron diversions on the Deschutes River.
- Three Sisters ID diverts live flow at Whychus Creek Diversion Headworks and one patron diversion on Whychus Creek.
- Tumalo ID diverts live flow and Crescent Lake Reservoir storage at Bend Diversion and Headworks on the Deschutes River, and live flow from diversions on Tumalo Creek, Crater Creek, Little Crater Creek, and Soda Creek.
- The City of Prineville diverts live flow from up to seven diversions on the Crooked River and one diversion on Ochoco Creek.

See Chapter 3 of the Draft Deschutes Basin HCP, Table 3-3 for an overview of the covered diversion structures.

## Water Diversions

Water diversion by the applicants is a covered activity. Most of the applicants divert a combination of in-channel reservoir storage and live streamflow, but one (Three Sisters ID) relies on out-of-channel storage (water storage facilities located outside an existing stream channel) and live streamflow, and one (Swalley ID) relies entirely on live streamflow. The amount of water diverted by each of the applicants is determined by the amount of water available for irrigation, the applicants' water rights, operations constraints of the conveyance system, and local demands. Water delivery of agricultural irrigation typically starts in April and ends in October. Annual diversion rates are highly variable. From November through March, intermittent live flow diversions from the river, which are conducted by only some districts, are smaller than irrigation diversions and are used for livestock water.

### Return Flow

Return flow, or water delivered from covered facilities that is allowed to flow back into a river or creek, is a covered activity. Return flow can be either tailwater or spill return flow. ***Tailwater*** is water that has been applied to irrigated lands and subsequently allowed to return to a river or creek through surface or groundwater flow. ***Spill return flow*** is diverted irrigation water that is returned to a river or creek without being applied to irrigated lands. Spill return flow is typically used to manage canal flow, during emergencies, or at the end of the irrigation season. The amount of spill return flow varies by delivery facility.

### Groundwater Withdrawals and Effluent Discharges

Current and projected future groundwater withdrawals and effluent discharges by the City of Prineville are covered activities. Please refer to Chapter 3 of the Draft Deschutes Basin HCP for further details.

## 2.1.2.3 Covered Species

The ITPs that would be issued to the applicants apply to three species listed as threatened under the ESA and two species that currently have no formal ESA status (Table 2-3). These five species are collectively referred to as the ***covered species***. The FWS ITP would cover Oregon spotted frog and bull trout; the NMFS ITP would cover the steelhead, Chinook salmon, and sockeye salmon.

**Table 2-3. Covered Species under the Deschutes Basin HCP**

| | | Listing Status | | |
|---|---|---|---|---|
| **Scientific Name** | **Common Name** | **Federal Status** | **Federal Authority** | **State Status** |
| *Rana pretiosa* | Oregon spotted frog | Threatened | FWS | Sensitive |
| *Salvelinus confluentus* | Bull trout | Threatened | FWS | Sensitive |
| *Oncorhynchus mykiss* | Steelhead, Middle Columbia River distinct population segment | Threatened[a] | NMFS | Sensitive |
| *Oncorhynchus tshawytscha* | Chinook salmon, Middle Columbia River evolutionarily significant unit, spring | None | NMFS | Sensitive |
| *Oncorhynchus nerka* | Sockeye salmon/Kokanee | None | NMFS | None |

[a] Steelhead trout is currently listed as threatened only downstream of the Pelton Round Butte Project. This limitation expires in January 2025 when the entire range of the distinct population segment will be listed as threatened.

FWS = U.S. Fish and Wildlife Service; NMFS = National Marine Fisheries Service

## 2.1.2.4 Conservation Strategy

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 and mitigate (i.e., offset) the adverse effects of covered activities that can result in the take of the covered species. The conservation measures are intended to address the effects of take on the covered species. Proposed conservation measures include actions that would change the timing and volume of water released from covered reservoirs and streamflow in covered rivers and creeks. Table 2-4

summarizes these conservation measures. Detailed descriptions of the conservation measures are provided in Chapter 6 of the Draft Deschutes Basin HCP, *Habitat Conservation*.

The conservation strategy also provides an adaptive management and monitoring program to ensure that it is achieving the intended benefits to the covered species.

**Table 2-4. Proposed Action Conservation Measures**

| Conservation Measure | Primary Focus |
|---|---|
| **Upper and Middle Deschutes River** | |
| CP-1: Crane Prairie Reservoir Operation | Adjusts the range and timing of reservoir storage and drawdown rate to improve habitat conditions for Oregon spotted frog. Establishes a recommended minimum instream flow of 75 cfs in the Deschutes River below Crane Prairie Dam. |
| WR-1: Wickiup Reservoir Operation | Adjusts the timing and volume of flow in the Deschutes River below Wickiup Dam based on annual coordination by FWS, North Unit ID, and the OWRD to regulate flows during spring months, increase minimum flows during fall and winter months per the schedule below, decrease flows during summer months, and limit ramp down rates at the end of the irrigation season.<br>Fall and winter (September 16–March 31) minimum flow schedule:<br>• 1–5 years: 100 cfs<br>• 6–10 years: 200 cfs<br>• 11–20 years: 300 cfs<br>• 21–30 years: 400 cfs<br>Fall and winter minimum flow targets could be greater than these minimum flow targets based on monthly fall and winter coordination of FWS, North Unit ID, and OWRD to assess available annual surplus fall storage in Crane Prairie and Wickiup Reservoirs and precipitation forecasts. Refer to Chapter 6 of the Draft Deschutes Basin HCP, Conservation Measure WR-1 for a detailed description of the annual flow decision-making process. |
| DR-1: Middle Deschutes River Flow Outside of the Irrigation Season | Provides for coordinated livestock diversions from November through March to prevent diversions from resulting in a flow of less than 250 cfs in the Middle Deschutes River. |
| **Crescent Creek and Little Deschutes River** | |
| CC-1: Minimum Instream Flow below Crescent Dam | Provides for minimum flow of at least 20 cfs below Crescent Dam provided there is sufficient inflow and storage in Crescent Lake Reservoir to support minimum flows. |
| CC-2: Crescent Dam Ramping Rates | Restricts the rate of flow increases and decreases below Crescent Dam. |
| CC-3: Crescent Lake Reservoir Irrigation Release Season | Limits the period for ramp down of irrigation releases from Crescent Dam to September 1–October 31 unless an earlier ramp down period is needed to protect infrastructure, avoid draining down the reservoir or for emergencies. |

| Conservation Measure | Primary Focus |
|---|---|
| **Whychus Creek** | |
| WC-1: Whychus Creek Instream Flows | Provides an additional 3 cfs in Whychus Creek for permanent instream use no later than 5 years following issuance of ITPs (for a total minimum instream flow of 31.8 cfs). |
| WC-2: Whychus Creek Temporary Instream Leasing | Provides $6,000 per year to fund temporary instream flow leasing during drought years and/or habitat restoration work. This amount will be adjusted annually for inflation. The fund may be used for activities that complement the HCP conservation measures, for restoration and/or habitat maintenance activities, in-stream leasing and/or to benefit the covered species within the Deschutes River.[a] Leasing would likely be administered by the Deschutes River Conservancy or a similar entity. |
| WC -3: Whychus Creek Diversion Fish Screens and Fish Passage | Provides for maintenance and operation of fish screens at the Three Sisters ID Whychus Creek diversion to meet NMFS downstream migrant fish screen criteria. |
| WC-4: Piping of Patron Laterals | Provides for Three Sisters ID assistance piping the remaining 11 miles of patron laterals within 15 years of issuance of ITPs. |
| WC-5: Whychus Creek Diversion Ramping Rate | Provides for diversion at the Whychus Creek intake to be increased or decreased no more than 10 cfs per hour when flows below the Three Sisters ID diversion are 50 cfs or less. |
| **Crooked River, Ochoco Creek, and McKay Creek** | |
| CR-1: Crooked River Flow Downstream of Bowman Dam | Supplements releases of uncontracted and City of Prineville mitigation storage required under the Crooked River Act when such flows are not available to meet the 50 cfs minimum flow during storage season. The supplemental flow to meet 50 cfs would be met through Ochoco ID bypass live flow or releasing its contracted storage from Prineville Reservoir. |
| CR-2: Ochoco Creek Flow | Provides for release of additional flow from the Ochoco Main Canal to contribute to flow increases in Ochoco Creek during the irrigation season and non-irrigation season subject to limitations. |
| CR-3: McKay Creek Flow | Provides for release of increased flow into McKay Creek during the active irrigation season. Outside the active irrigation season McKay Creek will be allowed to flow without diversion by Ochoco ID or its patrons. |
| CR-4: Crooked River Conservation Fund | Provides $8,000 annually for the Crooked River Conservation Fund to support conservation measures and benefit covered species in the Crooked River subbasin.[a] |
| CR-5: Screening of Diversion Structures | Provides for maintenance and operation of fish screens to prevent entrainment of juvenile salmonids on all Ochoco ID-controlled diversions and provides funding for screening Ochoco ID patron diversions. |

| Conservation Measure | Primary Focus |
|---|---|
| CR-6: Crooked River Flow Downstream of the Crooked River Pumps | North Unit ID will maintain flows below the Crooked River pumps required by the April 12, 2012, *Agreement Between NUID and DRC Regarding Minimum Instream Flows in the Crooked River* (NUID-DRC Agreement) and as described in Chapter 6 of the Draft Deschutes Basin HCP for Conservation Measure CR-6. From the first day of the permit term through December 31, 2024, the daily average flows (at OWRD Gauge 14087300) shall be no less than the minimums specified in CR-6, but the hourly average flows may be up to 20% less than the specified minimums. Starting on January 1, 2025, and continuing for the remainder of the permit term, daily average and hourly average flows shall both be no less than the specified minimums. |

Source: Deschutes Basin Board of Control and City of Prineville 2019.

cfs = cubic feet per second; ITP = incidental take permit; ID = Irrigation District; NMFS = National Marine Fisheries Service; OWRD = Oregon Water Resources Department.

[a] Use of the fund will be governed by an implementation committee established as the entity holding the funds. The Services will be members of the implementation committee. Funds may be used for instream leasing, habitat restoration and/or enhancement projects, or other projects that benefit the covered species.

### 2.1.3 Alternative 3: Enhanced Variable Streamflows

Under Alternative 3, the Services would issue 30-year ITPs to the applicants for incidental take of each agency's respective covered species likely to be caused by the covered activities in the Deschutes Basin. The applicants would implement the Deschutes Basin HCP, as described for the proposed action, but with modifications to the conservation strategy presented in Table 2-5. These modifications would increase fall and winter flows in the Deschutes River below Wickiup Dam sooner than under the proposed action, target higher minimum flows during above-normal and wet years, add an Upper Deschutes River Conservation Fund, provide improved certainty of flows at North Unit ID's Crooked River pumping plant, and protect uncontracted fish and wildlife 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.

**Table 2-5. Alternative 3 Conservation Measures**

| Conservation Measure | Primary Focus |
|---|---|
| **Upper and Middle Deschutes River** | |
| CP-1: Crane Prairie Reservoir Operation | *Same as proposed action*. |
| WR-1: Wickiup Reservoir Operation | Adjusts the timing and volume of flow in the Deschutes River below Wickiup Dam based on annual coordination by FWS, OWRD, and North Unit ID to regulate flows during spring months, increases minimum flows during fall and winter months per the schedule below, decrease flows during summer months, and limits ramp down rates at the end of the irrigation season.<br>Fall and winter (September 16–March 31) minimum flow schedule:<br>• 1–5 years: 200 cfs<br>• 6–10 years: 300 cfs<br>• 11–30 years: 400–500 cfs<br>Fall and winter minimum flow targets could be greater than these minimum flows, based on monthly fall and winter coordination of FWS, OWRD, and North Unit ID to assess available annual surplus fall storage in Crane Prairie and Wickiup Reservoirs and precipitation forecasts. Annual coordination will target providing greater than minimum flows during above-normal and wet years. |
| DR-1: Middle Deschutes River Flow Outside of the Irrigation Season | *Same as proposed action*. |
| DR-2: Upper Deschutes River Conservation Fund | Within 6 months of issuance of issuance of ITPs, and no later than March 1 of each year thereafter for the term of the permits, North Unit, Central Oregon, Arnold, Tumalo, Lone Pine and Swalley IDs will contribute a combined total of $150,000 annually to the Upper Deschutes River Conservation Fund. This amount will be adjusted annually for inflation. The fund may be used for activities that complement the HCP conservation measures, for restoration and/or habitat maintenance activities, in-stream leasing and/or to benefit the covered species within the Deschutes River.[a] Refer to Appendix 2-C, *Rationale for Oregon Spotted Frog Conservation Fund*, for more information. |
| **Crescent Creek and Little Deschutes River** | |
| CC-1: Minimum Instream Flow below Crescent Dam | *Same as proposed action*. |
| CC-2: Crescent Dam Ramping Rates | *Same as proposed action*. |
| CC-3: Crescent Lake Reservoir Irrigation Release Season | *Same as proposed action*. |
| **Whychus Creek** | |
| WC -1: Whychus Creek Instream Flows | *Same as proposed action*. |
| WC-2: Whychus Creek Temporary Instream Leasing | *Same as proposed action*. |

| Conservation Measure | Primary Focus |
|---|---|
| WC -3: Whychus Creek Diversion Fish Screens and Fish Passage | *Same as proposed action*. |
| WC-4: Piping of Patron Laterals | *Same as proposed action*. |
| WC-5: Whychus Creek Diversion Ramping Rate | *Same as proposed action*. |
| **Crooked River, Ochoco Creek, and McKay Creek** | |
| CR-1: Crooked River Flow Downstream of Bowman Dam | Same as proposed action but provides for instream protection of the uncontracted (fish and wildlife) releases from Bowman Dam to Lake Billy Chinook. |
| CR-2: Ochoco Creek Flow | *Same as proposed action*. |
| CR-3: McKay Creek Flow | *Same as proposed action*. |
| CR-4: Crooked River Conservation Fund | *Same as proposed action*. |
| CR-5 Screening of Diversion Structures | *Same as proposed action*. |
| CR-6: Crooked River Flow Downstream of the Crooked River Pumps | *Same as proposed action.* |

Source: Deschutes Basin Board of Control and City of Prineville 2019.
cfs = cubic feet per second; ITP = incidental take permit; ID = Irrigation District; NMFS = National Marine Fisheries Service; OWRD = Oregon Water Resources Department; SCADA = Supervisory Control and Data Acquisition; PCL = Programmable Logic Controller.

[a] Use of the fund will be governed by an implementation committee established as the entity holding the funds. The Services will be members of the implementation committee. Water purchased from district patrons with the Conservation Fund for temporary instream leasing may be stored in Wickiup Reservoir or Crane Prairie Reservoir, as appropriate, and released at any time during the legal irrigation season determined by the Services.

### 2.1.4 Alternative 4: Enhanced and Accelerated Variable Streamflows

Under Alternative 4, the Services would issue 20-year ITPs to the applicants for incidental take of each agency's respective covered species likely to be caused by the covered activities in the Deschutes Basin. The applicants would implement the Deschutes Basin HCP as described for the proposed action, but with a 20-year permit term and modifications to the conservation strategy presented in Table 2-6. A 20-year permit term is considered for Alternative 4 to address accelerating flow modifications and the uncertainty about covered species responses to flow modifications. A 20-year permit term would allow for adjusting the conservation strategy sooner than under a 30-year permit term for the proposed action and Alternative 3.

Alternative 4 is similar to Alternative 3 in that it increases fall and winter flows on the Deschutes River sooner than under the proposed action, requires implementation of the Upper Deschutes River Conservation Fund, provides improved flow certainty at North Unit ID's Crooked River pumping plant, increases minimum storage season flows to 80 cubic feet per second (cfs) below Bowman Dam, and protects releases of uncontracted storage on the Crooked River instream to Lake Billy Chinook. Alternative 4 also accelerates the timing of fall and winter flow increases on the Deschutes River and achieves a higher minimum flow compared to the proposed action and Alternative 3. Alternative 4 also increases releases of uncontracted storage on the Crooked River. All other conservation measures and the adaptive management and monitoring program are the same in Alternative 4 as under the proposed action.

**Table 2-6. Alternative 4 Conservation Measures**

| Conservation Measure | Primary Focus |
|---|---|
| CP-1: Crane Prairie Reservoir Operation | *Same as proposed action.* |
| WR-1: Wickiup Reservoir Operation | Adjusts the timing and volume of flow in the Deschutes River below Wickiup Dam based on annual coordination by FWS, OWRD, and North Unit ID to regulate flows during spring months, increase minimum flows during fall and winter months per the schedule below, decrease flows during summer months, and limit ramp down rates at the end of the irrigation season.<br>Fall and winter (September 16–March 31) minimum flow schedule:<br>• 1–5 years: 300 cfs<br>• 6–20 years: 400–600 cfs<br>Fall and winter minimum flow targets could be greater than these minimum flow targets based on monthly fall and winter coordination of FWS, OWRD, and North Unit ID to assess available annual surplus fall storage in Crane Prairie and Wickiup Reservoirs and precipitation forecasts. Annual coordination will target providing greater than minimum flows during above-normal and wet years. |
| DR-1: Middle Deschutes River Flow Outside of the Irrigation Season | *Same as proposed action.* |
| DR-2. Upper Deschutes River Conservation Fund | *Same as Alternative 3.* |
| **Crescent Creek and Little Deschutes River** | |
| CC-1: Minimum Instream Flow below Crescent Dam | *Same as proposed action.* |
| CC-2: Crescent Dam Ramping Rates | *Same as proposed action.* |
| CC-3: Crescent Lake Reservoir Irrigation Release Season | *Same as proposed action.* |

| Conservation Measure | Primary Focus |
|---|---|
| **Whychus Creek** | |
| WC -1: Whychus Creek Instream Flows | *Same as proposed action.* |
| WC-2: Whychus Creek Temporary Instream Leasing | *Same as proposed action.* |
| WC -3: Whychus Creek Diversion Fish Screens and Fish Passage | *Same as proposed action.* |
| WC-4: Piping of Patron Laterals | *Same as proposed action* |
| WC-5: Whychus Creek Diversion Ramping Rate | *Same as proposed action.* |
| **Crooked River, Ochoco Creek and MacKay Creek** | |
| CR-1: Crooked River Flow Downstream of Bowman Dam | Same as proposed action but increases storage season minimum flows to 80 cfs (with Ochoco ID responsible for up to 50 cfs), and provides for instream protection of the uncontracted (fish and wildlife) releases from Bowman Dam to Lake Billy Chinook. |
| CR-2: Ochoco Creek Flow | *Same as proposed action.* |
| CR-3: McKay Creek Flow | *Same as proposed action* |
| CR-4: Crooked River Conservation Fund | *Same as proposed action.* |
| CR-5: Screening of Diversion Structures | *Same as proposed action.* |
| CR-6: Crooked River Flow Downstream of the Crooked River Pumps | *Same as proposed action.* |

Source: Deschutes Basin Board of Control and City of Prineville 2019.

cfs = cubic feet per second; ITP = incidental take permit; ID = Irrigation District; NMFS = National Marine Fisheries Service; OWRD = Oregon Water Resources Department; SCADA = Supervisory Control and Data Acquisition; PCL = Programmable Logic Controller.

## 2.2 Comparison of Alternatives

Table 2-7 compares the primary components of the four alternatives analyzed in the EIS.

**Table 2-7. Comparison of Alternatives**

| Alternative Component | Alternative 1: No Action | Alternative 2: Proposed Action | Alternative 3: Enhanced Variable Streamflows | Alternative 4: Enhanced and Accelerated Variable Streamflows |
|---|---|---|---|---|
| Permit mechanism | Not applicable; no ITP would be issued. | ITPs issued to applicants by both FWS and NMFS. | | |
| Covered species | Not applicable; no covered species. The BiOp includes actions for Oregon spotted frog. | FWS: Oregon spotted frog, bull trout; NMFS: steelhead, spring Chinook salmon, sockeye salmon. | | |
| Covered activities | Actions currently required by the 2019 Deschutes Project BiOp and the 2005 NMFS BiOp are assumed to continue and to apply to the activities covered by the BiOp. | Operations and maintenance activities for four dams in the Deschutes Basin that are operated by local irrigation districts; operation and maintenance of diversions, pumps, and intakes by the applicants; water diversions and return flows by the applicants; groundwater use; effluent discharge; and HCP conservation measures. | | |
| Covered lands and waters | BiOp actions would apply in a portion of the area in the HCP. | Permits are limited to narrow corridors of covered river and stream segments, covered reservoirs, and covered diversion structures. | | |
| Permit term | No ITPs issued. | 30 years | 30 years | 20 years |
| Conservation strategy | Continues actions in the 2019 Deschutes Project BiOp and 2005 steelhead BiOp. | • Increases fall and winter Deschutes River flows based on schedule of flow increases.<br>• Supplements releases of uncontracted storage from | • Increases fall and winter Deschutes River flows sooner than under the proposed action with greater flows in above-normal and wet years. | • Increases fall and winter Deschutes River flows sooner than under the proposed action and Alternative 3 with greater flows in above-normal and wet years. |

| Alternative Component | Alternative 1: No Action | Alternative 2: Proposed Action | Alternative 3: Enhanced Variable Streamflows | Alternative 4: Enhanced and Accelerated Variable Streamflows |
|---|---|---|---|---|
| | | Prineville Reservoir on Crooked River.<br>• Provides other conservation measures to modify operation and maintenance of water facilities to enhance flows on the Deschutes River, Crescent Creek, Little Deschutes River, Whychus Creek, Crooked River, Ochoco Creek, and McKay Creek.<br>• Provides for Crooked River and Whychus Creek Conservation Funds.<br>• Includes an adaptive management and monitoring program. | • Provides Upper Deschutes River Conservation Fund<br>• Protects the releases of uncontracted Prineville Reservoir storage on the Crooked River to Lake Billy Chinook for fish and wildlife.<br>• All other conservation measures are the same as the proposed action. | • Provides Upper Deschutes River Conservation Fund<br>• Increases releases of uncontracted Prineville Reservoir storage on the Crooked River identified in the proposed action to 80 cfs, and protects this flows instream as described for Alternative 3.<br>• All other conservation measures are the same as the proposed action. |

HCP = Deschutes Basin HCP; BiOp = biological opinion; FWS = U.S. Fish and Wildlife Service; NMFS = National Marine Fisheries Service.

# 2.3 Alternatives Considered but Eliminated from Further Consideration

As set forth in NEPA regulations, an EIS analysis need not consider every possible alternative to a project, but rather a range of reasonable alternatives. Alternatives 3 and 4 described in Section 2.1, *Alternatives Analyzed in the EIS,* were selected for detailed analysis in this EIS from a broader range of 15 alternatives that were subjected to a three-phase screening process. This process ensures that the alternatives evaluated in detail in this EIS are able to meet the purpose and need for the proposed action and screening criteria for technical feasibility, economic feasibility, and reduction of environmental effects. The alternatives screening process narrowed the range of alternatives by eliminating similar or duplicative alternatives and those that failed to meet any of the screening criteria. Accordingly, the following alternatives were dismissed from further evaluation because they were similar to or duplicative of the proposed action and alternatives considered, or they otherwise failed to meet the screening criteria described above. Further explanation for why each alternative was not carried forward is detailed in Appendix 2-A.

## 2.3.1 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:

- 1 to 2 years: 100 cfs
- 3 to 5 years: 200 cfs
- 6 to 10 years: 300 cfs
- 11 to 30 years: 400 cfs

## 2.3.2 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, *Alternatives to the Proposed Incidental Take*).

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

Alternative 5 would increase minimum fall/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.

### 2.3.4 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.

### 2.3.5 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.

### 2.3.6 Alternative 8. Reduced Covered Species

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

### 2.3.7 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.

### 2.3.8 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 (and were greater than minimum flow requirements) but without other flow enhancements in the proposed action.

### 2.3.9 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.

### 2.3.10 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 ID and North Unit ID to improve water supply use efficiency in the Deschutes Basin.

### 2.3.11 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.

### 2.3.12 Alternative 14. Preliminary Injunction Alternative

Alternative 14, would attempt to maintain stable water levels in Crane Prairie and Wickiup Reservoirs year round.[5] This alternative would provide for 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.

### 2.3.13 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.

[5] 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).

Chapter 3

# Affected Environment and Environmental Consequences

## 3.1 Introduction

This chapter describes the existing environmental conditions and the potential direct and indirect impacts on the natural and human environment from the proposed action and alternatives. Cumulative impacts are discussed in Chapter 4, *Cumulative Impacts*.

Following this introduction, the chapter addresses the following resources: water resources (Section 3.2); water quality (Section 3.3); biological resources (Section 3.4); land use and agricultural resources (Section 3.5); aesthetics and visual resources (Section 3.6); recreation (Section 3.7); tribal resources (Section 3.8); socioeconomics and environmental justice (Section 3.9); and cultural resources (Section 3.10). Each resource section consists of a description of the methods, the potentially affected resource (***affected environment***), and the potential impacts on that resource (environmental consequences).

The following elements of the human environment were screened from detailed analysis in this EIS: transportation; air quality and greenhouse gases; noise; hazards and hazardous materials; geology, seismicity, and soils; and public services and utilities. These resource topics were not addressed because the proposed action and alternatives do not create construction activities or population growth effects that could affect these resources.

Appendix 3.1-A, *Regulatory Environment*, provides the regulatory context for each resource.

In each resource section, the ***study area*** for that resource is defined to encompass the area where the proposed action and alternatives have the potential to result in effects on the human environment. In most cases, the study area is limited to the vicinity of the covered lands and waters (Figure 1-1) because this is where effects would likely occur. However, in some cases, such as agricultural resources, where effects on the resource would occur beyond the covered lands and waters on irrigated lands in the Deschutes Basin, the study area extends to include these areas.

### 3.1.1 Alternatives Analyzed

The no-action alternative effects analysis considers a 30-year analysis period because that is the length of the longest permit term considered under the proposed action and Alternatives 3 and 4. The term *analysis period* is used because no permit would be issued under the no-action alternative. The proposed action and Alternative 3 effects analyses consider a 30-year permit term, and the Alternative 4 effects analysis considers a 20-year permit term.

Effects under the no-action alternative are compared to existing conditions and qualitatively consider the potential physical effects of continuing current water management operations and other possible projects and programs assumed under the no-action alternative could have on study area resources. The potential effects of climate change on study area resources is addressed qualitatively considering the potential hydrologic changes that could occur under future no-action

alternative conditions compared to existing conditions. Effects of the proposed action and Alternatives 3 and 4 are compared to the no-action alternative, although effects analyses for Alternatives 3 and 4 may reference and provide comparison to effects under the proposed action. Because climate change and other no-action alternative conditions and projects would, by definition, occur with or without the proposed action and Alternatives 3 and 4, their effects are not addressed for the proposed action and Alternatives 3 and 4.

## 3.1.2 Effect Determinations

Effect determinations are made at the conclusion of each impact discussion based on the thresholds identified for each resource.

- ***Adverse effects*** are those that exceed the stated thresholds.
- Effects determined to be ***not adverse*** are those that could occur but do not exceed thresholds.
- ***Beneficial effects*** are those effects that would improve environmental conditions.

In some cases, the alternatives would result in ***no effect*** on the human environment. A conclusion of no effect and not adverse is not equivalent. No effect means that no direct or indirect effects on the human environment would occur at all. Effects that are not adverse would result in some effect, but the magnitude of the effect would not exceed the effect threshold.

## 3.1.3 Modeling

Effects of the proposed action and Alternatives 3 and 4 on the natural and human environment are primarily a result of changes in water management operations, described in Chapter 2, *Proposed Action and Alternatives*. RiverWare modeling[1] was conducted to predict how these changes would affect water distribution, streamflow, reservoir storage and water supply, reservoir water surface elevation and flood storage capacity, and flood flows. Therefore, effects on these resources, described in Section 3.2, *Water Resources*, are direct model outputs, whereas effects on all other resources were evaluated based on consideration of how the resource would respond to these modeled changes. The model is a representation and simplification of the water management paradigm and the natural system and, therefore, does not capture every aspect of the natural system. Additionally, the model follows a set of assumptions and logic in a manner that would likely differ from how decision-makers may (and currently do) make decisions in real time. However, the model is informed by existing data sets, water management regimes, and knowledge of the natural system.

Table 3.1-1 shows the fall and winter flows in the Upper Deschutes River below Wickiup Reservoir under each alternative. Flows increase more quickly under Alternative 3 than under the proposed action and even more so under Alternative 4. The permit term considered under Alternative 4 is 20 years, compared to 30 years for the proposed action and Alternative 3.

[1] Appendix 3.1-B, *RiverWare Model Technical Memorandum*, documents the model representation of the alternatives and summarizes a selection of the results.

**Table 3.1-1. Timing of Implementation of Minimum Fall/Winter Flow Releases (cfs) from Wickiup Reservoir**

| Years | No Action | Proposed Action | Alternative 3 | Alternative 4 |
|---|---|---|---|---|
| 1–5 | 100 | 100 | 200 | 300 |
| 6–10 | 100 | 200 | 300 | 400 |
| 11–15 | 100 | 300 | 400 | 500 |
| 16–20 | 100 | 300 | 400–500[a] | 400–600[a] |
| 21–30 | 100 | 400[a] | 400–500[a] | |

[a] Flow levels at full implementation
cfs = cubic feet per second

As shown in Table 3.1-1, Alternative 3 targets a higher minimum flow (500 cubic feet per second [cfs]) in above-normal and wet years, than the proposed action (400 cfs). 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. Because the RiverWare model required an assumption for how flows in excess of the minimum would be managed, it was determined that the upper bound for the variability assumption would be 500 cfs for the no-action alternative and proposed action. Therefore, modeled flow values presented for the proposed action and Alternative 3 at their respective flow targets (400 cfs and 400–500 cfs) are the same. Alternative 3 refers to the proposed action for discussions of impacts related to model changes in water management and focuses discussion on how impacts would differ from the proposed action in response to the accelerated implementation schedule and additional conservation measures.

In general, the effects of district water conservation projects (i.e., canal piping or lining) completed prior to 2014 on streamflow and irrigation diversions are reflected in the RiverWare model (Table 1 in Appendix 2-B, *No-Action and Cumulative Scenarios*). Water conservation projects for which final NEPA review was completed were assumed under the no-action alternative, as described in Chapter 2, but are not included in the RiverWare model. However, the effects of these projects on streamflows were quantified outside of the RiverWare model. The effects of other planned water conservation projects on reservoir storage and streamflows also are not captured in the modeling results. These future projects would improve water supply efficiency and streamflow conditions but were not included as assumptions in the RiverWare model because of uncertainty about the extent and timing of their potential effects on basin hydrology. The potential effects of water conservation on irrigation district water supply can be quantified at the point of diversion; therefore, the analysis of effects on agricultural resources considered a range of potential water conservation (both district and on-farm). However, because effects on basin hydrology may be attenuated or concentrated during periods of low flow in different reaches of the Upper Deschutes Basin, depending on how water is conserved, hydrologic conditions, and other factors, the effects of these changes on resources were evaluated qualitatively in the cumulative analysis (Chapter 4).

# 3.2 Water Resources

This section describes the affected environment for water supply, surface water, and groundwater resources and effects that would result from the proposed action and alternatives.

## 3.2.1 Methods

The water resources study area includes surface- and groundwater resources and adjacent floodplains that could be affected by the hydrologic changes under the proposed action and alternatives (Figure 3.2-1). For surface water resources, the study area includes all covered waters downstream to the mouth of the Deschutes River as well as Prineville Reservoir. For water supply, the study area includes the Deschutes River and Crooked River and hydraulically connected surface water tributaries above Lake Billy Chinook. For groundwater resources, the study area includes the regional groundwater system, which is connected to the covered waters and Prineville Reservoir at various points throughout the system. For flood hazards, the study area includes those areas along the covered waters that are prone to flooding.

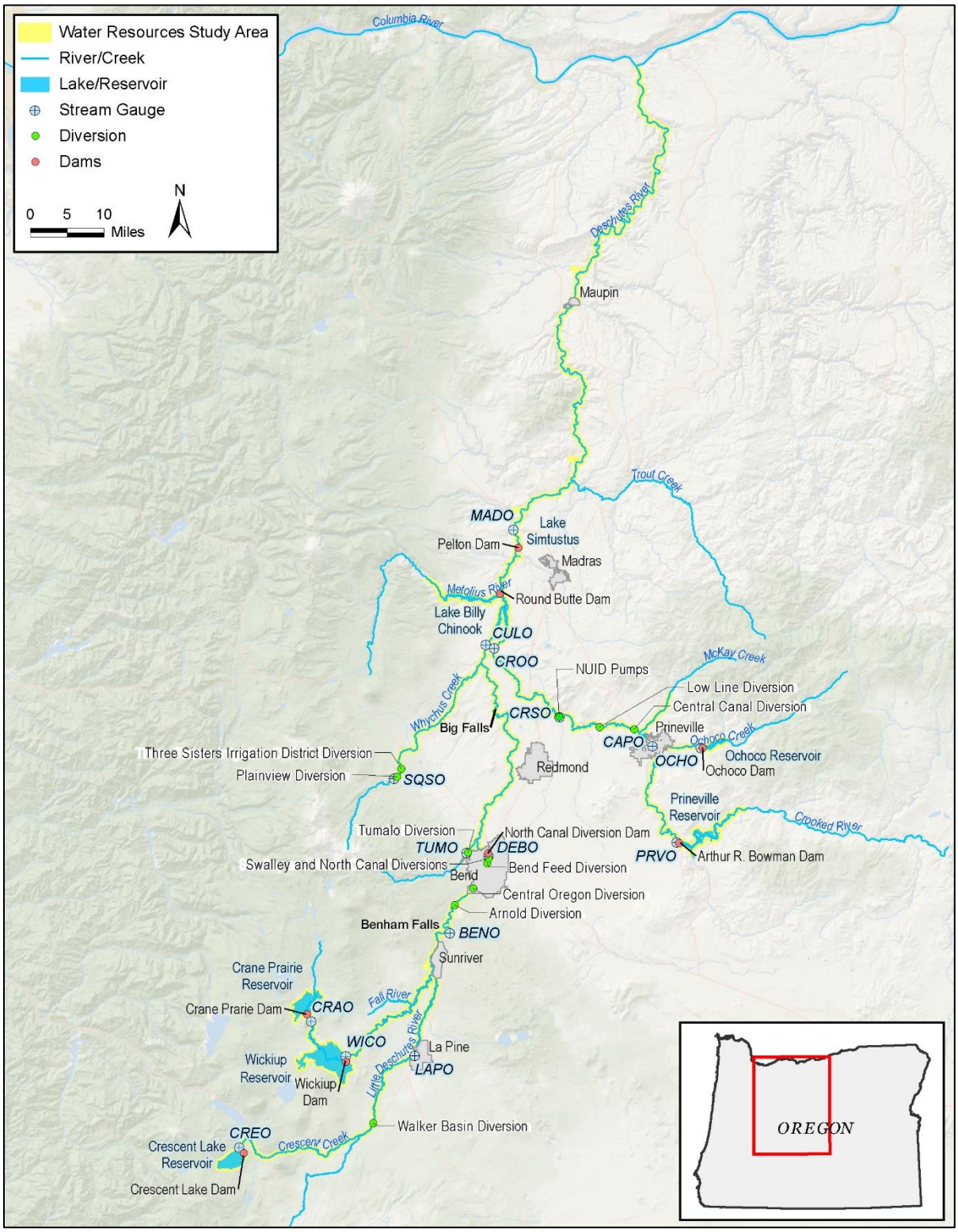
The description of the affected environment for water resources was based on a review of existing publications and data describing water resource conditions in the study area. Online data sources (e.g., river and reservoir gauges) and water resources specialists with expertise in the study area were also consulted.

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. The model is a representation and simplification of the water management paradigm and the natural system and, therefore, does not capture every aspect of the natural system. Additionally, the model follows a set of assumptions and logic in a manner that would likely differ from how decision-makers may (and currently do) make decisions in real time. However, the model is informed by existing data sets, water management regimes, and knowledge of the natural system.

The values presented in the effects analysis are direct RiverWare model outputs (without rounding) and are used for purposes of comparing among alternatives. 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. A detailed description of the RiverWare model is provided in Appendix 3.2-A, *Water Resources Technical Supplement*. Appendix 3.1-B, *RiverWare Model Technical Memorandum*, documents the model representation of the alternatives and summarizes a selection of the results.

[1] ***Upper Deschutes Basin*** is defined as the basin upstream from Lake Billy Chinook.

**Figure 3.2-1. Water Resources Study Area**



Streamflow, reservoir storage, and water supply under the proposed action and alternatives were compared over a 29-year modeling period (1980 to 2009),[2] which encompasses a variety of water year types. Table 3.2-1 defines each water year type based on equivalent flow percentile and describes representative hydrologic conditions. For example, a dry year is equivalent to the 20th percentile of streamflow, meaning streamflow conditions would be as dry or drier in 2 out of 10 years; streamflow conditions in wet years are equivalent to the 80th percentile, meaning 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. Water year type varies throughout the basin, as annual discharge is variable throughout the basin. For example, a dry year for the purposes of Crescent Creek flows and Crescent Lake Reservoir storage may be a normal year for Crooked River flows and Prineville Reservoir storage.

**Table 3.2-1. Water Year Types and Associated Hydrologic Conditions**

| Water Year Type | Equivalent Flow Percentile | Hydrologic Conditions (including annual volume of water and/or minimum rate of flow) |
|---|---|---|
| Very dry | <20% | Severe or extreme drought, especially dry years following dry years (e.g., water years of 1991–1992, especially in the Crooked River; 1994, 2006, especially in the Deschutes River). |
| Dry | 20% | Moderate or severe drought, including years following drought (e.g., 2001 in the Crooked River, 2002–2003 in the Deschutes River). |
| Normal | 50% | A median year. Agricultural water users are not likely to experience water supply shortages during a normal, wet, or very wet year under the no-action alternative (e.g. 2007, 2008). |
| Wet | 80% | A year with flows in excess of instream and out-of-stream demand, including years following very wet years (e.g., 1986, 1999). |
| Very wet | >80% | Especially wet years associated with flooding, (e.g., 1983–1984, 1997–1998). |

Effects related to conservation measures for Whychus Creek (Conservation Measures WC-1 through WC-5), Ochoco Creek (Conservation Measure CR-2), and McKay Creek (Conservation Measure CR-3) were not assessed using the RiverWare model. The addition of 3.0 cubic feet per second (cfs) to Whychus Creek (Conservation Measures WC-1) is assumed under the no-action alternative, so would have no effect under the proposed action or Alternatives 3 and 4.[3] Effects related to other conservation measures for Whychus Creek (Conservation Measures WC-2 through WC-5) were evaluated qualitatively. For Ochoco and McKay Creeks, the effects of the proposed action were evaluated based on historical discharge and reservoir stage data available through the HydroMet Data System (Bureau of Reclamation 2018) and the Oregon Water Resources Department (OWRD), or were assessed qualitatively.

Reservoir flood risk was assessed by reviewing the number of days in the modeling period that reservoir storage exceeded 90% of capacity, which is considered a level of elevated flood risk. In the Upper Deschutes River reservoirs, irrigation storage goals may conflict with the flood storage threshold. Reservoir managers have the flexibility to manage the reservoirs to minimize flood risk

[2] The period of hydrologic data input for the model is independent of the analysis period.

[3] Three Sisters ID has completed piping of their canals; therefore, the addition of 3.0 cfs to Whychus Creek (under Conservation Measure WC-1) is accounted for in the RiverWare model for the no-action alternative as well as the proposed action and Alternative 3 and 4.

and meet irrigation storage goals. River flood risk was assessed first by computing the flood frequency analysis for the modeling period using maximum daily flows. Predicted flows for the 100-year (1%, base flood) and 500-year events are reported to coincide with Federal Emergency Management Agency (FEMA) flood map classifications. More frequent near-channel shallow flooding was also assessed by comparing the number of days in the modeling period that river flows exceed flow thresholds associated with flooding on the Upper Deschutes River and Crooked River.

Effects on groundwater levels and recharge were assessed qualitatively based on published studies on the Upper Deschutes Basin (Gannet et al. 2001, 2013) and communications with OWRD staff with expertise in the groundwater–surface water interactions in the study area.

Potential effects of climate change on surface water, groundwater, and water supply were assessed qualitatively, based on forecasts for Oregon's Cascade Range (Dalton et al. 2017) and the Deschutes Basin (Halofsky et al. 2018; Bureau of Reclamation 2018).

The effects of future water conservation were not explicitly modeled in RiverWare. For the two water conservation projects assumed under the no-action alternative—the Swalley ID Irrigation Modernization Project and the Tumalo ID Irrigation Modernization Project—effects were assessed quantitatively based on final watershed plan environmental assessments (Farmers Conservation Alliance 2018a, 2018b). Effects of potential future water conservation over the permit term in combination with the proposed action and alternatives are addressed in Chapter 4.

The thresholds used for determining whether effects on water resources would be adverse are described as follows.

- Changes in water supply are not considered environmental effects in and of themselves and therefore no thresholds are defined. Results from this analysis were used to assess effects on other resources such as agriculture and socioeconomics.
- Effects on surface water would be considered adverse if they would result in any of the following conditions related to flooding. The effects of changes in streamflow and surface water elevations on other resources—including biological resources, recreation, and aesthetics—are assessed in those sections based on the results of this analysis.
    - An increase in the number of days that reservoir storage is within 90% of flood storage capacity compared to the no-action alternative such that reservoir operations for flood control would be compromised. The value of 90% accommodates the uncertainties of real-time flood operations versus modeling results.
    - An increase in the magnitude and frequency of peak mean daily flows.
- Effects on groundwater would be considered adverse if they would meaningfully change groundwater recharge conditions and subsequent groundwater elevations in the study area subbasins relative to changes induced by other influences on the system.

## 3.2.2 Affected Environment

### 3.2.2.1 Water Supply

Changes in timing and volume of releases from the study area reservoirs under the proposed action and alternatives would affect the amount of water stored in the reservoirs and consequently the amount of water supply available to entities with rights to use that stored water. Table 3.2-2 lists

each reservoir, its capacity, authorized water supply storage, and water rights.[4] The covered facilities, including reservoirs, water supply diversion structures, pumps, and intakes, are described in Chapter 3, *Scope of the HCP*, of the Draft Deschutes Basin HCP. Appendix 3.2-A (*Water Uses and Water Rights Administration* section) summarizes water rights associated with storage and use of stored water under Oregon water law.

**Table 3.2-2. Study Area Storage Reservoirs, Capacities, and Water Rights**

| Reservoir | Capacity (af) | Water Right Volume (af) | Primary Water Right Holder | Secondary Water Right Holder |
|---|---|---|---|---|
| Crane Prairie | 55,300 | 50,000 | Central Oregon ID | Central Oregon ID<br>Arnold ID<br>Lone Pine ID |
| Wickiup | 200,000 | 200,000 | North Unit ID | North Unit ID<br>Oregon Water Resources Department (Instream Water Rights) |
| Crescent Lake | 86,900 | 51,050; 35,000 | Tumalo ID | Tumalo ID<br>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 ID | Ochoco ID |

af = acre-feet; ID = Irrigation District.

The water rights authorizing storage of water in these reservoirs do not include a stated storage season (the specific time period of the year when water can be stored). Further, there is not an identified storage season in the Deschutes Basin. Depending on water year conditions, reservoirs may begin filling as early as September, and may fill through the end of July.

Changes in timing and volume of releases from the study area reservoirs under the proposed action and alternatives would also affect the amount of water supply from surface water (or live flow). Tables 2 and 3 in Appendix 3.2-A list water users with rights to surface flow in the Deschutes River and Crooked River, respectively, and their authorized water use. Only those with priority dates junior to (more recent than) October 31, 1900, have the potential to be affected.[5]

When there is insufficient live flow to meet the needs of all water users, OWRD regulates water rights by relative priority,[6] as summarized in Appendix 3.2-A (*Water Uses and Water Rights Administration* section). Regulation of live-flow water rights in a river does not affect the use of stored water under secondary water rights (i.e., rights for the use of stored water). If stored water is released into a stream for use under a secondary water right, it is considered a different source than the live flow in the stream. Consequently, users with secondary water rights can continue to divert water when users with live-flow water rights are regulated off (not allowed to divert live flow).

[4] The primary water right is for the right to store the water; the secondary water right is the right to use the stored water.

[5] RiverWare shows that water diverted under Central Oregon Irrigation District's live-flow water rights with October 31, 1900, priority would rarely be affected by the proposed action, and would never be fully regulated. Therefore, live-flow water rights senior to the district's October 31, 1900 priority would not be regulated.

[6] 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.

## 3.2.2.2 Surface Water

### Streamflow and Reservoir Storage

#### Upper and Middle Deschutes River

The headwaters of the Upper Deschutes River are located in hydrogeologic units characterized by highly permeable volcanic geology with rapid infiltration rates. Most of the 200 inches per year of precipitation that falls in the western portion of the Upper Deschutes Basin falls as snow in the Cascade Range. Precipitation infiltrates the volcanic geology and becomes groundwater before reemerging at springs. Direct surface runoff is a relatively small percentage of the flow in the Upper Deschutes River, although some drainages like the Little Deschutes River can produce significant surface runoff especially during rain-on-snow events. Although the Deschutes River has been managed since the later 1800s, the construction of Wickiup Dam in the early 1950s brought about more intensive water management to meet irrigation demand. Wickiup Dam operations have resulted in considerably more variable seasonal streamflow upstream of Bend. Seasonally variable streamflow downstream of Bend predates Wickiup Dam as diversions in Bend affected instream flows downstream of North Canal Diversion Dam. The storage, release, and diversion of irrigation water results in flows upstream of Bend that are generally high during the irrigation season and low during the storage season.[7] Flows downstream of Bend to approximately Lower Bridge (river mile [RM] 134.0) are similarly low during the storage season but are much lower during the irrigation season because most flow (90–95%) is diverted near Bend for irrigation. Groundwater inputs to the Middle Deschutes River from Lower Bridge to the Culver gauge (RM 120.0) may contribute more than 400 cubic feet per second (cfs) of flow to the lower river (Gannet et al. 2001).

Crane Prairie Reservoir and Wickiup Reservoir operations are coordinated to meet downstream irrigation use and needs of fish and wildlife under FWS' interim Oregon spotted frog biological opinion (U.S. Fish and Wildlife Service 2017, 2019). Both reservoirs fill from the fall through spring with the filling success or levels dependent on the surface water elevation at the start of the fall, climate conditions, and reservoir inflows. Stored water is released to meet irrigation needs during the irrigation season, and reservoir inflows include both surface water and groundwater. Although there are net inflows to the reservoirs, there are also seepage losses to the groundwater system. Crane Prairie Reservoir and Wickiup Reservoir typically reach their maximum and minimum storage elevations in late spring and at the end of irrigation season, respectively.

#### Crescent Creek and Little Deschutes River

Crescent Creek and the Little Deschutes River watersheds are located in the La Pine River Subbasin, a geologic formation characterized by fine-grained sediment with low permeability (Lite and Gannett 2002). Unlike most other streams in the Upper Deschutes Basin, where flows are supported largely by spring discharge, Crescent Creek and the Little Deschutes River have flows that show strong seasonal variation driven by surface runoff. 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, although natural fluctuations are dampened or experience alterations in flow by the operation of Crescent Lake Reservoir.

[7] For the purposes of this analysis, the irrigation season is considered April 1 to October 31 and the storage season is November 1 to March 31.

### Tumalo Creek

In the Tumalo Creek watershed, sediments have lower permeability relative to other tributaries in the Upper Deschutes Basin, and streamflow is more greatly influenced by surface runoff than by spring inputs. However, springs contribute approximately 20 cfs to streamflow and Tumalo Creek baseflows are higher relative to other tributaries in the basin. Upstream of the Tumalo Irrigation District (ID) diversion (RM 2.8), 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 Tumalo ID diversion, the lower 2.8 miles of the creek experience substantially reduced flows during the irrigation season, but flows outside the irrigation season are relatively unaffected. The City of Bend also diverts water from Tumalo and Bridge Creeks above RM 16. Tumalo ID has converted 11.8 cfs to instream water rights through water conservation projects, primarily the Tumalo Feed Canal Piping Project (Bureau of Reclamation 2010). Tumalo ID holds the right to store up to 1,100 acre-feet (af) in Upper Tumalo Reservoir, which is used primarily for reregulation purposes to provide a buffer against short-term fluctuations in demands. Additionally, water is diverted from Crater Creek, a tributary of Sparks Lake, to Tumalo Creek for rediversion at the Tumalo Feed Canal at RM 2.8. Diversions from Crater Creek will not be affected by the proposed action.

### Whychus Creek

Streamflows in Whychus Creek are influenced predominantly by snowmelt. Flows consistently peak in June, but extreme peak flows are often associated with mid- to late winter rain-on-snow events. Upstream of the Three Sisters ID diversion at RM 25.8, streamflow is influenced by surface water and groundwater sources. During the irrigation season, Three Sisters ID diverts flow for irrigation, reducing the instream flows downstream of the diversion. Outside of irrigation season, the diversion has a nominal influence on streamflow. Since 2015, Three Sisters ID has converted 28.18 cfs from irrigation rights to permanent instream water rights. Three Sisters ID also recently completed a piping project that is expected to allocate an additional 3 cfs to instream use, as described in Conservation Measure WC-1, pending completion of state administrative processes pertaining to the project. Flow increases downstream of Sisters are influenced by a single tributary, Indian Ford Creek, and multiple small springs.

### Lower Deschutes River

Flow in the Deschutes River increases more than twofold between Culver (RM 120) and Madras (RM 100), mostly due to inflow that originates as spring discharge to the Deschutes River, Metolius River and Crooked River in the vicinity of Lake Billy Chinook. 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 Crooked River Subbasin upstream from Smith Rocks State Park is differentiated from the western portion of the Upper Deschutes Basin by low-permeability sediments and lower annual precipitation. Less permeable sediments result in more surface water runoff and less surface water–groundwater exchange compared to the western region of Upper Deschutes Basin. The hydrology of the Crooked River Subbasin upstream from Smith Rocks State Park is also distinctly different from the wetter, higher-elevation mountains of the Cascade Range that form the western boundary of the study area. Compared to the more than 200 inches of precipitation per year in the Cascade Range,

the Crooked River Subbasin receives less than 10 inches per year on average. With less permeable sediments and lower average precipitation, most precipitation becomes surface runoff, and with little input from groundwater, streamflow tends to drop dramatically after the end of snowmelt in early spring.

Inflows to Prineville Reservoir typically peak in spring during snowmelt and fall close to zero by late summer. Spring inflows contribute to reservoir storage, which in some years rapidly increases from a February low to maximum levels by early April. The reservoir storage volume typically remains at maximum levels through early June, when outflows to meet downstream irrigation needs exceed reservoir inflow. According to the reservoir rule curve, reservoir storage is drawn down through October and storage generally reaches a steady level by December. Flood control considerations also require the reservoir not to exceed 88,000 acre-feet (af) of storage between November 15 and February 15.

Stored water is released from Prineville Reservoir to provide mitigation for groundwater pumping by the City of Prineville (starting in 2018) and irrigation water to water users downstream from Prineville Reservoir and the North Unit ID pump station on the lower Crooked River. Compared to historical conditions, flows on the Crooked River are lower during winter and higher during summer, reflective of the storage and release of irrigation water. The Crooked River Collaborative Water Security and Jobs Act of 2014 (Crooked River Act) made more than 62,000 af of uncontracted storage in Prineville Reservoir available for fish and wildlife use. Summer flows at Terrebonne have increased from recent historical low flows due to storage releases from Prineville Reservoir and Ochoco Reservoir as well as return flows from upstream irrigation. North Unit ID through an agreement with the Deschutes River Conservancy and codified in their water rights, will not operate the Crooked River pumps to divert water unless minimum flows of 43 to 181 cfs, varying by month and year type, are maintained at the Crooked River at the Smith Rocks stream gauge (CRSO). Table 4 in Appendix 3.1-B shows how the amount of flow varies depending water year conditions and month.

Ochoco Reservoir typically begins filling in the early spring before reaching maximum reservoir stage between mid-April and May. The reservoir remains at maximum stage through mid-June, when released water exceeds inflows. Ochoco Reservoir is drawdown through irrigation season.

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. Between Ochoco Dam and the mouth of Ochoco Creek, summer flow is reduced by multiple irrigation diversions.

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. Ochoco ID and non-district users divert water from McKay Creek.

Groundwater discharge to the lower Crooked River contributes to streamflow downstream from Terrebonne. In excess of 1,000 cfs enters the Crooked River between Osborne Canyon and Opal Springs Dam year-round through groundwater inputs originating in the Deschutes Basin.

## Flood Risk and Management

The southwestern part of the study area (headwater area of the Deschutes River) is underlain by porous volcanic soils with high infiltration and permeability rates. The porous soils have a dampening effect on runoff as precipitation and snowmelt largely infiltrate into the subsurface materials. The following locations within the study area are identified as at risk of flooding in the *Flood Insurance Study for Deschutes County* (Federal Emergency Management Agency 2007). Figure 3.2-2 shows these areas as well as the 100- and 500-year floodplain and other floodway areas identified by FEMA (2019).

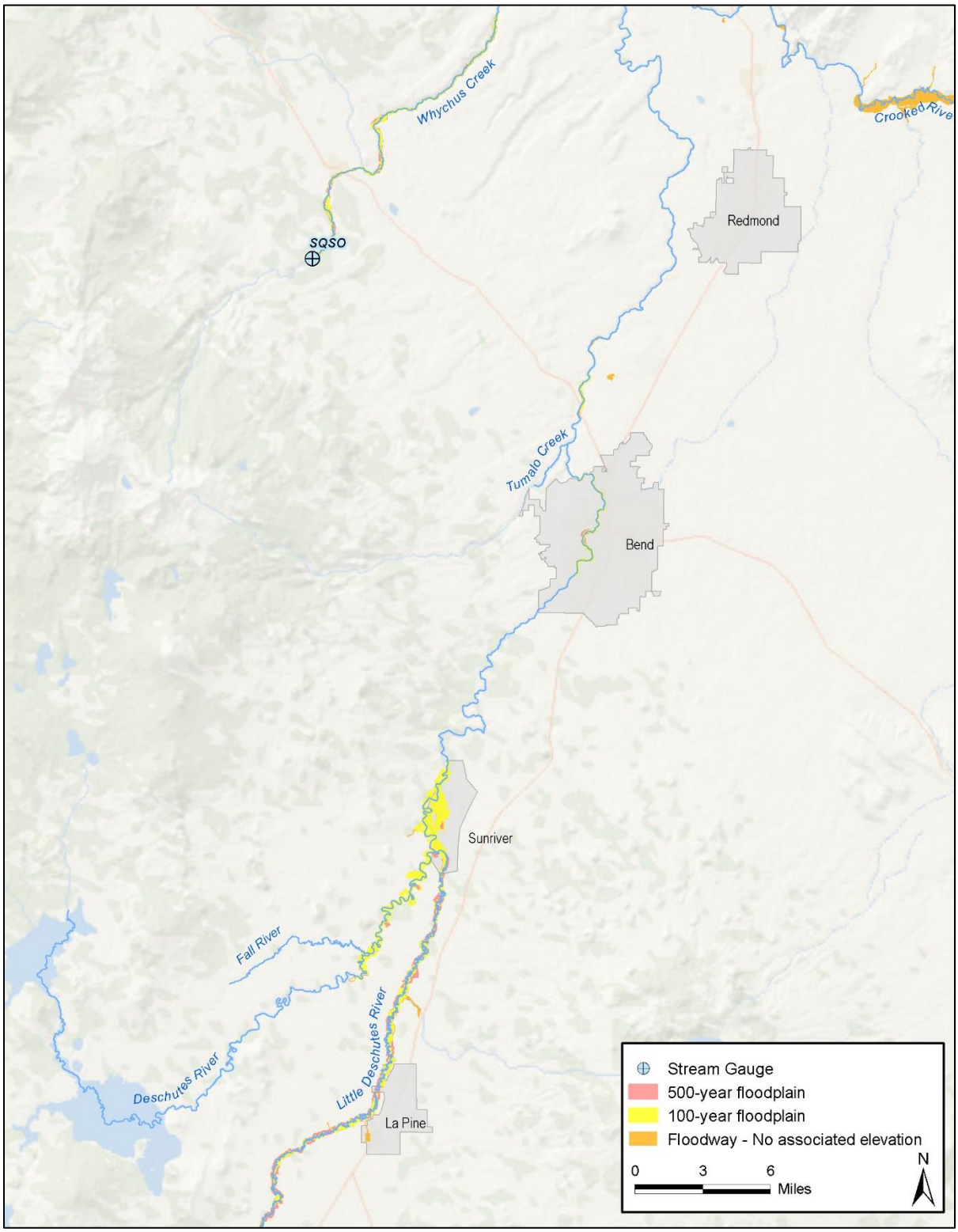
- Deschutes River in Deschutes River Recreation Homesites, from the Fall River confluence to Little Deschutes River confluence (6.1 miles).
- Little Deschutes River from its confluence with Deschutes River upstream to the Klamath County line (45.2 miles).
- Deschutes River in the vicinity of Sunriver (9.67 miles), Bend (7.5 miles), and Tumalo (2 miles).
- Whychus Creek from the Jefferson County line upstream to the OWRD stream gauge at RM 26.6 (18.6 miles).

Flood season for the Upper Deschutes River is from November through July. In general, the Deschutes River is subject to high water levels from snowmelt in late spring, and irrigation releases in August and September where irrigation releases have been compared to an equivalent of a 25-year flood event (U.S. Forest Service 1996). Infrequently, floods are caused by rain-on-snow events in the surrounding mountains (Federal Emergency Management Agency 2007).

According to OWRD (Gorman pers. comm.; La Marche [a] pers. comm.), flooding characterized by shallow floodplain inundation occurs in the Upper Deschutes River between the Fall River confluence and the Little Deschutes River confluence from July to September because of elevated Wickiup Reservoir flow releases to meet irrigation demand, and vegetation growth in the channel that reduces channel capacity. Deschutes River flooding may also occur downstream from Bend near the town of Tumalo during storm or snow-melt runoff events.

The annual flood season for the Little Deschutes River is from November through June although flooding may also occur in March and April if the Little Deschutes River experiences high water and the stream is backwatered by elevated flows on the Deschutes River. Whychus Creek may experience rain-on-snow events and snowmelt flooding from November through April. Flooding on the Crooked River occurs upstream of the city of Prineville and near Smith Rocks State Park. The annual flood season for the Crooked River is December through April and is associated with rain-on-snow events and spring runoff. However, in May of 1998, there was an unusually large precipitation event upstream of Ochoco Reservoir that filled the reservoir and severely flooded downstream properties from the dam to the mouth of the Creek.

**Figure 3.2-2. Flood Zones and Flood Hazard Areas in the Study Area**




Source: Federal Emergency Management Agency 2019.

### 3.2.1.1 Groundwater

The permeable geology underlying the Deschutes Basin, combined with the large annual precipitation in the Cascade Range, results in a large aquifer system that is highly productive and a river system that is influenced by groundwater–surface water interactions. Water moves through the groundwater system toward the discharge regions along the margin of the Cascade Range and near the confluence of the Deschutes, Crooked, and Metolius Rivers. Annual recharge to the groundwater system includes precipitation, inter-basin flows, and irrigation canal leakage. At the basin scale, fluctuations in the groundwater levels generally follow climate cycles, with periods of high groundwater levels generally corresponding to high precipitation and lower water levels corresponding to low precipitation. This effect dampens going eastward and away from the recharge area.

In the Upper Deschutes Basin, the groundwater system discharges to the river system (Gannet et al. 2001:34–37). Estimated gains and losses from select stream reaches in the Upper Deschutes Basin are depicted in Figure 3 in Appendix 3.2-A). The extent of interchange between surface water and groundwater varies throughout the study area due to differences in groundwater table elevation, stream gains and loss, and reservoir stage.

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 Range. Crane Prairie Reservoir contributes to the groundwater system through leakage, with a large fraction of these losses likely returning to the river system through springs located just below Crane Prairie Reservoir and along the edges of Wickiup Reservoir. Wickiup Reservoir is not as well understood but generally has a net inflow of water through springs and rivers with some leakage occurring from the periodic development of sinkholes. In the La Pine area, the groundwater table elevation is near land surface. Stream gains and losses along most of these reaches of the Deschutes River, Little Deschutes River, and Crescent Creek are small, indicating relatively little net exchange of water between the groundwater and river systems. The exception is the significant inflow to the Deschutes River is from the Spring River area near Sunriver. The only significant losing reach[8] of the Deschutes River occurs between Sunriver and Bend (Gannet et al. 2001: 73).

The Deschutes River from Bend to Lower Bridge is a relatively neutral reach, with no or very small groundwater- surface water interactions. From approximately Lower Bridge to the confluence of the Metolius, Deschutes, and Crooked Rivers, the groundwater system discharges large volumes of water to the Deschutes, Metolius and the Crooked River systems (Gannet et al. 2001:44–46).

The Tumalo Creek headwater region is a gaining stream, with the net exchange between the groundwater system and surface water flows changing to a neutral reach below the Skyliners Road bridge.

Whychus Creek is either a neutral or gaining river system with the exception of the short segment just upstream of Sisters that loses flow. Significant springs are present along the eastern flank of McKinney Butte just downstream of Three Sisters providing significant inflows to the creek downstream of the main diversion (TSID). Groundwater discharges into the creek significantly increasing flows near the Deschutes River confluence.

[8] ***Losing reaches*** have a channel that is higher than the groundwater table and tend to lose water into the groundwater system. ***Gaining reaches*** have a channel that is lower than the groundwater table and tend to gain water from the groundwater system. ***Neutral reaches*** neither lose nor gain water from the groundwater system.

The Crooked River and Ochoco Creek are also either neutral or gaining river systems that only interact with the local shallow groundwater system and do not generally interact with the regional groundwater system until approximately 5 miles downstream of the Smith Rocks State Park (La Marche [b, c] pers. comm.).

Additional details and supporting information about groundwater in the study are can be found in Appendix 3.2A.

## 3.2.3 Environmental Consequences

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.

### 3.2.3.1 Alternative 1: No-Action

Continuation of existing water management operations under the no-action alternative, described in Chapter 2, *Proposed Action and Alternatives*, would result in no changes in water resources compared to existing conditions. However, other variables, such as climate change and water conservation, would affect water resources over the analysis period.

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 (Halofsky et al. 2018).

Extreme climate events, such as drought, and ecological disturbances, such as flooding and wildfire, are forecast to increase with climate change. These events could alter streamflow throughout the study area (Halofsky et al. 2018). Upper Deschutes River tributaries are likely to experience more rain and less snowfall with a warming climate. Tributaries, especially those such as the Crooked River that are more influenced by surface water runoff and less so by groundwater hydrology, are likely to become flashier, with earlier annual runoff and lower summer flows.

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 supply later in the season. 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. The Crooked River reservoirs 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.

Water supply from runoff would be expected to be lower during the irrigation season and particularly late in the irrigation season due to climate change effects. Water users who rely on stored water for a portion of their water supply would be expected to rely on stored water for a

longer duration and for a greater proportion of their overall supply. Stored water supplies may be exhausted earlier in the season.

Under a climate change scenario that includes significant variation in annual precipitation, there may be more years in which reservoirs do not fill and water users experience supply shortages. Conversely, groundwater-influenced systems may be less affected because of the longer residence time of water passing through subsurface geology. Precipitation and snowmelt infiltration and groundwater discharge to surface water occurs over a longer period of time and groundwater-dominated systems, compared to surface-dominated systems, are less influenced by annual precipitation.

Based on the historical record, basin-scale groundwater levels will continue to fluctuate in response to climate cycles that affect the overall recharge to the system. The magnitude of water level changes will generally dampen moving eastward across the basin away from the basin's primary recharge source (the Cascade Range). The exception is groundwater levels in wells immediately adjacent to canals with planned piping projects, where declines in water levels may exceed the climate cycle driven fluctuations.

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. Over the analysis period, on an annual basis, the anticipated effect of future groundwater pumping is a decrease in groundwater discharge to surface water in the ***Lower Deschutes River***, and an approximately equal increase in surface water flow at the Madras gauge, below Lake Billy Chinook. Therefore, future groundwater pumping is not expected affect streamflows.

In the case of the City of Prineville, the water needs of future growth will continue to be met through additional groundwater production from the Prineville Valley. Impacts on surface flows from future pumping will be mitigated by the release of the City's 5,100 af (7 cfs) of annual mitigation water from Prineville Reservoir under the Reclamation-recommended release rates and timings to maximize benefits to downstream fish and wildlife. Additional information related to the City's pumping is provided in Appendix 3.2-A (*Supporting Analysis for Environmental Consequences*, *Alternative 1: No Action, Groundwater*). Over the analysis period, on an annual basis, the City's increased groundwater pumping, combined with the release of the City's 5,100 af of annual mitigation water from Prineville Reservoir, would result in a slight decrease in groundwater levels in the Prineville Valley Floor aquifer and an approximately equal or greater increase in Crooked River surface water flow below Prineville Reservoir.

Recent and reasonably foreseeable water conservation projects, described in Chapter 2, could also affect the study area hydrology over the analysis period by changing the timing and amount of water diverted as well as seepage for irrigation networks. Three district water conservation projects are assumed under the no-action alternative: the Swalley ID Irrigation Modernization Project, the Tumalo ID Irrigation Modernization Project, and the addition of 3.0 cfs to instream flow on Whychus Creek under Conservation Measure WC-1. Water conservation projects completed prior to 2017 and the addition of 3.0 cfs to Whychus Creek (under Conservation Measure WC-1) are accounted for in the RiverWare model for the no-action alternative as well as the proposed action and Alternative 3

and 4. Water saved through these projects would be protected instream under the State of Oregon's Allocation of Conserved Water process, and would thereby increase instream flows below irrigation diversions in the Deschutes River and Tumalo Creek (Farmers Conservation Alliance 2018a, 2018b). Flows would increase incrementally over the first 10 years of the analysis period as projects are completed. The flow increases are detailed in Table 4 of Appendix 3.2-A and are reflected in the streamflow analysis (Impact WR-4, Change Seasonal River and Creek Flows) in Alternatives 2 through 4 for the affected reaches. The groundwater levels in wells immediately adjacent to these planned piping projects will potentially experience local-scale declines in water levels that exceed the existing climate cycle driven fluctuations. Effects of other potential future water conservation on water resources over the permit term in combination with the proposed action and alternatives are addressed in Chapter 4.

**Effect Conclusion:** Continuation of current operation and maintenance of covered facilities under the no-action alternative would have no effect on water supply, surface water, or groundwater in the study area compared to existing conditions. However, climate change could have an adverse effect on water supply, surface water, and groundwater resources. Covered facility operation may need to be adapted to capture, store, and release surface water to meet water user demands and fish and wildlife needs.

Planned water conservation projects assumed under the no-action alternative would result in increased instream flows below Bend during the irrigation season and water supply for irrigation districts. These changes would be positive for water supply and beneficial for surface water flow because improving the efficiency of water delivery infrastructure allows for improved multiple-use water management flexibility. These changes are considered not adverse for groundwater resources because minor local-scale declines in the groundwater levels associated with these conservation projects would be attenuated and absorbed by the regional groundwater system and would not affect the overall basin-scale groundwater system.

### 3.2.3.2 Alternative 2: Proposed Action

This section describes effects on water resources under the proposed action compared to the no-action alternative. More detailed data, analysis, and graphics are provided in Appendix 3.2-A.

#### WR-1: Change Reservoir Storage

This section compares reservoir storage under the proposed action to the no-action alternative using direct model outputs.

**Crane Prairie Reservoir.** Water supply storage in Crane Prairie Reservoir would generally be higher from approximately late September through early May and lower from mid-May through mid-September (Table 5 and Figures 5 and 6 in Appendix 3.2-A). On average, the maximum volume of storage attained during the storage season would increase by 4.9%, while maximum irrigation season storage would decrease by 1.1%. The changes are attributable to restrictions on the water surface elevation of Crane Prairie Reservoir under Conservation Measure CP-1, which effectively reduce maximum Crane Prairie storage for irrigation supply from 15,000 af under the no-action alternative to approximately 10,000 af under the proposed action.

**Wickiup Reservoir.** As winter flow releases from Wickiup Reservoir increase above no-action levels at year 6 (Conservation Measure WR-1), Wickiup Reservoir storage would decline, with the greatest declines observed in years 21 through 30 of the permit term (Table 6 and Figure 7 in

Appendix 3.2-A). In a normal water year during years 21 through 30, water supply storage would be reduced by 52,778 af (a 42% reduction).

**Crescent Lake Reservoir.** Reduction of minimum flows below the Crescent Lake Dam from 30 cfs to 20 cfs from March 15 through November 30 (Conservation Measure CC-1) would generally result in an increase in Crescent Lake Reservoir storage (Figure 8 in Appendix 3.2-A). In years 1 through 5 of the permit term, the maximum storage volume attained would increase by approximately 28% in a dry year, although there would be a minimal increase in a normal year (Table 8 in Appendix 3.2-A). This increase in storage would decrease slightly over the permit term because increased winter releases from Wickiup Reservoir (Conservation Measures WR-1, D-G), and the requirement to maintain Crane Prairie storage elevations (Conservation Measure CP-1), may result in an increased frequency of regulatory calls on junior water rights, including the Tumalo ID Deschutes River natural flow water right for 9.5 cfs (Certificate 74149) and the Tumalo ID water right to store water in Crescent Lake Reservoir beyond 35,000 af.[9] Appendix 3.2-A (Impact WR-1: Change Reservoir Storage) provides an expanded discussion of Crescent Lake Reservoir storage rights.

**Prineville Reservoir.** As winter flow releases out of Wickiup Reservoir increase starting in year 6 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 decrease of 170 af during wet and very wet years to a reduction of 9,533 af during a very dry year. Although the reduction in Prineville Reservoir storage is high during dry and very dry years, the average reduction in storage would be approximately 1,800 af, equivalent to less than 2% of total storage. Figure 9 in Appendix 3.2-A, compares Prineville Reservoir storage during years 21 through 30 of the permit term. 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.

**Ochoco Reservoir.** Release of additional flow from the Ochoco Main Canal downstream of Ochoco Reservoir to maintain flows of 3 cfs during the irrigation season and 5 cfs during the nonirrigation season (Conservation Measure CR-2) would reduce Ochoco Reservoir storage by up to 1,516 af. Increasing bypass flows in McKay Creek and Ochoco Creek, bypassing additional flows associated with instream water rights (regardless of priority date as compared to Ochoco ID storage) originating above Ochoco Reservoir, 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 Ochoco Reservoir storage.

**Effect Conclusion:** Changes in reservoir storage under the proposed action compared to the no-action alternative would increase slightly during the storage season and decrease slightly during the irrigation season in Crane Prairie, progressively decrease in normal and dry years over the permit

[9] 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. Additionally, during some years, there are decreases in live flow due to management of Crane Prairie water levels that lead to TID regulation. Under these circumstances, maximum Crescent storage may be decreased, but end of irrigation season storage would not necessarily be affected, as storage accounts are rebalanced late in the season.

term in in Wickiup Reservoir, increase during dry years in Crescent Lake Reservoir, decrease in Prineville Reservoir, and decrease slightly in Ochoco Reservoir. These changes in reservoir storage are used to inform the analysis of effects on water supply described in Impact WR-2 and on groundwater in Impact WR-5. Effects on reservoir recreation are described in Section 3.7, *Recreation*.

## WR-2: Change Water Supply for Irrigation Districts and Other Surface Water Users

This section compares water supply under the proposed action to the no-action alternative using direct model outputs.

Changes in reservoir storage described in Impact WR-1 (Change Reservoir Storage) would reduce water supply for irrigation districts and other surface water users by reducing the availability of stored water from Wickiup Reservoir, Crane Prairie Reservoir, and Prineville Reservoir. Additionally, in the Deschutes River, 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 would increase.[10] With the exception of water users holding only live- flow water rights junior to 1913 in the Upper Deschutes River Basin, who are expected to face regulation even during wet years, the proposed action is not expected to reduce water supply during wet or very wet years for irrigation districts and other water users.

Irrigation season diversions (as absolute volumes) in normal, dry, and very dry years as a percentage of diversions under the no-action alternative are presented for North Unit, Central Oregon, Arnold, Lone Pine, Ochoco, and Tumalo IDs. Values are presented for the entire irrigation season, but effects would be concentrated from June through September. The comparison considers the four stages over the permit term as minimum winter flows below Wickiup Reservoir increase from 100 to 400 cfs). Comparing diversions in the first 5 years of the permit term, when minimum winter instream flows downstream of Wickiup Reservoir would be at 100 cfs, isolates the effects of Conservation Measures CP-1 and CR-1. The allocation of 3 cfs of Three Sisters ID water rights instream under measure WC-1 for is assumed under the no-action alternative, and other conservation measures are not expected to affect Three Sisters ID water supply. Swalley ID water supply would not be affected by the proposed action.

**North Unit Irrigation District.** Reduced storage in Wickiup Reservoir, described in Impact WR-1 (Change Reservoir Storage), would reduce stored water supply available to North Unit ID starting in year 6 of the permit term in dry and very dry years and in year 11 in normal years. (Figures 11 and 16 in Appendix 3.2-A). During wet and very wet years, there would be no reduction in stored water supply. In years 1 through 5, water supply would increase by 6,086 af in a dry year. In year 6, North Unit ID's diversions would decline by 10,907 af in a dry year. Beginning in year 21, North Unit ID's diversions would decline by 54,070 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 [a, b] pers. comm.). 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

[10] Historically, flows at gauge 14085300 below Ochoco Reservoir have regularly dropped below 3 cfs during the storage season in normal, dry, and very dry years, and this is expected to be the same under the no-action alternative.

beginning in year 6.[11] During years 21 through 30, when Crooked River water use would be highest, North Unit ID would increase use of the Crooked River pumping plant by 4,928 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.

**Central Oregon Irrigation District.** Reduced storage in Crane Prairie Reservoir available for release during the irrigation season, described in Impact WR-1, would reduce water supply available to the entities with water rights to use stored water in Crane Prairie Reservoir—Central Oregon ID, Arnold ID, and Lone Pine ID—as depicted in Figures 12, 13, and 14 in Appendix 3.2-A.

Water supply available to Central Oregon ID would decrease slightly beginning in year 1 of the permit term in normal, dry, and very dry water years, but the effects would be small relative to Central Oregon ID's diversions. In a dry year, Central Oregon ID's diversions would decline by 1,737 af starting in year 1 and by 3,873 af starting in year 21. This represents approximately 0.6 and 1.4% of diversions under the no-action alternative, respectively.

**Arnold Irrigation District.** Reduced water supply storage in Crane Prairie Reservoir and increased Wickiup Reservoir outflows, as described for Central Oregon ID, 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 3,972 af starting in year 1 of the permit term and by 7,583 af starting in year 21. This represents approximately 16 and 30% of diversions under the no-action alternative, respectively. Because Crane Prairie must be held above 46,800 af prior to July 15 (Conservation Measure CP-1), supply shortages for Arnold ID cannot be addressed by release of Crane Prairie stored water. As described in Section 3.2.2.1, *Water Supply,* under Oregon Law, when there is insufficient water to meet the needs of all water users, OWRD can regulate water rights by relative priority. 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 are expected to increase, which may affect Arnold ID, as well as Lone Pine ID and other Deschutes River water users with junior water rights (Figures 13 and 17 in Appendix 3.2-A).[12]

**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 (Figures 14 and 17 in Appendix 3.2-A). 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 818 af starting in year 1 and by 2,306 af starting in year 21. This represents approximately 8 and 21% of diversions, respectively.

**Ochoco Irrigation District.** Decreased storage in Prineville Reservoir, described in Impact WR-1 (Change Reservoir Storage), combined with North Unit ID's increased use of Crooked River live flow and stored water from Prineville Reservoir, would result in a reduction of Ochoco ID water supply in a very dry year beginning in year 1 (Figure 17 in Appendix 3.2-A). In very dry water years, Ochoco ID water supply would be reduced by 8,843 af starting in year 1 and by 9,301 af starting in year 21.

[11] 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.
[12] 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.

This represents approximately 16 to 17% of OID's diversions under the no-action alternative, respectively. Reduced Prineville Reservoir and Ochoco Reservoir storage, described in Impact WR-1 related to Conservation Measures CR-2, CR-3, and CR 4, could further reduce Ochoco ID water supply in very dry water years depending on the extent of implementation. As described under impact WR-1, above, Ochoco Reservoir storage may be reduced by up to 1,516 af as a result of minimum flow requirements below Ochoco Dam under Conservation Measure CR-2. The impact of instream leasing under Conservation Measure CR-2 and Conservation MeasuresCR-3 and CR-4 depend on the amount, timing, and management of instream leases of Ochoco Creek and Crooked River instream leases, including leases of supplemental storage rights, and, therefore, cannot be quantified.

**Tumalo Irrigation District.** Increased storage in Crescent Lake Reservoir, described in Impact WR-1 (Change Reservoir Storage), is expected to increase Tumalo ID's stored water supply. However, increased regulatory calls on Tumalo ID's live flow Deschutes River water right are expected to decrease water supply. Tumalo ID's diversions would decrease by 501 af in a dry year beginning in year 21 (Figure 18 in Appendix 3.2-A).

**Three Sisters Irrigation District.** Conservation Measures WC-1, WC-2, WC-4, and WC-5 have the potential for small and unquantifiable effects on Three Sisters ID water supply under certain flow conditions.

**Swalley Irrigation District.** Swalley ID water supply would not be affected by the proposed action.

**Other Deschutes River Water Users.** Other water users with live-flow water rights junior to North Unit ID (Table 2 in Appendix 3.2-A) are expected to experience reduced water supply due to increased regulatory calls by North Unit ID. Although North Unit ID is expected to experience shortages during normal to very dry years, regulatory calls on water users with water rights junior to North Unit ID are expected to occur nearly every year under the proposed action starting in year 1. The reduced likelihood of filling Wickiup Reservoir would provide an incentive to North Unit ID to preserve stored water for carry over to the next irrigation season.

Similarly, water users with water rights junior to Central Oregon, Arnold, and Lone Pine IDs (Table 2 in Appendix 3.2-A) could experience reduced water supply due to increased regulatory calls by Central Oregon, Arnold, and Lone Pine IDs starting in year 1 in dry and very dry years. Regulation would be less frequent and for a shorter duration than for water rights junior to North Unit ID.

**Other Crooked River Water Users.** Other water users, including small irrigation districts, private irrigators using shared conveyance systems, and private irrigators with individual diversions (Table 3 in Appendix 3.2-A), could experience reduced water supply in dry or very dry years as a result of decreased stored water supply in Prineville and Ochoco Reservoirs and increased North Unit ID use of Crooked River water, as described for Ochoco ID. In a very dry year starting in year 1, water supply to other Crooked River water users would be reduced by approximately 5% (Figure 20 in Appendix 3.2-A)

**Effect Conclusion:** Overall, changes in reservoir storage under the proposed action would result in varying degrees of water supply reductions for DBBC irrigation districts and other live flow diverters compared to the no-action alternative. Most of these reductions would occur during dry and very dry years. North Unit ID, Arnold ID Lone Pine ID, and Ochoco ID would experience the largest water supply reductions. Central Oregon ID, Tumalo ID, and Three Sisters ID would experience relatively minor water supply reductions. Swalley ID would not be affected. The effects

of these water supply changes are addressed in Section 3.5, *Land Use and Agriculture*, and Section 3.9, *Socioeconomics and Environmental Justice*.

## WR-3: Change Reservoir Water Surface Elevations and Flood Storage Capacity

This section compares reservoir water surface elevation and reservoir flood storage under the proposed action to the no-action alternative using direct model outputs. Flood risk, measured as the percentage of days in the permit term when reservoir water surface elevations exceed 90% of reservoir capacity, is described for each study area reservoir as follows.

**Crane Prairie Reservoir.** Crane Prairie Reservoir median water surface elevations over the permit term would be higher during storage season and lower through most of the irrigation season (Figure 21 in Appendix 3.2-A). Increased winter storage would start in September, when storage would increase 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 (Figure 22 in Appendix 3.2-A), when reservoir storage would be prioritized for Oregon spotted frog overwintering habitat. Average median water surface elevations would be approximately 0.5 foot higher over the permit term.

Flood risk would decrease, as the number of days of the reservoir exceeding 90% of reservoir capacity would decreases from 88 to 0 days over the permit term.

**Wickiup Reservoir.** Wickiup Reservoir would see the greatest change from increased prioritization of Crane Prairie Reservoir water levels and increased minimum winter instream flows in the Upper Deschutes River (Conservation Measures CP-1 and WR-1). These measures would result in Wickiup Reservoir median water surface elevations becoming more variable and much likely lower, especially in years 21 through 30 as less water would be stored year-round compared to earlier periods of the permit term (Figure 23 in Appendix 3.2-A). 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. Average median annual water surface elevations would be approximately 8.5 feet lower over the permit term. Maximum reservoir water surface elevations would be similar (Figure 24 in Appendix 3.2-A).

Flood risk would decrease as the number of days of the reservoir exceeding 90% of reservoir capacity would decrease over the permit term. Days of exceedance would go from 54 days to 50 days per year in years 1 through 5, and to 38 days per year in years 21 through 30.

**Crescent Lake Reservoir.** Crescent Lake Reservoir would experience higher median water surface elevations because of lower minimum flows downstream from Crescent Lake Dam from March 15 through November 30 (Conservation Measure CC-1). Water surface elevation differences would be greatest during the storage season and least during irrigation season when water is released to meet irrigation demand (Figure 25 in Appendix 3.2-A). There would be minor differences in median and maximum water surface elevations over the permit term (Figure 26 in Appendix 3.2-A). Average median water surface elevations would be approximately 0.7 foot higher over the permit term.

Flood risk would increase as the number of days of the reservoir exceeding 90% of reservoir capacity would increase over the permit term. However, the overall flood risk would remain low as the number of days of exceedance would go from 2 days to 4 days per year in years 1 through 5, and to 5 days per year in years 21 through 30, respectively.

**Prineville Reservoir.** Prineville Reservoir would experience similar median water surface elevations late in winter storage (month to month), but lower median water surface elevations would occur through irrigation season and early in winter storage (Figure 27 in Appendix 3.2-A). Lower median reservoir water surface elevations 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 flows (Figure 28 in Appendix 3.2-A). Average median and maximum water surface elevations would be approximately 0.6 foot lower and 0.1 foot lower, respectively, over the permit term. Flood capacity would be nearly unchanged.

**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 and maximum reservoir water surface elevations (Figure 29 and 30 in Appendix 3.2-A). Modeling results suggest there would be no difference in the average median and maximum water surface elevations over the permit term. Flood capacity would be nearly unchanged.

**Effect Conclusion**: The proposed action would not result in an increase in median or maximum reservoir water surface elevations exceeding 90% of reservoir storage capacity. Under the proposed action, reservoir managers would continue to have flexibility to manage the reservoirs for both irrigation storage and to minimize flood risk. Therefore, effects on flood storage capacity under the proposed action would be not adverse. Effects of changes in surface water elevations are addressed in Sections 3.3, *Water Quality*, 3.4, *Biological Resources*, 3.6, *Aesthetics and Visual Quality*, and 3.7, *Recreation*.

## WR-4: Change Seasonal River and Creek Flows

This section presents percentage change in flows under the proposed action compared to the no-action alternative using direct model outputs. Visual ***hydrographs*** and tables with direct model flow outputs in Appendix 3.2-A are referenced for more detail. Results are provided for normal and dry water years for years 1 through 5 and years 21 through 30 of the permit term; wet years generally have fewer streamflow differences. Intervening periods of the proposed action, including years 6 through 10 and years 11 through 20, typically have results that are bracketed by results for the first and last periods of the permit term. Appendix 3.2-A includes additional explanation for water year types and the intervening periods of the proposed action.

The greatest change under the proposed action is the staged increases in fall/winter minimum flows downstream of Wickiup Dam over the permit term (Conservation Measure WR-1). These increased storage season releases would result in lower flows on the Upper Deschutes River during the April 1 to October 31 irrigation season. This relationship becomes more pronounced as the fall/winter flow releases increase over the permit term. The effects of these increased releases on flows downstream of the dam are most apparent in a dry water year during years 21 through 30.

**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. Generally, flows would be higher 4 months of the year (January through February, mid-May, and mid-July through mid-August), lower 5 months of the year (March through mid-April, early July, and mid-August through September) and unchanged for 3 months (mid-April to May, and mid-May through June) (Figure 31 in Appendix 3.2-A). Irrigation season flows would increase 3% in a normal

year and decrease 3% in a dry year (Table 11 in Appendix 3.2-A). Total flow volume in this reach would decrease 3% in normal years and decrease 5% in dry years. Monthly flows would remain consistent over the permit term, as minimum flows downstream from Wickiup Dam have minimal effect on this reach. Monthly total flow volumes would be less variable in both normal and dry years, reflecting higher winter minimum flow releases. Flow changes would be most pronounced in September of a normal water year as Crane Prairie Reservoir outflows would be curtailed in favor of reservoir filling to support Oregon spotted frog habitat.

**Deschutes River from Wickiup Dam to the Little Deschutes River.** Implementation of Conservation Measure WR-1 would cause flows in this reach to increase during winter over the permit term. Increased minimum winter flows would result in decreased Wickiup Reservoir storage, which would decrease the amount of stored water available during the irrigation season. The biggest change in flows would occur in years 21 through 30 during the winter storage season when more flow is released from November through March (Figure 33 in Appendix 3.2-A). Irrigation season flows would decrease 2% in a normal year and 17% in a dry year (Table 13 in Appendix 3.2-A). Winter storage flows would increase 26% in a normal year and 120% (54,505 vs. 119,802 af) in a dry year. Total flow volume in this reach would increase 4% in normal years and be unchanged in a dry year. Monthly flows would be less variable over the permit term, as winter storage season flows would increase and irrigation season flows would decrease.

**Deschutes River from the Little Deschutes River to Benham Falls.** Implementation of Conservation Measure WR-1 would increase Upper Deschutes River minimum winter flows and begin to affect irrigation season flows in year 21 of the permit term, with a decrease in flows occurring in July and August (Figure 35 in Appendix 3.2-A). Median flows from mid-July through mid-September would decrease starting in year 21. In a dry year, the sequentially higher winter storage season minimum flows would result in decreasing irrigation season flows ranging from decreases of 3% (years 6–10) to a decrease of 11% (years 21–30) (Table 15 in Appendix 3.2-A). Conversely, winter storage season flows would increase up to 21% and up to 29% in a normal year and dry year, respectively. Total flow volume in this reach would exhibit minimal change in both normal and dry years. Monthly total flow volumes would be less variable in both normal and dry water years because of higher winter flows and lower irrigation season flows.

**Deschutes River from Benham Falls to Bend.** Conservation Measure WR-1 would also influence streamflow in the Benham Falls to Bend reach by increasing minimum winter flows. Proposed action flows in year 1 through 5 would be similar to the no-action alternative (Figure 37 in Appendix 3.2-A). In years 21 through 30, winter storage flows would be higher and irrigation season flows would be lower relative to the no-action alternative. Irrigation season flows in this reach would increase by up to 7% in a normal year and increase by up to 15% in a dry year (Table 17 in Appendix 3.2-A). Winter flows would increase up to 29% in a normal year and up 38% in a dry year. Total flow volume in this reach would increase by 21% and 30% in normal and dry years, respectively. Monthly total flow volumes would be more variable in both a normal water year and dry year because of substantially higher winter flows relative to the no-action alternative.

**Deschutes River from Bend to Culver.** Implementation of Conservation Measure WR-1 would increase minimum winter instream flow targets below Wickiup Reservoir and achieve a minimum 250 cfs stockwater target for the Middle Deschutes River (Bend to Lake Billy Chinook) from November 1 to March 31 (Conservation Measure DR-1). With implementation of Conservation Measures WR-1 and DR-1, flows in this reach would be higher in the winter, similar to upstream reaches (Figure 45 in Appendix 3.2-A). Irrigation season flows would be negligibly different,

increasing up to 1% in a normal year and up to 2% in a dry year over the permit term (Table 23 in Appendix 3.2-A). Total flow volume would increase up to 8% in a normal year and up to 11% in a dry year starting in year 21. Monthly total flow volumes would be more variable in both a normal and a dry year because of higher winter flows.

**Deschutes River from Culver to Lake Billy Chinook.** Flows in this reach would be similar to the Deschutes River from Bend to Culver although spring inputs may decline over time as irrigation districts implement conservation measures and pipe irrigation canals. Reduced canal leakage is anticipated to reduce losses (potentially 50 to 75 cfs) to groundwater and affect eventual groundwater inputs into the Deschutes River (J. La Marche, personal communication). No additional gaging stations are located between the Culver gauge and Lake Billy Chinook, and Lake Billy Chinook was not included as a node in the RiverWare model.

**Deschutes River from Lake Billy Chinook to Madras.** Flow in the Deschutes River increases more than twofold between Culver and Madras because of inflow that originates as spring discharge to the Deschutes River, Metolius River, and lower Crooked River (Figure 47 in Appendix 3.2-A). This large, relatively constant inflow reduces the relative influence of upstream irrigation activities and, therefore, river flows experience less seasonal fluctuation compared to upstream reaches. By years 21 through 30, winter flows would increase up to 2% in a normal year and up to 4% in a dry year (Table 25 in Appendix 3.2-A). There would be no change in irrigation season flows. Annual flows would increase 1% in a normal year and 2% in a dry year. Flows would be 3% and 18% more variable in years 21 through 30 in normal and dry years, respectively.

**Deschutes River from Madras to the Mouth of the Deschutes River.** Tributary and groundwater inputs downstream of the Madras gauge[13] reduce the relative importance of the proposed action on seasonal river flows on the lower Deschutes River.

**Crescent Creek from Crescent Lake to the Little Deschutes River.** Implementation of Conservation Measure CC-1 would cause flows in this reach to decrease slightly during winter in response to lower minimum flow targets (and would generally be slightly higher during the irrigation season). Flows would be lower in October and November as irrigation season flows are reduced prior to the start of Oregon spotted frog overwintering period (Conservation Measure CC-3) (Figure 39 in Appendix 3.2-A). Flow patterns would be similar over the permit term with irrigation season flows increasing 15% and winter storage flows decreasing 13% compared to the no-action alternative in a normal year (Table 19 in Appendix 3.2-A). In a dry year, irrigation season flow volumes would range from a reduction of 5% to an increase of 2%, and winter storage flow volumes would decrease 15% over the permit term. Total flow volumes in this reach would increase between 3% and 9% in a normal water year and decrease from 4% (years 1–5) to 1% (years 21–30) in a dry year. Monthly total flow volumes are more variable in both normal and dry years because of the lower winter minimum flows.

**Little Deschutes River from Crescent Creek Confluence to the Deschutes River.** Flows in this reach would experience minimal changes. In years 21 through 30 of the permit term, median streamflow during the irrigation season (mid-May through early June) would increase slightly, likely reflecting the releases from Crescent Creek Reservoir to meet Tumalo ID water demand (Figure 41 in Appendix 3.2-A). Flows would increase in June and July in a dry year and decrease no earlier than September 1 and be completed by October 31, as directed by Conservation Measure CC-3. Over the

[13] The Madras gauge is the furthest downstream gauge in the RiverWare model.

permit term, irrigation season flows would increase 2% in both normal year and dry years, and total flow volume would increase 1% in a normal water year but would be unchanged in a dry year (Table 21 in Appendix 3.2-A). Over the permit term, winter storage flows would decrease 2% in both normal year and dry years. Monthly total flow volumes would be slightly more variable (increase up to 2%) in both normal and dry years.

**Tumalo Creek.** Tumalo Creek flows would be unchanged.

**Whychus Creek.** 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 and therefore would result in no further changed under the proposed action. Conservation Measures WC-2, WC-4, and WC-5 have the potential for small and unquantifiable effects on streamflows in Whychus Creek

**Crooked River outflow from Bowman Dam.** Increases in Upper Deschutes River minimum fall/winter flow over the permit term would result in a water delivery shortage for North Unit ID from Wickiup Reservoir, which would require North Unit ID to rely more heavily on Crooked River water (Figure 50 in Appendix 3.2-A). To meet North Unit ID demand, additional water would be released from Prineville Reservoir earlier in the year. For example, in years 21 through 30 of the permit term, flow releases to meet North Unit ID demand in a dry year would occur from mid-June through mid-July, whereas no such releases would occur under the no-action alternative. Irrigation season flows would also decrease 2% during years 21 through 30 for a dry year (Table 29 in Appendix 3.2-A). Total flow volume in this reach would increase 1% in a dry year. Monthly total flow volumes would be less variable in a typical dry year because of higher flow releases in June and July to meet irrigation demand. Flow changes in a normal year would be minimal.

**Crooked River from Bowman Dam to OR 126 Crossing.** Several diversions draw water from the Crooked River between Bowman Dam and the OR 126 bridge (location of the Crooked River at Prineville gauge [CAPO]) The primary diversions in the reach are the Rice Baldwin, Peoples, and the Crooked River Feed Canals, in addition to several smaller, secondary diversions. Flow changes would be minimal in a normal year. In a dry year, starting in year 21 of the permit term, streamflow would increase in May and June and then be sharply reduced in July (Figure 52 in Appendix 3.2-A). Irrigation season flows would decrease up to 5% and total streamflow would decrease 3% in a dry year (Table 31 in Appendix 3.2-A).

**Ochoco Creek from Ochoco Dam to Crooked River.** Effects in this reach would be limited to slightly higher seasonal minimum and maximum median flows throughout the permit term.

**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 ID Pump Station to Smith Rock State Park.** The proposed action's influence on the ***hydrograph*** would increase in this reach over the permit term. By year 11, the median flow in July and August would begin to decrease and by year 21, there would be a clear reduction in median streamflow (Figure 56 in Appendix 3.2-A). Effects on irrigation season flows would likely result from the increased North Unit ID reliance on Crooked River flows to compensate for lower Deschutes River irrigation flows. Irrigation season flows would decrease 8% for normal and 6% for dry years (Table 33 in Appendix 3.2-A) in years 21 through 30. Total flow volume in this

reach would also decrease up to 5% in normal years, and remain similar to the no-action alternative in dry years (1%). Monthly total flow volumes would remain similar to the no-action alternative.

**Crooked River from Smith Rock State Park to Opal Springs Dam.** Median summer flows would decrease from mid-June to early August in years 11 through 30 as the upstream North Unit ID pump station withdraws water (Figure 58 in Appendix 3.2-A). Irrigation season flows would decrease by 1% starting in year 21 for normal and dry years as water use is in part masked by the large volume of groundwater that enters this reach (Table 35 in Appendix 3.2-A). Total flow volume in this reach would decrease 1% in both normal and dry years. Monthly total flow volumes would be similar in a normal year and more variable in a dry year.

**Deschutes River Flood Flows.** The flood analysis included review of changes to flows of the 100-year flood, the 500-year flood, and more frequent, lower-magnitude floods that cause shallow inundation of the near-channel floodplain. At the Deschutes River at Benham Falls (BENO) gauge, the 100-year flood associated with the proposed action would be essentially the same as the no-action alternative, and the 500-year event would have a small reduction in the predicted flow.

Flooding on the Deschutes River is influenced by Wickiup Dam releases and dense in-channel vegetation that reduces channel capacity during the irrigation season, and snowmelt-related tributary and mainstem flooding during the winter storage season. 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 Deschutes River below Wickiup Reservoir (WICO) (1,600 cfs), upstream of Bend at the BENO gauge (2,000 cfs), and at the Deschutes River below Bend gauge (DEBO). To assess flooding in the vicinity of the Town of Tumalo, the summation of the DEBO gauge and the TUMO gauge (1,400 cfs and 2,000 cfs) were used. Daily RiverWare output was evaluated and the total number of days of flood flow exceedance over the 29-year modeling period was determined. The average number of days of flood flow exceedance for the 29-year modeling period is reported for the no-action alternative and proposed action periods (Table 26 in Appendix 3.2-A). Over the permit term, there is a reduction in the number of days of flood flow exceedance at the WICO and BENO gauges, and an up to 12% increase in the number of days (26.8 days vs. 30 days in years 1–5) for the summation of the DEBO and TUMO gauges at the 1,400 cfs threshold. There is a slight reduction in days exceedance for DEBO and TUMO at the 2,000 cfs threshold (1.9 days vs. 1.3 days).

The proposed action would not result in substantial flow changes on the Little Deschutes River or Whychus Creek. Based on the flood thresholds and RiverWare model results, the proposed action is anticipated to have a minimal effect on flood flows.

**Crooked River Flood Flows.** The 100-year (base flood) and 500-year flood regimes were evaluated for the CAPO gauge (OR 126 crossing) to capture flood risk areas between the CAPO gauge and Prineville. Base flood flows would increase approximately 5% and 500-year event flows would increase 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 100-year 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 for the Crooked River upstream of Prineville were used to determine threshold flood flows

at the CAPO gauge. There was no change in the average number of days per year (4 days) where daily flows exceeded the flood flow threshold (2,500 cfs).

**Effect Conclusion:** Changes in season streamflows under the proposed action would occur in the study area, especially in dry years, when compared to the no-action alternative. On the Deschutes River, seasonal flow changes would be most pronounced from Wickiup Dam downstream to the Deschutes River near Culver (CULO gauge). Streamflow would generally be higher during winter storage to meet minimum flows set for Oregon spotted frog habitat and lower during the irrigation season because of diminished storage volumes from the minimum winter flow releases. These differences would be most pronounced during dry years, and less apparent in normal and wet years. On the Crooked River, flows below Bowman Dam (PRVO and CAPO gauges) would become less variable, especially during dry years as irrigation season and storage season flows become more similar. Streamflow changes in the remainder of study area would be minor, although seasonally important differences may affect water users and other resources. Effects of the changes in streamflow described in this section are addressed in Sections, 3.3, *Water Quality,* 3.4, *Biological Resources,* 3.6, *Aesthetics and Visual Resources,* 3.7, *Recreation,* and 3.8, *Tribal Resources.*

The proposed action would result in little change in the magnitude and frequency of 100-year and 500-year flood events. Reduced irrigation season flows on the Upper Deschutes River associated with the proposed action are anticipated to reduce the frequency of irrigation season lower magnitude flooding compared to the no-action alternative. The proposed action is not anticipated to affect the frequency of lower-magnitude flood events on the Crooked River. Therefore, based on expected proposed action changes to flood flows, effects of the proposed action on flood flows would be not adverse compared to the no-action alternative.

## WR-5: Affect Groundwater Recharge

This section evaluates the potential for changes in reservoir storage and streamflows under the proposed action compared to the no-action alternative to affect groundwater levels in the basin.

**Reservoirs and Deschutes River.** Changes to the operation of Crane Prairie Reservoir would generally result in higher reservoir water levels during the fall, winter, and spring and relatively lower water levels during the summer-. Throughout the year, water leaks through porous geologic material result in water loss from the bottom and sides of the reservoir, which is known as seepage. Changes to the operation of Crane Prairie Reservoir could result in a change in seepage loss that varies with water level. As water levels increase, seepage increases. It is likely that the majority of the seepage loss from Crane Prairie Reservoir returns to the river system just downstream of the reservoir at the Sheep Springs complex based on the geology, the groundwater head gradient and the proximity of a large groundwater discharge zone to the localized recharge coming from the reservoir.

Adjustments to the timing and flow in the Deschutes River below Wickiup Dam would not affect 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 would be proportional to the flow rate (Figure 12 in Appendix 3.2-A). Increased winter flows under the proposed action would result in increased recharge of the groundwater system starting in year 6 of the permit term. However, over the permit term, increases to groundwater recharge would be minimal and likely masked by the naturally occurring basin-scale groundwater level fluctuations associated with climatic cycles (Gannet et al. 2013).

Changes to flows in the Middle Deschutes River during the winter are not expected to affect the groundwater system because the stream reaches downstream of Bend are either neutral or gaining reaches. Increases in streamflow in gaining reaches could result in minor localized effects on groundwater levels that would be attenuated and absorbed by the regional groundwater system and would not affect the overall system.

**Crescent Creek and Little Deschutes River.** Changes in the release rates and volumes 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 reaches of Crescent Creek are small, indicating relatively little net exchange of water between the groundwater and river systems.

**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 a gaining stream. Potential minor localized effects on the water levels from increases in streamflow would be attenuated and absorbed by the regional groundwater system. The effect of City of Prineville pumping on surface flows would be unchanged compared to the no-action alternative and would continue to be mitigated by the release of the City's 5,100 af (7 cfs) of annual mitigation water under the Reclamation-recommended release rates and timings to maximize benefits to downstream fish and wildlife.

**Effect Conclusion:** Effects on groundwater recharge under the proposed action compared to the no-action alternative would be minor changes in the study area. These minor changes would likely be *de minimis* compared to the average annual groundwater recharge and likely masked by the naturally occurring basin-scale groundwater level fluctuations associated 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, effects on groundwater recharge under the proposed action would be not adverse compared to the no-action alternative.

### 3.2.3.3 Alternative 3: Enhanced Variable Streamflows

This section describes effects on water resources 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.

#### WR-1: Change Reservoir Storage

Changes in reservoir storage under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action for Crane Prairie, Wickiup, Crescent Lake, and Ochoco Reservoirs, except that changes in Wickiup and Crescent Lake Reservoirs would occur earlier in the permit term (Table 3.1-1).

Changes in Prineville Reservoir storage under Alternative 3 compared to the no-action alternative would be similar to those described for the proposed action. However, reductions in storage would be slightly (0.2%) greater than under the proposed action 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, slightly greater than under the proposed action but still equivalent to less than 2% of total storage. Figure 59 in Appendix 3.2-A

compares Prineville Reservoir storage under Alternative 3 (years 11–30) to the no-action alternative.

**Effect Conclusion:** Changes in reservoir storage under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action except for Prineville Reservoir, where reductions in storage would be slightly greater. Changes would occur earlier in the permit term under Alternative 3 than under the proposed action.Related effects on water supply to irrigation districts and other water users are analyzed in Impact WR-2. Related effects on groundwater are analyzed in Impact WR-5.

## WR-2: Change Water Supply for Irrigation Districts and Other Surface Water Users

Changes in water supply under Alternative 3 compared to the no-action alternative would be the same or nearly[14] the same as described for the proposed action for all users (Table 47 in Appendix 3.2-A) except that changes for North Unit, Central Oregon, Arnold, Lone Pine, Ochoco, and Tumalo IDs, and other Deschutes and Crooked River water users would occur earlier in the permit term (Table 3.1-1).

**Effect Conclusion:** Changes in water supply under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all users, except that changes for North Unit, Central Oregon, Arnold, Lone Pine, Ochoco, and Tumalo IDs, and other Deschutes and Crooked River water users would occur earlier in the permit term. The effects of these water supply changes are addressed in Section 3.5, *Land Use and Agriculture*, and Section 3.9, *Socioeconomics and Environmental Justice*.

## WR-3: Change Reservoir Water Surface Elevations and Flood Storage Capacity

Changes in reservoir water surface elevations and flood storage capacity under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action for all reservoirs except Prineville. Additionally, elevation changes in Wickiup and Crescent Lake Reservoirs would occur earlier in the permit term (Table 3.1-1).

Changes in Prineville Reservoir water surface elevations and flood storage capacity under Alternative 3 compared to the no-action alternative would be similar to those described for the proposed action. However, instream protection of releases of uncontracted storage water on the Crooked River past the North Unit ID pumps, as part of Conservation Measure CR-1 under Alternative 3, would result in slightly lower median and maximum Prineville Reservoir elevations compared to the proposed action. However, median and maximum monthly water surface elevations would remain under the 90% flood storage capacity.

**Effect Conclusion:** Changes in reservoir water surface elevations and flood storage capacity under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action. Alternative 3 would not result in an increase in median or maximum reservoir water surface elevations exceeding 90% of reservoir storage capacity. Reservoir managers would continue to have flexibility to manage the reservoirs for both irrigation storage and to minimize flood risk. Therefore, effects on flood storage capacity under Alternative 3 would not be adverse compared to the no-action alternative. Effects of changes in surface water elevations are

[14] North Unit water supply is slightly (less than 2%) lower under Alternative 3 in normal water years at full implementation compared to the proposed action.

addressed in Sections 3.3, *Water Quality*, 3.4, *Biological Resources*, 3.6, *Aesthetics and Visual Quality*, and 3.7, *Recreation*.

### WR-4: Change Seasonal River and Creek Flows

Modeled changes in seasonal river and creek flows under Alternative 3 compared to the no-action alternative are the same as described for the proposed action in all reaches, except the Crooked River between the North Unit ID pumps and Osborne Canyon, described below. Additionally, flow changes described under the proposed action for the Upper Deschutes River below Wickiup Dam and the Middle Deschutes River would occur earlier in the permit term (Table 3.1-1).

Crooked River modeled streamflow at the Smith Rock gauge (CRSO) located downstream from the North Unit ID pump station is lower under Alternative 3 compared to the no-action alternative from mid-June through early August as water is diverted by the North Unit ID pump station to meet water user demand. The differences 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 (Figure 66 in Appendix 3.2-A). Irrigation season flows would decrease 3% for normal and 5% for dry years in years 11 through 30 (Table 41 in Appendix 3.2-A). Total flow volume in this reach would also decrease up to 3% in wet and normal years but remain similar to the no-action alternative in dry years (1%). The changes are slightly less than under the proposed action.

**Effect Conclusion:** Modeled changes in seasonal river and creek flows under Alternative 3 compared to the no-action alternative are the same or nearly the same as described for the proposed action in all reaches, except the Crooked River between the North Unit ID pumps and Osborne Canyon where changes would be of slightly lower magnitude. Additionally, flow changes described under the proposed action for the Upper Deschutes River below Wickiup Dam and the Middle Deschutes River would occur earlier in the permit term and therefore be of longer duration. Effects of the changes in streamflow described in this section are addressed in Sections, 3.3, *Water Quality,* 3.4, *Biological Resources,* 3.6, *Aesthetics and Visual Resources,* 3.7, *Recreation,* and 3.8, *Tribal Resources*.

Changes in flood flows under Alternative 3 compared to the no-action alternative would be the same as under the proposed action; effects would be not adverse for the reasons described for the proposed action.

### 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 seepage associated with the Deschutes River segment downstream of Sunriver would occur earlier in the permit term (Table 3.1-1). Effects of Alternative 3 on the groundwater recharge would be not adverse compared to the no-action alternative.

## 3.2.3.4 Alternative 4: Enhanced and Accelerated Variable Streamflows

This section describes effects on water resources under Alternative 4 compared to the no-action alternative. Where effects are the same as or similar to the proposed action, the description of effects under the proposed action are referenced for brevity.

## WR-1: Change Reservoir Storage

Changes in reservoir water supply storage under Alternative 4 compared to the no-action alternative would be the same as described for the proposed action for Crane Prairie and Ochoco Reservoirs. Changes in Crescent Lake Reservoir would be nearly the same as described for the proposed action (years 6–30), but occur earlier in the permit term than under the proposed action or Alternative 3 (Table 3.1-1).

Changes in Wickiup and Prineville Reservoirs storage under Alternative 4 compared to the no-action alternative are described below.

**Wickiup Reservoir.** 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 Appendix 3.2-A). In a normal water year at full implementation (years 6–20), water supply storage would be reduced by 73,278 af (a 58% reduction) compared to the no-action alternative, approximately 16% greater reduction than proposed action or Alternative 3 at full implementation.

**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 winter minimum flows in the Crooked River (Conservation Measure CR-1), would result in reduced Prineville Reservoir storage in most years compared to the no-action alternative. 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 (slightly greater than under the proposed action and Alternative 3). Although the reduction in Prineville Reservoir storage is high during very dry years, the average reduction in storage would be 2,723 af, greater than under the proposed action or Alternative 3, but still equivalent to less than 2% of total storage. Figure 72 in Appendix 3.2-A, compares Prineville Reservoir storage under Alternative 4 (years 6–20) to the no-action alternative.

**Effect Conclusion:** Changes in reservoir storage under Alternative 4 compared to the no-action alternative would be the same as described for the proposed action for Crane Prairie and Ochoco Reservoirs. Changes in Crescent Lake Reservoir would be nearly the same as described for the proposed action. Reductions in Wickiup Reservoir storage in normal and dry years would be 16% greater than under the proposed action and Alternative 3, at full implementation. Reductions in Prineville Reservoir storage would be slightly greater. Changes in Wickiup, Crescent Lake, and Prineville Reservoirs would occur earlier in the permit term compared to both the proposed action and Alternative 3 but would end sooner due to the shorter permit term. These changes in reservoir storage are used to inform the analysis of effects on water supply described below in Impact WR-2 and groundwater in Impact WR-5. Effects on reservoir recreation are described in Section 3.7, *Recreation*.

Related effects on water supply to irrigation districts and other water users are analyzed in Impact WR-2. Related effects on groundwater are analyzed in Impact WR-5.

## WR-2: Change Water Supply for Irrigation Districts and Other Surface Water Users

Changes in water supply under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all users except North Unit ID;

however, the changes would occur earlier in the permit term than under the proposed action or Alternative 3 (Table 3.1-1). Changes in water supply for North Unit, Arnold, and Lone Pine IDs, described below, would be of greater magnitude than under the proposed action because of increased fall and winter releases from Wickiup Reservoir.

**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 compared to the no-action alternative. 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 dry years (Table 47 in Appendix 3.2-A). Beginning in year 6, North Unit ID's diversions would decline by 64,050 af in dry years (approximately 20% more than under the proposed action in years 21–30). 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 [a, b] pers. comm.). 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.[15] 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 normal years. However, in very dry years, 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.

**Effect Conclusion:** Changes in water supply under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all users except North Unit ID, but the changes would occur earlier in the permit term than under the proposed action or Alternative 3. Changes in water supply for North Unit ID would also occur earlier in the permit term, but changes at full implementation compared to the no-action alternative would be approximately 20% greater in magnitude during a dry water year than described for the proposed action.

## WR-3: Change Reservoir Water Surface Elevations and Flood Storage Capacity

Changes in reservoir water surface elevations under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for Crane Prairie, Ochoco, and Crescent Lake Reservoirs. Changes in Crane Prairie, Wickiup, Crescent Lake, and Prineville Reservoirs would occur earlier in the permit term than under the proposed action or Alternative 3 (Table 3.1-1).

Changes in Wickiup and Prineville Reservoir elevation and flood storage capacity are described below.

**Wickiup Reservoir.** Wickiup Reservoir would see the greatest change from increased minimum winter instream flows in the Upper Deschutes River (Conservation Measures CP-1 and WR-1). These measures would result in Wickiup Reservoir median water surface elevations becoming more variable and much likely lower, especially in years 6 through 20 as less water would be stored year-round compared to earlier periods of the permit term (Figure 73 in Appendix 3.2-A). Median

[15] 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.

reservoir water surface elevations would, on average, be 14.0 feet lower during the storage season and 12.3 feet lower during the irrigation season in years 6 through 20. Average median annual water surface elevations would be approximately 13.0 feet lower in years 6 through 20. Maximum reservoir water surface elevations would be similar (Figure 24 in Appendix 3.2-A). Average median water surface elevations would be about 3.5 feet lower relative to the proposed action in years 6 through 20.

**Prineville Reservoir.** Changes in Prineville Reservoir water surface elevations under Alternative 4 would be 0.7 feet lower and 0.3 feet lower during the storage and irrigation seasons, respectively, and 0.5 feet lower on an annual basis relative in years 1 through 5. In years 6 through 20, water surface elevations would be less than 1 foot lower year-round. Water surface elevation differences are more miniscule relative to the proposed action. The slight water surface elevation differences are related to Conservation Measure CR-1 and the accelerated minimum flow releases on the Upper Deschutes River (Conservation Measure WR-1) which requires North Unit ID to use more Crooked River water.

**Effect Conclusion:** Changes in flood storage capacity under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action. Alternative 4 would not result in an increase in median or maximum reservoir water surface elevations exceeding 90% of reservoir storage capacity. Under Alternative 4, reservoir managers would continue to have flexibility to manage the reservoirs for both irrigation storage and to minimize flood risk. Therefore, effects on flood storage capacity under Alternative 4 would not be adverse compared to the no-action alternative. Effects of changes in surface water elevations are addressed in Sections 3.3, *Water Quality*, 3.4, *Biological Resources*, 3.6, *Aesthetics and Visual Quality*, and 3.7, *Recreation*.

## WR-4: Change Seasonal River and Creek Flows

This section presents percentage change in flows under Alternative 4 compared to the no-action alternative using direct model outputs. Visual hydrographs and tables with direct model flow outputs in Appendix 3.2-A are referenced for more detail. Results are provided for normal and dry water years for years 1 through 5 and years 6 through 20 of the permit term; wet years generally have fewer streamflow differences. Appendix 3.2-A includes additional explanation for water year types.

Modeled changes in flows under Alternative 4 compared to the no-action alternative are the same or nearly the same as presented for the proposed action in the following reaches: Deschutes River between Crane Prairie and Wickiup Reservoirs and below Culver, the Crooked River below Osborne Canyon (CROO gauge), and Crescent, Whychus, Tumalo, Ochoco, and McKay Creeks.

As under the proposed action and Alternative 3, the greatest change under Alternative 4 compared to the no-action alternative is the staged increases in fall/winter minimum flows downstream of Wickiup Dam over the permit term (Conservation Measure WR-1) and the resulting decrease in irrigation season flows on the Upper Deschutes River. Under Alternative 4, however, these changes would be slightly more extreme, occur earlier in the permit term, and have an overall shorter duration (Table 3.1-1).

**Deschutes River from Wickiup Dam to the Little Deschutes River.** Implementation of Conservation Measure WR-1 would cause flows in this reach to increase during winter over the permit term. Increased minimum winter flows would result in decreased Wickiup Reservoir storage, which would decrease the amount of stored water available during the irrigation season. The

biggest change in flows would occur in years 6 through 20 during the winter storage season when more flow is released from November through March (Figure 79 in Appendix 3.2-A). Irrigation season flows would decrease 2% in a normal year and 21% in a dry year (Table 49 in Appendix 3.2-A). Winter storage flows would increase 38% in normal years and 136% (54,505 vs. 128,727 af) in dry years. Total flow volume in this reach would increase 7% in normal years and be unchanged in a dry year. Monthly flows would be less variable over the permit term, as winter storage season flows would increase and irrigation season flows would decrease. Streamflows under Alternative 4 would be proportionally greater in the winter (16%) and lower (6%) in the irrigation season relative to the proposed action, mainly due to the accelerated minimum flow schedule associated with Conservation Measure WR-1 and the impact the flow schedule has on stored water supplies in Wickiup Reservoir.

**Deschutes River from the Little Deschutes River to Benham Falls.** Implementation of Conservation Measure WR-1 would increase Upper Deschutes River minimum winter flows and begin to affect irrigation season flows with a decrease in flows occurring in July and August (Figure 81 in Appendix 3.2-A). Median flows would decrease in mid-July beginning in year 1, and further decrease by early July beginning in year 6. In dry years, the sequentially higher winter storage season minimum flows would result in decreasing irrigation season flows ranging from a decrease of 8% (years 1– 5) to a decrease of 13% (years 6– 20) (Table 51 in Appendix 3.2-A). Conversely, winter storage season flows would increase up to 23% and up to 33% in a normal year and dry year, respectively. Total flow volume in this reach would exhibit minimal change in both normal and dry years. Monthly total flow volumes would be less variable in both normal and dry water years because of higher winter flows and lower irrigation season flows. Streamflows under Alternative 4 compared to the proposed action would decline approximately 2 weeks earlier during the irrigation season, but be similar during the last period of the permit term. Alternative 4 flows would be minimally greater in the winter (4%) and be similar in the irrigation season relative to the proposed action.

**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. Like the WICO and BENO gauges, winter storage season flows are higher and irrigation season flows are lower under Alternative 4 compared to the no-action alternative (Figure 83 in Appendix 3.2-A). Storage season flow differences are relatively larger in years 6 through 20 compared to years 1 through 5. Median irrigation season flows show less difference compared to the no-action alternative. Irrigation season flows in this reach would increase by up to 6% in a normal year and increase by up to 15% in a dry year (Table 53 in Appendix 3.2-A). Winter flows would increase up to 32% in a normal year and up 41% in a dry year. Total flow volume in this reach would increase by 23% and 33% in normal and dry years, respectively. Monthly total flow volumes would be more variable in both a normal water year and dry year because of substantially higher winter flows relative to the no-action alternative. The Alternative 4 hydrographs are similar compared to the proposed action. Alternative 4 flows would be minimally greater in the winter (up to 7% difference) and be similar in the irrigation season relative to the proposed action. Annual flows would also be similar under Alternative 4 and the proposed action.

**Deschutes River from Bend to Culver.** There are no additional conservation measures for the Deschutes River between Bend and Culver under Alternative 4. 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 in Appendix 3.2-A) and proposed action. In both

years 1 through 5 and years 6 through 20, Alternative 4 results in higher winter storage season minimum and maximum flows (12% and 11% in years 6– 20) and higher irrigation season flows (15% in years 6–20) relative to the no-action alternative. Water year type and seasonal flow differences for Alternative 4 are similar when compared to both the no-action and proposed action flows.

**Crooked River Outflow from Bowman Dam.** Conservation Measure CR-1 provides guidance for Crooked River flows downstream from Bowman Dam. Under Alternative 4, Conservation Measure CR-1 includes a storage season minimum instream flow of 80 cfs in the Crooked River from Bowman Dam downstream to Lake Billy Chinook. 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 in Appendix 3.2-A). 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. The Alternative 4 hydrographs are similar compared to the proposed action, but with higher minimums and lower maximum storage season flows. Of the water year types and seasons, only the winter storage season flows in a dry year showed a moderate difference (10% increase) between Alternative 4 and the proposed action flows. Annual flows would also be similar under Alternative 4 and the proposed action, with the greatest difference occurring in dry years (3%).

**Crooked River from Bowman Dam to OR 126 Crossing.** Flow changes would be minimal in a normal year. Under Alternative 4, irrigation season median flows are higher from mid-May through early June compared to the no-action alternative in order to provide flows to meet North Unit ID irrigation needs. Minimum winter flows are higher than both the no-action alternative and proposed action, but maximum flows are lower. Alternative 4 irrigation season minimum flows are lower than the no-action alternative and proposed action, and maximum flows are similar. Streamflow volume differences between Alternative 4 and the proposed action are minor, although Alternative 4 has an 8% difference in dry years, winter storage season streamflow compared to the proposed action.

**Crooked River from North Unit ID Pump Station to Smith Rock State Park.** Under Alternative 4, irrigation season flows decrease relative to the no-action alternative as water releases to meet North Unit ID water demand reduce the available storage in Prineville Reservoir. Median flows reach baseflow levels by early July in years 1 through 5, and mid-June in years 6 through 20 (Figure 97 in Appendix 3.2-A). Irrigation season flows decrease relative to the no-action alternative flows. Alternative 4 winter minimum flows are higher (8%) and maximum flows lower (6%) than the no-action alternative flows. Like the upstream reaches, irrigation season minimum flows are lower (12%) than the no-action alternative flows. A comparison of flows by water year type and season, results in minimal differences between Alternative 4 and proposed action flows relative to the no-action alternative. The 6% difference in winter storage season flows in a dry year is the greatest difference between Alternative 4 and the proposed action flows.

**Deschutes River Flood Flows.** Alternative 4 would result in fewer days of flows exceeding flood flow thresholds measured at the WICO (2 days vs. 1 day in years 6–20) and BENO gauges (27 days vs. 18 days in years 6–20) compared to the no-action alternative (Table 62 in Appendix 3.2-A). The flood flow threshold would be exceeded approximately 3 more days per year in the vicinity of

Tumalo at the lower flood threshold of 1,400 cfs (27 days vs. 30 days in years 6–20), and decrease slightly at the 2,000 cfs flood threshold (2 days vs. 1 day in years 6–20). Alternative 4 flood flow results are similar to the proposed action.

**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, therefore, is not anticipated to increase the frequency of shallow floodplain inundation relative to the no-action alternative or proposed action.

**Effect Conclusion:** Modeled changes in seasonal river and creek flows under Alternative 4 compared to the no-action alternative illustrate the effects of accelerated winter storage releases on the Upper Deschutes River (Conservation Measure WR-1) and higher flow releases on the Crooked River to meet minimum storage season flow targets (Conservation Measure CR-1). Accelerated Upper Deschutes River winter flows draw down stored water in Wickiup Reservoir, requiring the North Unit ID to rely on Crooked River water to meet irrigation demand. As such modeled flows would be the same or nearly the same as described for the proposed action in all reaches except the Upper and Middle Deschutes River and the Crooked River, where winter storage flows would generally be higher and irrigation season flows lower compared to the proposed action and no-action alternative. Effects of the changes in streamflow described in this section are addressed in Sections, 3.3, *Water Quality,* 3.4, *Biological Resources,* 3.6, *Aesthetics and Visual Resources,* 3.7, *Recreation,* and 3.8, *Tribal Resources*.

Changes in flood flows under Alternative 4 compared to the no-action alternative would be nearly the same as described for the proposed action, but with a reduced number of days of flood flow exceedance on the Upper Deschutes River. Effects would be not adverse for the reasons described for the proposed action.

## 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, except that changes in the seepage associated with the Deschutes river segment downstream of Sunriver would occur earlier in the permit term. Effects on the groundwater recharge under Alternative 4 would be not adverse compared to the no-action alternative.

# 3.3 Water Quality

This section describes the affected environment for water quality, analysis methods, and environmental consequences for surface water quality that could result from the proposed action and alternatives.

## 3.3.1 Methods

The study area for water quality consists of reservoirs, rivers, and streams where water quality could be affected under the proposed action and alternatives, which includes all of the covered waters downstream to the confluence of Lake Billy Chinook and Prineville Reservoir (Figure 3.2-1). Effects downstream of this point, including Lake Billy Chinook, Lake Simtustus, and the Lower Deschutes were not addressed because the magnitude of the proposed changes for water quality purposes would be indiscernible relative to the size of the downstream surface water resources.[1] Inputs to the Lower Deschutes River include approximately 800 cubic feet per second (cfs) of groundwater inputs, 1,000 cfs on the Crooked River, and 1,500 cfs on the Metolius River. Other waterbodies within the Upper Deschutes River Basin were not evaluated for changes in water quality because they would not be affected by changing flows in the Deschutes or Crooked Rivers.

The Upper Deschutes River from downstream of Wickiup Dam to the confluence with Tumalo Creek was assessed quantitatively; all other waterbodies were assessed qualitatively.[2]

The affected environment was characterized using GIS-based sources including digitally mapped rivers and LiDAR data for the Deschutes and Crooked River Subbasins. Water quality data were obtained from a variety of public sources including the City of Bend, the Oregon Department of Environmental Quality (ODEQ), the Crooked River Watershed Council, U.S. Geological Survey, and the Bureau of Reclamation (Table 3.3-1). Water quality criteria assessed in this analysis were selected based on a review of existing conditions and data available for each waterbody. The available water quality data were assumed to represent baseline conditions from which to evaluate change.

[1] As described in Appendix 3.2-A, *Water Resources Technical Supplement*, the Middle Deschutes River currently represents about 20% of the mean discharge to Lake Billy Chinook after accounting for groundwater inputs to the impoundment (cf. Eilers and Vache 2019). The minimum flows under the most extreme alternative (Alternative 4, years 21–30) would result in a decrease in discharge from 623 cfs to 618 cfs during the irrigation season. The Crooked River and its tributaries receive little groundwater support. Groundwater discharge (originating from the Upper Deschutes Basin) 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.

[2] In this water quality analysis, the Upper Deschutes River refers to the reach of the Deschutes River between Wickiup Dam and Tumalo Creek because available data for the quantitative analysis extended to Tumalo Creek. This differs from the standard use of *Upper Deschutes River* as defined elsewhere in this document.

**Table 3.3-1. Water Quality Parameters of Concern in the Study Area**

| Parameter | Beneficial Use | Standard | Season | Primary Data Source |
|---|---|---|---|---|
| Temperature | Salmonid rearing and migration | 18°C | Year-round | ODEQ[b]/City of Bend[c]/ CRWC[d] |
| | Bull trout spawning and rearing | 12°C | August 15–June 15 | ODEQ/City of Bend/ CRWC/USGS |
| Dissolved oxygen | Non-spawning | 8.0 mg/L or 90% saturation | Year-round | ODEQ/City of Bend/ CRWC |
| | Spawning | 11.0 mg/L or 95% Saturation | Jan 1–May 15 | ODEQ/City of Bend/ CRWC |
| pH | Multiple uses[a] | 6.5–8.5 | Year-round | ODEQ/City of Bend CRWC / |
| Chlorophyll *a*[b] | Multiple uses[a] | 0.015 mg/L | Summer | ODEQ/City of Bend/ CRWC |
| Turbidity[c] | Multiple uses[a] | >10% NTU increase | Spring, summer | ODEQ/City of Bend CRWC |
| Sedimentation | Salmonid fish spawning, resident fish & aquatic life; salmonid fish rearing | Narrative Standard[d] | Year-round | City of Bend/ CRWC |

Source: Environmental Science Associates & MaxDepth Aquatics 2019; Crooked River Watershed Council unpublished water quality monitoring data.

[a] Includes fisheries (spawning/rearing), aquatic life, and in the case of chlorophyll and sedimentation, recreation.

[b] Not a standard criterion.

[c] Defined as increase over natural.

[d] Oregon Department of Environmental Quality, https://secure.sos.state.or.us/oard/displayDivisionRules.action?selectedDivision=1458.

The quantitative analysis method for the Upper Deschutes River involved compiling available data to define meteorology, hydrology, hydrography and water quality using a numerical model (QUAL2Kw). QUAL2Kw is a one-dimensional water quality model developed by the U.S. Environmental Protection Agency and available in the public domain (Pelletier et al. 2006). The model was developed to use input data from the RiverWare (Zagona et al. 2001) simulations, along with local climate data and water quality data provided by the Bureau of Reclamation, ODEQ, and the City of Bend. RiverWare is described in Section 3.2, *Water Resources,* and Appendix 3.2-A, *Water Resources Technical Supplement*. One of the most comprehensive data set within the study area was the water quality data collected by the City of Bend from 2008 to 2017 at 11 sites from river mile 163 to 172. This data set includes data from multiple sondes (temperature, pH, dissolved oxygen, turbidity, specific conductance) and analytical measurements from grab samples[3] (total phosphorus, ortho-phosphorus, nitrate/nitrite, total suspended solids, chloride, fluoride, sulfate, total coliform

[3] ***Grab samples*** are instantaneous sample of the water at a given time and location.

and *E. coli*). An additional major source of water quality data included data collected at several sites in the Upper Deschutes River and the Crooked River by ODEQ (Brown pers. comm.). Additional water quality data for the Crooked River was collected by the Crooked River Watershed Council. These data sets include an extensive list of parameters. The model was calibrated to be consistent with the RiverWare flow calculations and effects were assessed by comparing current model water quality output with model output derived for the proposed action and alternatives. Guidance for selection of the calibration parameters was assisted by results from similar modeling conducted on the Lower Deschutes River (Eilers and Vache 2019).

The QUAL2Kw model depends upon river shape and dimensions, as well as measured streamflow and water quality data. Water quality data is required at the headwater and at locations within the simulated reach to support model calibration. Typically, the model is calibrated to periods where observed headwater conditions (flow and water quality), as well as flow diversions, correspond to periods of internal flow and water quality data. Parameters are adjusted to ensure that the model adequately captures the observations made within the system, with different scenarios of change evaluated. However, for this analysis, the overlap of required data was unavailable. Detailed river dimensions (channel width) data were developed from available LiDAR-based Digital Elevation Models, and stream discharge and temperature observations at the headwater (Wickiup Reservoir) were available for the 2015 to 2018 period. However, diversion data were not available during the 2015 to 2018 period, and only partial water quality data was available. In addition, the RiverWare model simulations were generated from 1980 to 2009.

To accommodate the data gap, a model calibration was developed using continuous temperature and flow data to represent conditions below Wickiup Dam during the summer of 2016, along with average values for each water quality parameter from the available ODEQ data. Daily average diversion rates from the no-action alternative RiverWare simulation were used to represent diversions.

Despite these shortcomings, a reasonable calibration was achieved for most variables of note (temperature, pH, DO, conductivity, TP, $NO_3$), in part, by making use of the calibration coefficients used for the same model on the Lower Deschutes River as a starting point. Continuous water temperature and periodic water quality samples in the Upper Deschutes River below Wickiup Reservoir outflow were also used to more fully refine the calibration.

Some of the most notable changes forecasted under the alternatives would result in drawing down the stage of Wickiup Reservoir to elevation 4,290 feet for longer durations during the summer. There were only four sets of water quality samples collected from Wickiup Reservoir available for assessing potential changes to the reservoir operation. However, because of the potential importance of the increased duration of these drawdowns to water quality in Wickiup Reservoir and to the discharge water from the reservoir into the Upper Deschutes River, it was judged necessary to use the available data, in a modified form, as input to additional model runs for the Upper Deschutes River.

Management changes affect Crane Prairie and Wickiup Reservoirs, which in turn affects water quality in the river below Wickiup. Unfortunately, no mechanism was developed to estimate water quality in the reservoirs related to management changes. As a result, estimates were made to determine how the changes in water levels may impact the water quality at Wickiup. The estimate assumed 1996 represented a wet year, 2001 a dry year, and 2006 a normal year, and that drought

conditions resulted in increased concentrations of nutrients in the reservoir. The resulting matrix of water quality assumptions is outlined in Table 3.3-2.

**Table 3.3-2. Estimated Water Quality for Wet, Normal and Dry Years for Wickiup Reservoir**

| | Wet | | Normal | | Dry | |
|---|---|---|---|---|---|---|
| **Parameter** | **Surface[a]** | **Bottom[a]** | **Surface** | **Bottom** | **Surface** | **Bottom** |
| Temp (C) | 20 | 13 | 21.5 | 13 | 23.5 | 14 |
| pH (su) | 8.5 | 7.5 | 8.8 | 7.1 | 9.3 | 6.8 |
| Dissolved Oxygen (mg/L) | 8.5 | 6.5 | 8 | 5.5 | 8 | 3 |
| Chlorophyll (µg/L) | 5 | | 8 | | 11 | |
| TP (mg/L) | 0.018 | 0.06 | 0.022 | 0.07 | 0.03 | 0.1 |
| $PO_4$ (mg/L) | 0.003 | 0.035 | 0.003 | 0.04 | 0.003 | 0.05 |
| TN (mg/L) | 0.25 | 0.25 | 0.3 | 0.4 | 0.4 | 0.5 |
| $NO_3$ (mg/L) | 0 | 0 | 0 | 0 | 0 | 0 |
| $NH_3$ (mg/L) | 0 | 0 | 0 | 0 | 0.01 | 0.06 |

[a] Values represent measurements from samples collected near the surface of the lake and just above the bottom of the lake.

Assessments of change in water quality for the qualitative portion of the analysis were based on examination of the available data combined with knowledge of related processes and model forecasts of changes in flow (for rivers) and stage (for reservoirs). For pH and dissolved oxygen, anticipated changes were based on the likelihood of increases or decreases in flow, time of year and resulting anticipated changes in water temperature.

An overview of how the parameters of concern affect water quality are described below.

- **Temperature.** Water temperature is one of the most critical factors affecting aquatic organisms, most notably fish and amphibians, and is highly regulated by ODEQ. Most of the effects of temperature on aquatic organisms are detrimental when temperatures increase above thresholds for tolerance. In rivers, a decrease in discharge during the warmer months often results in increased water temperatures. The opposite pathways operate when streamflow increases. In the cold months, changes in streamflow have a more muted effect on water quality because primary production is greatly reduced and, as long as biochemical oxygen demand remains low, deviations in dissolved oxygen or pH are seldom a problem. Reservoirs can exert considerable impacts on the temperature of downstream waters. In reservoirs with a bottom withdrawal structure, such as Wickiup Reservoir, discharge waters remain cool as long as the volume of the bottom waters is adequate to supply cold water. Once the waters in the bottom layer of the reservoir are exhausted the temperature of the discharge waters can increase markedly.
- **Dissolved Oxygen and pH.** Dissolved oxygen is that oxygen that is soluble in water. Colder water allows for higher concentration of oxygen to become dissolved in water and thus available for aquatic organisms. When dissolved oxygen concentrations become low, many aquatic organisms are unable to survive. pH is related to the hydrogen ion concentration, expressing the acidity or alkalinity of a solution. Most natural waters have a pH slightly greater than 7, providing some alkalinity to water. Water quality standards for the Deschutes Basin establish an acceptable pH range of 6.5 to 8.5 for waters outside the Cascade Range. For High Cascade Lakes (not included in the study area), the pH standard is 6.0 to 8.5.

In rivers, a decrease in discharge during the warmer months (other factors remaining unchanged) often increases daytime peaks in pH and dissolved oxygen because of the increase in water temperature and the likely increase in primary production[4]. At night, pH and dissolved oxygen decrease because of the transition of algae from photosynthesis to respiration which causes oxygen to decrease. Increases in water temperature result in increased rates of algal growth (Robarts and Zohary 1987). For reservoirs, pH and dissolved oxygen in the surface waters are driven largely by primary production associated with phytoplankton, which is described below. If a lake thermally stratifies[5] in the summer, the bottom waters can become depleted in oxygen. These anoxic[6] waters promote release of nutrients back into the water column. In rivers, much of the daily change in pH and dissolved oxygen is driven by primary production associated with periphyton (benthic algae) growth. However, physical processes associated with turbulence can also alter pH and dissolved oxygen in rivers and streams. In slow-moving rivers dissolved oxygen can be removed from the water column through respiration and decomposition causing dissolved oxygen to decrease, especially at night.

**Chlorophyll *a*.** Chlorophyll *a* is a pigment in plants. There are several chlorophyll pigments, but all references here are to chlorophyll *a.* When chlorophyll is measured in water it provides a quantitative measure of the algal biomass suspended in the water. Concentrations of chlorophyll are not regulated in the same manner as temperature, pH, and dissolved oxygen. Instead, chlorophyll guidelines indicate if too much algae is present for a healthy lake or river. Moderately low concentrations of chlorophyll are generally deemed desirable because they indicate that algae are present for organisms to consume; high concentrations of chlorophyll can indicate that algae growth has become excessive and is perhaps a nuisance. Primary production in reservoirs, associated with phytoplankton, affects pH and dissolved oxygen. High biomass of algae increases the likelihood that pH and dissolved oxygen will fluctuate outside the range of water quality standards. Factors that increase the availability of nutrients (especially nitrogen and phosphorus) also increases primary production (algal growth). Holding a reservoir stage stable can present challenges because stable or stagnant conditions can be favorable for growth of cyanobacteria (Reynolds 1984). Higher water surface elevation can result in reduced algal problems in some lakes because a greater depth can reduce interactions and nutrient transfer from the sediments to the water column. Cyanobacteria (blue-green algae) species can produce cyanotoxins that pose a threat to wildlife in the affected waterbodies.

**Turbidity and Sedimentation.** Turbidity is a measure of light scattering caused by particles suspended in the water. Turbidity is important because if great enough, may harm aquatic organisms. Sedimentation is the process whereby particles suspended in the water column begin to settle out and accumulate on the lake or river bottom. Too much sedimentation can be harmful to organisms found in the stream or reservoir bottom (benthic organisms) by settling over the substrate. Turbidity, which can be caused by erosion and sedimentation or phytoplankton, reduces the amount of light able to penetrate a waterbody. If primary production in the reservoir increases, it will promote greater turbidity for transport downstream. Entrainment of fine-grained material, such as clay, can remain in the water column for extended periods and can also be transported downstream where it will remain in

[4] Primary production is the production of chemical energy in organic compounds by living organisms.

[5] Thermal stratification refers to a change in the temperature at different depths in the lake that is related to the change in water's density with temperature.

[6] Absent of oxygen

suspension and continue to inhibit transmittance of light. Reduced light associated with increased turbidity can inhibit the growth of aquatic plants and affect aquatic animal species.

Effects of the proposed action and alternatives on water quality would be considered adverse if they would result in any of the following conditions.

- Cause exceedance of applicable state or federal numeric or narrative water quality objectives or standards.
- Cause long-term degradation of water quality in one or more waterbody of the affected environment, resulting in sufficient use of available assimilative capacity such that occasionally exceeding water quality objectives or standards would be likely and would result in substantially increased risk for adverse effects on one or more beneficial uses.
- Further degrade water quality by measurable levels, on a long-term basis, for one or more parameters that are already impaired and, thus, included on the Clean Water Act Section 303(d) list for the waterbody, such that beneficial use impairment would be made discernibly worse.

## 3.3.2 Affected Environment

The Upper Deschutes River Basin is located in central Oregon and receives most of its inflow from surface and groundwater discharge emanating from the slopes of the Cascade Range. Annual precipitation declines substantially from the crest of the Cascade Range to the east side of the basin. Major headwater lakes include Odell, Crescent, Cultus, and Lava. Odell Creek flows into Davis Lake which discharges through a lava field to Wickiup Reservoir. Cultus and Lava Lakes drain into Crane Prairie Reservoir which then flows into Wickiup Reservoir. Crescent Lake Reservoir discharges into Crescent Creek, which then flows into the Little Deschutes River and joins the Upper Deschutes River downstream of the outlet from Wickiup Reservoir in the community of Sunriver. The Upper Deschutes River flows north through the City of Bend and eventually discharges into Lake Billy Chinook north of Culver. The headwater systems for the Crooked River are Prineville Reservoir and Ochoco Reservoir. The Crooked River downstream of Prineville Reservoir joins with Ochoco Creek just east of the City of Prineville. The Crooked River flows west and increases greatly in discharge from Opal Springs just before the confluence with Lake Billy Chinook.

Water quality in a typical surface waterbody is influenced by processes and activities that take place in the watershed. The quality of the surface water runoff from the study area and surrounding urban and forested areas is typical of watersheds where water quality is affected primarily by discharges from both point and nonpoint sources. Changes in seasonal magnitude of stream discharge has the potential to alter a variety of water quality variables. Changes that increase streamflow are typically associated with beneficial responses to water quality; conversely, reductions in streamflow are typically associated with adverse water quality effects. Reductions in flow that occur during summer are generally more likely to cause water quality degradation associated with increased temperature, increased pH, and greater extremes of dissolved oxygen. Changes in other variables such as chlorophyll, turbidity and nutrients are more likely to be expressed when the proportion of source-water changes. For example, a greater percentage of summer discharge from Wickiup Reservoir, assuming groundwater inputs to the Upper Deschutes River remain constant, would likely result in increased chlorophyll, turbidity, and nitrogen in the river.

The factors affecting the reservoirs include some of the same factors that affect rivers, including nutrient and organic loading. However, deeper reservoirs such as Wickiup, stratify in the warmer

months, thus inhibiting mixing between the cooler, deeper waters and the warmer surface waters. The surface waters are favorable habitat for algae and cyanobacteria because of the availability of light and warmer water temperatures for growth. This assumes that there are sufficient nutrients available to support phytoplankton growth.

Constituents of concern in the study area are identified in Table 3.3-3 by location. An "X" designates an impairment in that location for the water quality constituent. These constituents of concern are derived from classifications of water quality by ODEQ (referred to as Category 5 listings, meaning that these are listings that should be addressed under a basin TMDL).

### 3.3.2.1 Deschutes River Subbasin

**Crane Prairie Reservoir.** Crane Prairie Reservoir is fed by discharge from the Cultus Lake and Lava Lakes drainages. The Lava Lake drainage is noteworthy because of the naturally high phosphorus concentrations and frequent cyanobacterial blooms (Eilers et al. 2005). As shown in Table 3.3-3, constituents of concern are phosphorus, pH and nuisance algae. Concentrations of phosphorus are naturally high in the reservoir from weathering of volcanic rocks in the watershed (Caldwell and Tuini 1997). The reservoir has a number of introduced native and non-native fish species including rainbow trout, largemouth bass, three-spined stickleback, tui chub, black crappie and bullhead. Algal blooms, including toxic cyanobacteria, are an issue in the reservoir due to the high phosphorus levels and likely internal loading associated with introduced fish species (Schaedel 2011). There have been two reported cyanobacteria blooms since 2007 (Urness 2018) and postings for cyanobacteria in 2004 and 2005 (Oregon Health Authority 2019). However, monitoring by the U.S. Forest Service has also indicated additional cyanobacteria blooms have occurred.

**Wickiup Reservoir.** Wickiup Reservoir receives inputs from Crane Prairie Reservoir and Davis Lake, the latter which flows under/through a lava bed that dammed Odell Creek and caused the formation of Davis Lake. Additional flow from spring inputs supplement the surface inflows. Wickiup Reservoir has been posted for harmful algal bloom advisories five times between 2007 and 2018 (Urness 2018) and once in 2004 (Oregon Health Authority 2019). It is unclear if upstream sources contribute to the harmful algal blooms issues in Wickiup Reservoir, but it is noted that Odell Lake, a source water for Wickiup Reservoir, has been experiencing harmful algal blooms almost continuously since 2001 (Oregon Health Authority 2019) and cyanobacterial blooms in Crane Prairie Reservoir may affect Wickiup Reservoir. However, the available data are insufficient to demonstrate synchronization in blooms between Crane Prairie and Wickiup Reservoirs, although the August 2009 bloom in Wickiup Reservoir was preceded by a July 2009 bloom in Crane Prairie Reservoir (Oregon Health Authority 2019).

**Table 3.3-3. Water Quality Impairments in the Study Area**

| | Parameter | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Location** | **Temperature** | **Dissolved Oxygen** | **pH** | **Chlorophyll** | **Turbidity** | **Sedimentation** | **Total Dissolved Gas** | **Nuisance Algae** | **Biological Impairment** |
| **Deschutes River Subbasin** | | | | | | | | | |
| Crane Prairie Reservoir | - | - | - | - | - | -[c] | - | X | - |
| Wickiup Reservoir | - | - | - | - | - | -[c] | - | X | - |
| Upper Deschutes River | X | X | X | - | X | X[d] | - | - | - |
| Middle Deschutes River | X | X | X | X | X | - | - | - | - |
| Whychus Creek | X | - | - | - | - | - | - | - | X |
| Little Deschutes River[a] | X | X | - | - | - | - | - | - | - |
| Tumalo Creek | X | - | - | - | - | - | - | - | - |
| Crescent Lake[b] | - | - | - | - | - | - | - | - | - |
| Crescent Creek | X | - | - | - | - | - | - | - | - |
| **Crooked River Subbasin** | | | | | | | | | |
| Prineville Reservoir[b] | - | - | - | - | - | -[c] | - | - | - |
| Ochoco Reservoir | - | - | - | - | - | -[c] | - | - | X |
| Crooked River | X | - | X | X | - | - | X | - | - |
| McKay Creek | X | X | - | - | - | - | - | - | - |
| Ochoco Creek | X | - | - | - | - | - | - | - | X |

Sources: Primary source for both the Deschutes and Crooked Rivers and their impoundments is the ODEQ data (Brown pers. comm.). For the portion of the Upper Deschutes River passing through Bend, the primary source is the City of Bend (Environmental Science Associates and MaxDepth Aquatics, Inc. 2019). Supplemental data for the Crooked River and its tributaries is the Crooked River Watershed Council (Sanders pers. comm.).

[a] Does not include post-2012 data.

[b] No category 5 listings.

[c] No quantitative sediment surveys are available to assess sedimentation.

[d] Sedimentation is present in Mirror Pond, an impoundment of the Deschutes River in Bend, Oregon.

**Upper Deschutes River.** The Upper Deschutes River, for the purpose of this water quality assessment, refers to the reach between Wickiup Dam and Tumalo Creek. The drainage for the Upper Deschutes Basin is underlain by volcanic rock, largely basalt, andesite and vent deposits) which is exposed at the upper elevations and found deeper in the valley floor. The low-relief portion of the basin is comprised of alluvial and lacustrine deposits (Lite and Gannett 2002). The Deschutes River has naturally high concentrations of phosphorus derived from weathering of the underlying volcanic rocks. Groundwater in the Deschutes Basin showed that wells sampled had an average phosphate concentration of 97 µg/L and springs had concentrations ranging from 50 to 120 µg/L (Caldwell and Truini 1997). Elevated concentrations of nitrate and ammonium were observed in groundwater in the area of the Little Deschutes River extending to the Upper Deschutes River (Hinkle et al. 2007). However, ODEQ surface water data showed that concentrations of inorganic nitrogen were relatively low. Despite the elevated nitrogen concentrations in the underlying aquifers, the Upper Deschutes River still appears to be nitrogen-limited (Allan 1995). The Upper Deschutes River currently experiences periods of elevated pH (above the water quality standard of 8.5) and low dissolved oxygen (being less than 8 mg/L year round or less than 11 mg/L during spawning season). Percent saturation of dissolved oxygen also exceeds 110% in the Bend reach (Environmental Science Associates & MaxDepth Aquatics 2019). In addition, it occasionally experiences elevated turbidity, both from erosional inputs associated with bank erosion downstream of Wickiup Reservoir and from biogenic turbidity caused by release of phytoplankton from Wickiup Reservoir.

**Middle Deschutes River.** The Middle Deschutes River, for purposes of this water quality assessment, refers to the reach from Tumalo Creek to Lake Billy Chinook. The beginning of this reach has low flow during the irrigation season because much of the water is diverted for irrigation purposes in and near Bend. Flows begin to recover as discharge from springs enter the reach, especially from Spring #12, which is located near the town of Culver. This reach of the Deschutes River is listed on the 303(d) list for pH.

**Whychus Creek.** Whychus Creek is a tributary to the Deschutes River that drains the east side of the Cascades in the vicinity of the Three Sisters Wilderness. It flows in a northeasterly direction before its confluence with the Deschutes River just south of Crooked River Ranch. Whychus Creek is on the 303(d) list for elevated temperature.

**Little Deschutes River.** The Little Deschutes River originates on the east side of the Mt. Thielsen Wilderness, flows through the Deschutes National Forest and reaches the confluence of the Deschutes River between Three Rivers and Sunriver. The middle to lower reaches of the Little Deschutes River are low-gradient and exhibit considerable channel meandering. This contributes to relatively low stream velocity and low rates of reaeration. The Little Deschutes River is on the 303(d) list for temperature and dissolved oxygen.

**Tumalo Creek.** Tumalo Creek originates on the east side of Broken Top, passes through the Deschutes National Forest and joins with the Deschutes River between Bend and Tumalo. Tumalo Creek has historically been 303(d) listed as impaired for temperature, particularly in the lower reach below points of irrigation withdrawal. Current water temperatures in Tumalo Creek would be considered impaired for bull trout, however there are no bull trout in the system.

**Crescent Lake.** Crescent Lake is a natural lake with a modified outlet to allow for controlled discharge into Crescent Creek. Crescent Lake deep (285 feet) and low in nutrients with no reported water quality issues.

**Crescent Creek.** Crescent Creek originates at the controlled outlet of Crescent Lake (a surface outlet). Crescent Creek flows east and reaches its confluence with the Little Deschutes River just north of Little River. Crescent Creek is on the 303(d) list for temperature.

#### 3.3.2.2 Crooked River Subbasin

**Prineville Reservoir.** Prineville Reservoir experiences a high degree of turbidity associated with influx from drainage in a region with low moisture. The high turbidity is an impediment to algal blooms because of light limitation to the phytoplankton. The surface layer of the reservoir gradually becomes more transparent over the summer, but the bottom layer remains turbid. Low light associated with turbidity may retard the growth of plankton algae. Cyanobacteria blooms are delayed until autumn, and may be related to turbidity. (Johnson et al. 1985).

**Ochoco Reservoir.** Ochoco Reservoir was classified as eutrophic by Johnson et al. (1985). Although the reservoir has not been posted for harmful algal blooms, it appears it is susceptible to high algal production. Johnson et al. (1985) reported blooms of the cyanobacterium *Aphanizomenon flos-aquae,* which is likely related to high concentrations of total phosphorus reported for the lake (0.059 mg/L).

**Crooked River.** The Crooked River, for the purpose of this assessment, originates from the discharge of Prineville Reservoir to Lake Billy Chinook. The Crooked River is described by ODEQ as having poor water quality and is on the 303(d) list for dissolved oxygen, temperature, biological criteria, flow modification, *e. coli*, pH, and total dissolved gas (Oregon Department of Environmental Quality 2016). Additionally, the Crooked River has high concentrations of nitrogen and phosphorus as reported by both ODEQ and the Crooked River Watershed Council.

**McKay Creek.** McKay Creek originates in the Ochoco National Forest north of the City of Prineville and flows south where it joins with the Crooked River. McKay Creek does not meet water quality standards for temperature.

**Ochoco Creek.** Ochoco Creek originates in the Ochoco National Forest and flows west to Ochoco Reservoir. The outlet from Ochoco Reservoir is the source for Ochoco Creek as it flows toward Prineville where it intersects the Crooked River upstream of the confluence of McKay Creek/Crooked River. Ochoco Creek is on the 303(d) list for temperature and biological impairment.

### 3.3.3 Environmental Consequences

#### 3.3.3.1 Alternative 1: No Action

Continuation of existing water management operations under the no-action alternative would result in continuation of existing water quality conditions over the analysis period, including impairments identified in Table 3.3-3. However, climate change, ongoing development, river restoration actions, and water conservation under the no-action alternative would affect water quality over the analysis period. The degree to which these processes offset one another is currently uncertain.

Changes in climate assumed under the no-action alternative are expected to increase mean annual temperature and decrease annual precipitation, as described in Section 3.2. This would likely increase cyanobacteria blooms in the study area reservoirs because of the positive association between water temperature and favorable cyanobacteria habitat (Paerl and Huisman 2008). Water temperatures in the rivers and creeks also are expected to increase as a result of warming in the

reservoirs and greater heat transfer from atmospheric warming during river flow. Increased water temperature would also increase the likelihood of increased ***periphyton*** (attached algae) growth. All of these gradual changes would likely increase pH and daytime concentrations of dissolved oxygen and nighttime reductions in dissolved oxygen, possibly resulting in exceedances of water quality standards. These changes are expected to be proportional to the increases in air temperature and decreases in precipitation. Effects may be greater in the Crooked River Subbasin because the subbasin has lower permeability and fewer springs[7] and less recharge. Also, because the subbasin has less precipitation, relatively small increases in annual air temperature (and associated increases in evaporation) and decreases in summer precipitation, greater effects on water temperature and streamflow could occur.

Continued population growth and development in the basin over the analysis period could increase the disturbance of land cover and increase the delivery of nutrients to study area waters. This often occurs through an increase in impervious surfaces, thus promoting increased runoff. The four counties in the Deschutes Basin (Crook, Deschutes, Jefferson, and Wasco) have experienced steady population growth over the past 50 years. Growth is expected to continue, especially for Deschutes County, over the analysis period. Increased delivery of nutrients, particularly nitrogen, is expected to increase the algal growth in study area waters. Most soils in the region have high infiltration rates, allowing inorganic nitrogen to infiltrate into aquifers, while other nutrients, such as phosphorus, attach to soil particles and subject to transport by sediment transport such as erosion. Nitrogen is often the nutrient most likely to limit algal growth in rivers and streams in the basin so any action that contributes additional nitrogen to the river could lead to increased growth of algae. The other nutrient that is often associated with limiting algal growth is phosphorus. Phosphorus would play a critical role in phytoplankton growth in the lakes and reservoirs of the study area but is not expected to greatly alter algal growth in the rivers and streams. The export of nutrients from agriculture may be offset by expected improvements and efficiencies in agricultural practices in the basin.

Increased development often results in increased demand for water associated with industrial/commercial operations and residential use for household and landscaping applications. In addition, development could result in increased urban runoff. The largest municipality in the basin, the City of Bend, obtains approximately half of its water supply from surface water from the Tumalo Creek watershed and the other half from groundwater from the Deschutes Regional Aquifer. Long-term demands are likely to be met through additional groundwater pumping. Development in unincorporated areas is expected to meet water needs through current infrastructure and groundwater sources. The effect is expected to be an increase in groundwater pumping and decrease in groundwater discharges to the Deschutes River. However, as described in Section 3.2, Water Resources, with mitigation required under the Deschutes Groundwater Mitigation Program, future groundwater pumping is not expected affect streamflows. Therefore, increased groundwater pumping is not anticipated to have effects on water quality.

Water conservation projects assumed under the no-action alternative—the Swalley Irrigation District (ID) Irrigation Modernization Project and the Tumalo ID Irrigation Modernization Project—would increase flows to the Middle Deschutes River compared to existing conditions, as described in Appendix 3.2-A, *Water Resources Technical Supplement*, under *No-Action Alternative, Water*

[7] An exception is Opal Springs, which discharges about 1,100 cfs; however, this spring is located near the confluence of the Crooked River and Lake Billy Chinook, so only supports the lowest reach of the river.

*Conservation Projects*. Increased flows could improve temperature and other water quality constituent conditions.

Restoration projects being pursued by the Crooked River Watershed Council assumed under the no-action alternative, which are primarily in the Crooked River Subbasin, are expected to improve water quality over the permit term. Projects developed for the City of Prineville wastewater treatment wetlands would improve water quality in the Crooked River by reducing the discharge of nitrogen, phosphorus, suspended solids (contributing to turbidity), and biochemical oxygen demand. Reduction in discharge of nutrients reduces growth of algae in the river bottom, thereby reducing the daily fluctuations in pH and dissolved oxygen. Reduction in suspended solids increases water transparency and improves the aesthetic property of water. Reduction of biochemical oxygen demand reduces the amount of oxygen that is consumed by bacteria in water; bacteria consume oxygen in water during the process of decomposing organic wastes. The river restoration projects in the Deschutes River Subbasin assumed under the no-action alternative would improve water quality by stabilizing stream banks and thus increasing water transparency. Suspended solids also contain phosphorus which can become available to aquatic plants when transported in water.

**Effect Conclusion:** Continuation of ongoing water management operation and maintenance of covered facilities under the no-action alternative is expected to have little effect on water quality in the study area compared to existing conditions. Water quality impairments identified in Table 3.3-3 would continue in basin waterbodies. Potential negative effects on water quality associated with climate change and ongoing development in the basin would likely be offset somewhat by beneficial effects associated with water conservation and river restoration projects assumed under the no-action alternative over the analysis period. Overall, the effect on water quality would be adverse because water quality impairments would not improve appreciably, and potential effects from climate change and land development would continue.

### 3.3.3.2 Alternative 2: Proposed Action

The effects of the proposed action are described in comparison to the no-action alternative.

#### WQ-1: Affected Water Quality in Deschutes River Subbasin

There would be no change to flows in Whychus Creek or Tumalo Creek and changes in water elevation in Crescent Lake Reservoir and associated changes in flows in Crescent Creek and the Little Deschutes River would be minor. As such, these waterbodies would not experience measurable changes in water quality conditions.

**Crane Prairie Reservoir.** A more stable water surface elevation would be maintained at the reservoir under the proposed action (Conservation Measure CP-1). On average, the maximum storage volume during the storage season would increase by 4.9%, while maximum irrigation season storage would decrease by 1.1%. The change in storage volume during winter would have little effect on water quality in the reservoir, but holding a stable surface water elevation from mid-January to mid-July (an additional 2.5 months) would increase the length of uninterrupted time water is present in the reservoir, and reduce water movement. This could result in greater surface temperatures and reduced circulation, providing a more favorable habitat for cyanobacteria (Paerl and Huisman 2008) that could increase the duration and intensity of blooms. When greater reservoir drawdown occurs during summer months cyanobacteria blooms could be inhibited. For example, Ochoco Reservoir has high concentrations of phosphorus (Johnson et al. 1985), yet it has not been posted for cyanobacteria problems, possibly because the water surface elevation declines

steadily through the irrigation season. However, no agency has allocated the resources to sample Ochoco Reservoir to regularly post for harmful algal blooms. One factor that may minimize cyanobacteria blooms in Crane Prairie Reservoir is that reservoir stage from mid-July through the fall would continue to decline at a time when cyanobacteria blooms have a greater probability of developing (Oregon Health Authority 2019). Additional depth in a reservoir can minimize cyanobacterial blooms by reducing interactions between the sediment and the water column. A stable surface water elevation can promote hydrodynamic stability and decrease the probability of cyanobacterial blooms. These opposing processes preclude determining whether the frequency or duration of cyanobacterial blooms in Crane Prairie will be altered under the proposed action.

**Deschutes River between Crane Prairie Reservoir and Wickiup Reservoir.** River flows in this reach are not expected to substantially change. Therefore, no measurable water quality effects are expected. If cyanobacteria blooms in Crane Prairie Reservoir cause export of cyanobacteria downstream, this reach could experience an increase in river turbidity and may increase daily variations in pH and dissolved oxygen. These potential water quality effects are considered relatively minor and not possible to predict with the available information.

**Wickiup Reservoir.** Wickiup Reservoir has been subject to cyanobacteria blooms (4 in the past). The listings occurred in the months of September and October, suggesting that the likely period for Wickiup Reservoir to experience cyanobacteria blooms occurs late in the season when surface water elevation is low. Some of the most intense cyanobacterial blooms in Wickiup Reservoir occurred at low pool (Gritzner pers. comm. 2019). Remote sensing of chlorophyll a concentrations in Wickiup Reservoir also indicates blooms starting in early August and continuing into mid-October (Schaedel 2011). One documented mid-summer bloom in Wickiup Reservoir in 2009 occurred shortly after a bloom on Crane Prairie Reservoir, which suggests that water quality challenges in Crane Prairie Reservoir could lead to a similar response in Wickiup Reservoir. It is unknown if these two cyanobacterial blooms are independent or if the Wickiup Reservoir bloom was initiated by "seeding" of cyanobacteria from Crane Prairie Reservoir. The most recent available data for Wickiup Reservoir (BLM, unpublished data) were collected during July of different years and provide little indication regarding how the water chemistry in Wickiup Reservoir changes during the summer and fall.

Water quality data available for Wickiup Reservoir[8] (Table 3.3-4 and Figure 3.3-1) were used to understand how water quality has responded to historical reservoir operations and to infer how proposed operations would affect water quality. Although these data provide only a snapshot of water quality conditions in Wickiup Reservoir, reservoirs with these types of conditions generally behave in a predictable manner. As shown in Table 3.3-4 and Figure 3.3-1, water quality in the reservoir has responded as follows to historical operations:

- Concentrations of phosphorus are moderate.
- Although dissolved oxygen concentrations decline with depth, they remain greater than 3 mg/L (Figure 3.3-1). If dissolved oxygen concentrations in the bottom waters remain well above 0 mg/L, dissolution of phosphorus from the bottom waters would not occur to any significant degree and the potential for blooms would remain moderate.
- Surface pH values measured at a depth of 1 meter exceed water quality standards (pH 8.5).

[8] Wickiup Reservoir has been sampled four times (all in July) from 2007 to 2016 (every third year, Bureau of Reclamation unpublished data).

- Chlorophyll concentrations in the samples were less than ODEQ guidelines for surface waters; however, no water samples were collected from the reservoir during its postings for the presence of harmful algal blooms.

Based on these responses to historical operations, lower water surface elevations throughout the year under the proposed action are expected to result in increases in the frequency and duration of exceedances in dissolved oxygen, pH, chlorophyll, turbidity, nuisance algae, and potentially increased cyanobacteria blooms.

**Table 3.3-4. Water Quality Measurements for Wickiup Reservoir, 200 m South of Dam (All samples collected in July)**

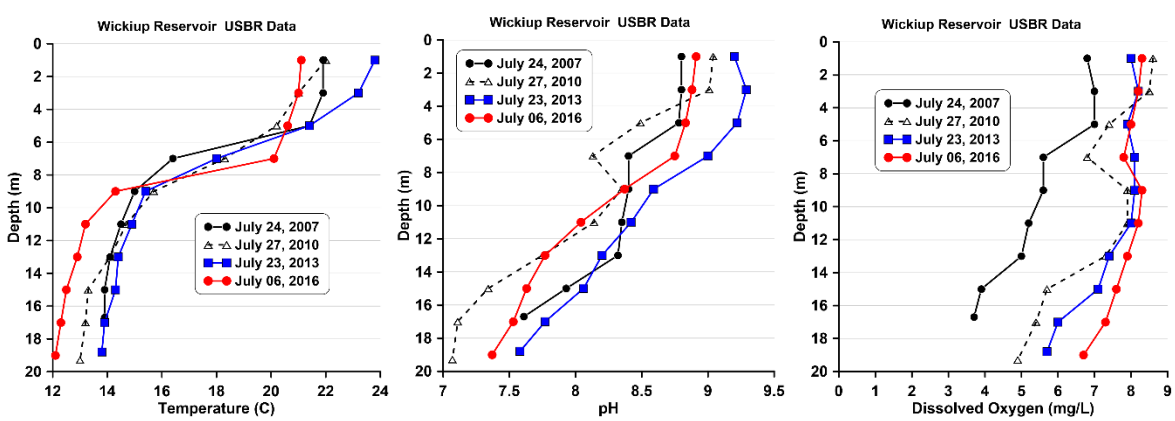
| Parameter | Units | 2007 | | 2010 | | 2013 | | 2016 | |
|---|---|---|---|---|---|---|---|---|---|
| Depth | m | 1 | 16.7 | 1 | 19.3 | 1 | 18.8 | 1 | 19 |
| Temp | ˚C | 21.9 | 13.9 | 22 | 13 | 23.8 | 13.8 | 21.1 | 12.1 |
| pH | su | 8.8 | 7.61 | 9.04 | 7.07 | 9.2 | 7.58 | 8.91 | 7.37 |
| Dissolved oxygen | mg/L | 6.8 | 3.7 | 8.6 | 4.9 | 8 | 5.7 | 8.3 | 6.7 |
| Chlorophyll[a] | µg/L | 6.3 | - | 9.3 | - | 6 | - | 7.3 | - |
| Secchi[a] | m | 3 | - | 4.4 | - | 3.3 | - | 3.2 | - |
| TP | mg/L | 0.018 | 0.127 | 0.02 | 0.071 | 0.02 | 0.082 | 0.03 | 0.07 |
| $PO_4$ | mg/L | 0.002 | 0.04 | 0 | 0.036 | 0 | 0.042 | 0 | 0.039 |
| TKN | mg/L | 0.4 | 0.25 | 0.29 | 0.26 | 0.33 | 0.19 | 0.35 | 0.3 |
| $NO_3$ | mg/L | 0.005 | 0.005 | 0.01 | 0.005 | 0.01 | 0.005 | 0.01 | 0.01 |
| $NH_3$ | mg/L | NA | NA | NA | NA | 0.01 | 0.06 | 0.01 | 0.09 |

Source: Monek pers. comm.

[a] Values apply to the entire water column.

TP = total phosphorus; PO4 = ortho-phosphorus; TKN = total Kjeldahl nitrogen; $NO_3$ = nitrate; $NH_3$ = ammonia; NA = data not available.

**Figure 3.3-1. Water Quality Profiles Collected 200m South of Wickiup Dam, 2007–2016**




**Upper Deschutes River.** Impacts on water quality in the Upper Deschutes are based on modeled output for flow and related water quality parameters at the BENO gauge (Deschutes River at Benham Falls) and DEBO gauge (just north of Bend and after major irrigation withdrawals have reduced streamflow) as well as data considered for Wickiup Reservoir described above.

Increasing discharge in the colder months would minimize the chances of concentrations of dissolved oxygen dropping to low levels. Greater flows would result in reduced interaction between sediment in the river and the overlying water because of a greater ratio of water volume to sediment area. Additionally, greater winter flows would increase stream velocity, which promotes greater rates of reaeration.

Decreased summer flows during dry years would increase water temperature and promote greater daily increases in pH and dissolved oxygen because of increased periphyton growth. Greater periphyton density could also occur as a result of a reduction in "flood flow" frequency under the proposed action starting in year 11 of the permit term (*WR-4: Change Seasonal River and Creek Flows* in Section 3.2). A reduction in flood flow frequency could affect water quality by allowing periphyton growth to continue unabated longer than might normally be the case (Biggs 2000). A potential benefit of a reduction in high flow events is reduced bank erosion, turbidity, and sediment transport. However, high flow events in the Deschutes Basin are muted compared to other areas of Oregon because of the moderating effect of the high infiltration rates in much of the contributing area. Greater periphyton density resulting from long periods of stable flow regimes could be a contributor to increased daily variation in pH and dissolved oxygen.

Downstream of confluence with Fall River, the river gains additional flow. Additional inputs come from Little Deschutes River, and further downstream, discharge from Spring River and other groundwater sources in the Sunriver area. Although the river loses about 90 cfs between Sunriver and Bend (Gannett et al. 2001), the influence of spring inputs remains important. Through Bend, the flows decrease dramatically as a consequence of the irrigation withdrawals; however, the Bend to Culver reach experiences considerable groundwater input and flows recover and remain relatively stable, especially towards the lower end of this reach. In reaches where the proportion of groundwater flow increases relative to discharge from Wickiup Reservoir, it is expected that the proposed action would result in little change in water quality. This includes the reach of river from Wickiup Reservoir to Benham Falls. Flows from upstream of Bend to downstream of Bend (roughly RM172 to RM163) will continue to experience depleted flows because of withdrawals from COID (near RM171 and the North Canal Dam near RM165). Discharge of the Middle Deschutes River increases slightly with the input from Tumalo Creek (RM160) but does not achieve significantly greater flows under spring inputs in the vicinity of Steelhead Falls and BLM Spring #12. Though there may be a net loss of flow during the driest years, the stabilizing effect of groundwater input would help to maintain a reasonably stable water temperature; by extension, pH and dissolved oxygen would likely respond in a similar manner. To more fully outline this response, model results representing the year 2006, which was an unusually dry period, are presented in Figure 3.3-3. A dry year was selected because it results in largest simulated effects on water quality. These results were taken from simulations representing conditions in the summer of 2006 and compared the no-action alternative. Results outline changes in summer discharge that do not markedly increase temperature, but do show small increases in pH and dissolved oxygen, as well as periphyton. In short, the potential negative effect of lower summer flows is offset by the streamflow consisting of a lower proportion of water from Wickiup Reservoir, or inversely, a higher proportion of cold water from springs.

**Figure 3.3-2. Percentage of Water Derived from Wickiup Reservoir under Current Calibrated Flow Conditions for Several Locations Downstream of the Reservoir for the Period (April–December)**

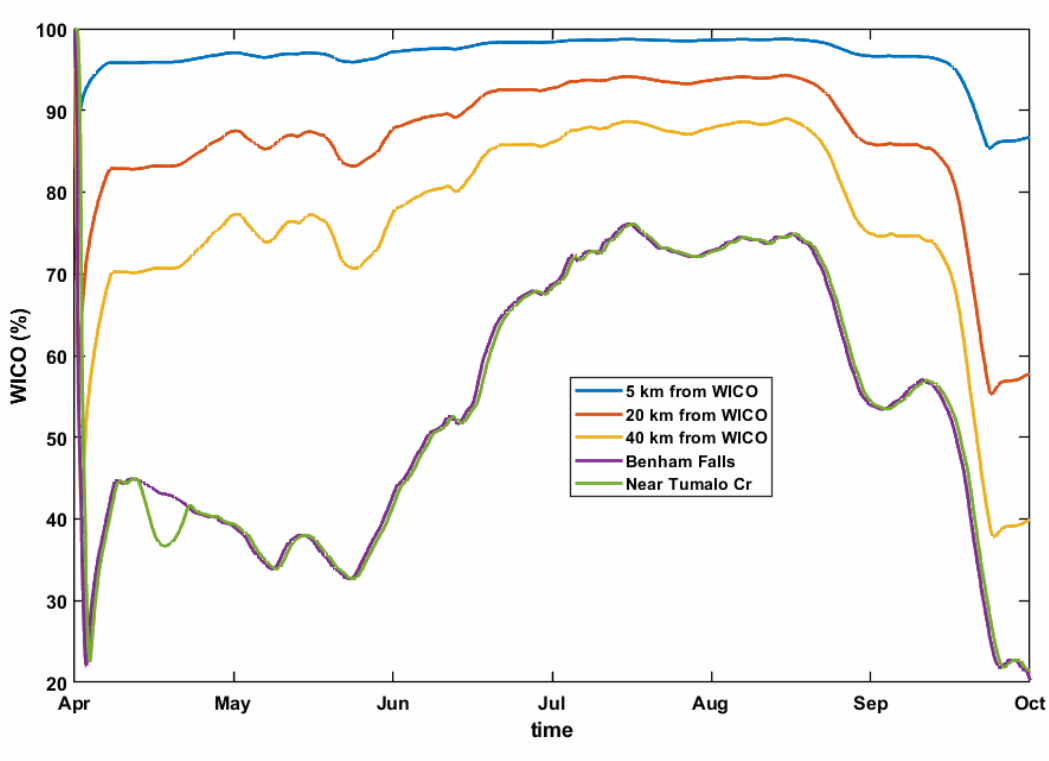
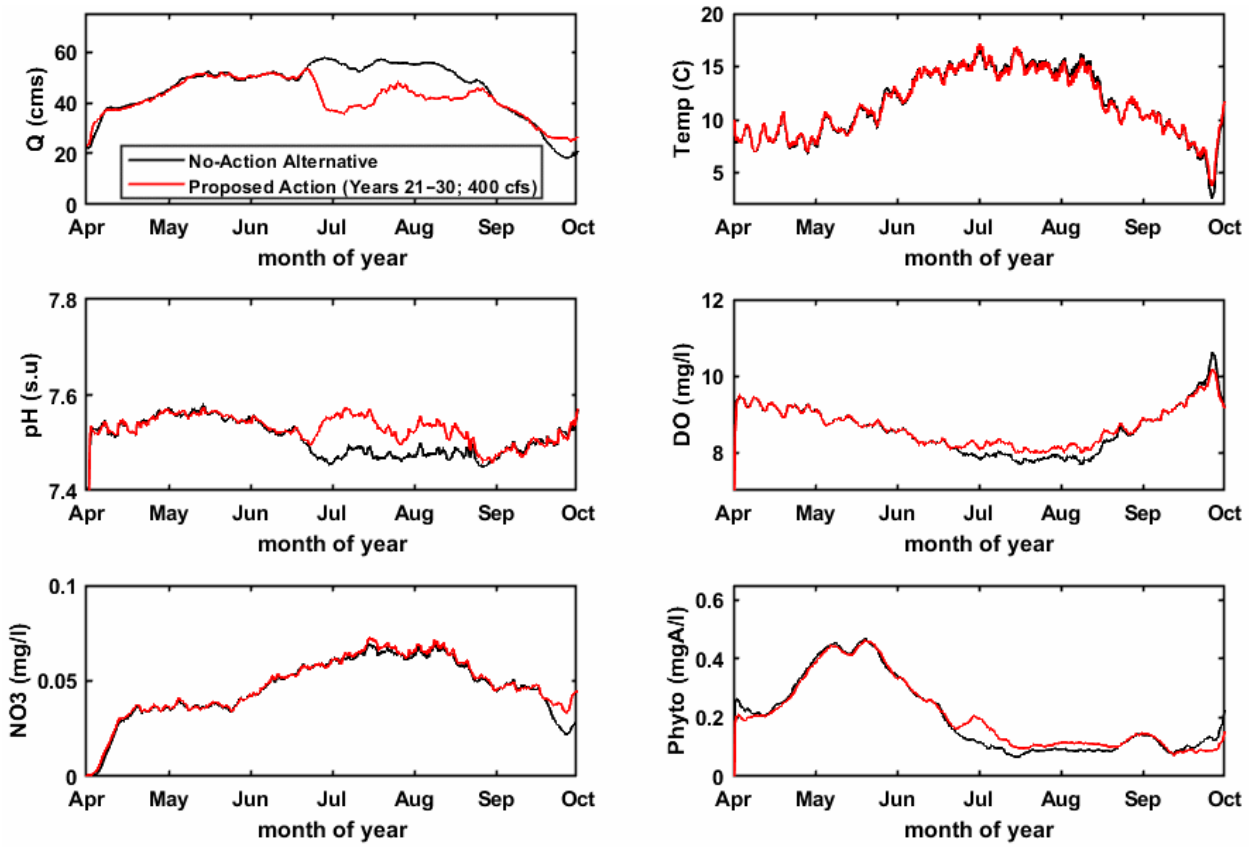


**Figure 3.3-3. Simulated Stream Discharge, Water Temperature, and Water Quality Parameters from the BENO Gauge**




**Middle Deschutes River.** Effects on water quality in the Middle Deschutes River reach (from north of Tumalo Creek to Culver) are expected to be modest because this reach experiences considerable groundwater inputs, particularly in the lowest (northern) portion of the reach, that would reduce water quality effects of the proposed action. The upstream reach of the Middle Deschutes River may experience a decrease in water quality during the summer (increased daytime temperature, pH and dissolved oxygen) because it has less groundwater discharge input to offset effects of reductions in flow. These changes are likely to be small and, therefore, are expected to be not adverse.

**Effect Conclusion:** The proposed action would have no detectable effect on Whychus Creek, the Little Deschutes River, Tumalo Creek, and Crescent Lake Reservoir compared to the no-action alternative. Crane Prairie Reservoir could experience increases in daytime temperature, dissolved oxygen, pH, chlorophyll, turbidity and nuisance algae as a result of changes in reservoir volume and surface water elevation. The surface waters of Wickiup Reservoir are expected to exhibit daytime increases in pH, dissolved oxygen, chlorophyll, turbidity, and nuisance algae. The bottom waters of Wickiup Reservoir are expected to experience decreases in dissolved oxygen and pH. The changes in Wickiup Reservoir would likely occur because of a lowered surface water elevation during the summer causing greater sediment/water interactions and release of nutrients from the sediment as oxygen in the bottom layer becomes depleted. This would supply additional nutrients to support elevated density of phytoplankton. In the Upper Deschutes River, changes in temperature, pH, dissolved oxygen, nitrate or phytoplankton (from Wickiup Reservoir) would be minor, as potential effects of decreased flows downstream of Wickiup Reservoir during irrigation season would be

offset by a higher percentage of flow from springs and groundwater input. A reduction in peak flows (i.e., a more stable hydrograph) would be expected to reduce streambank erosion along the Upper Deschutes River and reduce turbidity associated with inorganic sources; turbidity from organic sources (phytoplankton from Wickiup Reservoir) would be expected to offset this gain. Effects on the Middle Deschutes River would be small and, therefore, not adverse. Cyanobacteria blooms could increase in Crane Prairie Reservoir, but data are not sufficient to confidently confirm. Increased blooms are more likely in Wickiup Reservoir as a result of reducing to minimum surface water elevation for a longer period in summer and into fall. If blooms in Wickiup Reservoir were discharged to the Upper Deschutes River, they could affect these reaches; however, the likelihood of such an event is undetermined. Increased bloom frequency in Wickiup Reservoir would negatively affect water quality in the Upper Deschutes River (Table 3.5-5). Overall, water quality effects in the Upper Deschutes River Subbasin are expected to be adverse because of the effects on Wickiup and, to a lesser extent, Crane Prairie Reservoirs, the potential to export cyanobacteria downstream into the Upper Deschutes River, and variable temperature effects on some reaches of the Upper Deschutes River during summer months.

## WQ-2: Affect Water Quality in the Crooked River Subbasin

**Prineville Reservoir.** Prineville Reservoir water surface elevation is expected to be lower because of increased use of Crooked River water and increased minimum flows in the winter below the reservoir. However, Prineville Reservoir is deep (maximum depth of 130 feet) and is highly turbid from suspended inorganic material. Consequently, the reduced elevation (forecasted maximum of 0.6 foot) is expected to have no effect on water quality constituents in the reservoir.

**Crooked River.** Decreased irrigation season flows below Bowman Dam (PRVO gauge) by 10% for dry water years in years 1 through 5 would result in adverse effects on water quality. Smaller decreases in flows in normal and wet years would result in lesser effects that would not be adverse. Irrigation season flows downstream of the North Unit ID pumps (CRSO gauge) to Smith Rock State Park would increase slightly in years 1 through 5 but decrease in years 21 through 30 (as much as 8% in normal water years); this would likely result in adverse effects on water quality (increased daytime temperature, pH, and dissolved oxygen) in this reach. Elsewhere on the Crooked River, there would be no effect on water quality.

**Ochoco Reservoir.** Small changes in median and maximum water surface elevation in Ochoco Reservoir are expected to have no effect on water quality.

**Ochoco and McKay Creeks.** Small increases in flow would likely have a small beneficial effect on water quality.

**Effect Conclusion:** Small changes in Prineville and Ochoco Reservoir water elevations under the proposed action compared to the no-action alternative would result in no discernable effect on water quality in these reservoirs. Small increases in flow in Ochoco and McKay Creeks would likely have a small beneficial effect on water quality. Decreased irrigation season flows below Bowman Dam in years 1 through 5 and between the North Unit ID pumps and Smith Rock State Park in years 21 through 30 would have an adverse effect on water quality in those reaches during those stages of the permit term. Overall, effects of the proposed action on water quality in the Crooked River Subbasin would be not adverse compared to the no-action alternative because adverse effects on the Crooked River would be limited to two reaches during certain water year types and stages of the permit term and would be offset somewhat by benefits in Ochoco and McKay Creeks.

### 3.3.3.3 Alternative 3: Enhanced Variable Streamflows

#### WQ-1: Affect Water Quality in Deschutes River Subbasin

Modeled changes in streamflows and surface water elevations and variability and related water quality effects under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action for all reaches in this subbasin, except effects on Wickiup Reservoir and the Upper Deschutes River below Wickiup Reservoir would occur earlier in the permit term.

**Effect Conclusion:** Effects of Alternative 3 on water quality in the Deschutes River Subbasin compared to the no-action alternative would be the same as described for the proposed action, except that effects on Wickiup Reservoir and the Upper Deschutes River below Wickiup Reservoir would occur earlier in the permit term.

#### WQ-2: Affect Water Quality in Crooked River Subbasin

Changes in streamflows and surface water elevations and variability under Alternative 3, compared to the no-action alternative, and their related effects on water quality in the Crooked River Subbasin would be the same as described for the proposed action for all reaches except for the Crooked River between the North Unit ID pumps and Smith Rock State Park. Instream protection of uncontracted releases from Prineville Reservoir past the pumps would generally result in higher minimum flows between the North Unit ID pumps and Smith Rock State Park during the irrigation season compared to the no-action alternative and proposed action; however, total monthly irrigation seasons flows in this reach would both increase and decrease over the permit term depending on water year type. The resulting effects on stream temperature, pH, and dissolved oxygen in this reach would therefore be both slightly beneficial and slightly adverse depending on the water year type and stage in the permit term and would essentially result in no net effect on water quality in the Crooked River.

**Effect Conclusion:** Effects of Alternative 3 on water quality in the Crooked River Subbasin compared to the no-action alternative would be the same as described for the proposed action, except on the Crooked River, where a combination of slight increases and decreases in flows between the North Unit ID pumps and Smith Rock State Park depending on the water year type and stage of the permit term, would result in no net effect on water quality. Overall, effects of Alternative 3 on the Crooked River Subbasin would be slightly beneficial because of slight benefits in Ochoco and McKay Creeks and because there would be no net effects in the remainder of the subbasin compared to the no-action alternative.

### 3.3.3.4 Alternative 4: Enhanced and Accelerated Variable Streamflows

#### WQ-1: Affect Water Quality in Deschutes River Subbasin

Modeled changes in streamflows and surface water elevations and variability and related water quality effects under Alternative 4 compared to the no-action alternative would be the same as described for the proposed action for Crane Prairie Reservoir, Crescent Creek, the Little Deschutes River, Tumalo Creek, and Whychus Creek. Effects in Wickiup Reservoir and the Upper and Middle Deschutes River under Alternative 4 in years 1 through 5 compared to the no-action alternative would be the same as under the proposed action in years 11 through 20; effects in these

waterbodies in years 6 through 20, described below, would be similar to the proposed action in years 21 through 30 but of greater magnitude.

**Wickiup Reservoir.** Wickiup Reservoir elevations would decline under Alternative 4 at full implementation (years 6–20) would decline on average by 23 feet during the storage season and 29 feet during the irrigation season compared to the no-action alternative (approximately 30% more of a decrease than under the proposed action and Alternative 3). This increases the likelihood that the bottom waters would become anoxic, an effect that would solubilize material in the sediment including phosphorus. This would also increase the period in which the reservoir is maintained at a stable, low pool that is more favorable for cyanobacteria and high pH in the surface waters. The cyanobacteria not only promote high pH and dissolved oxygen in the surface waters, but can pose a threat to wildlife, pets and humans who encounter toxigenic species. The probability of increased cyanobacteria in Wickiup Reservoir remains uncertain under this alternative. The water quality profiles of Wickiup Reservoir (Figure 3.3-2) show that Wickiup Reservoir currently exceeds water quality standards for pH and the declining concentrations of dissolved oxygen in the bottom waters indicate a propensity for oxygen depletion in the bottom waters. Cyanobacteria blooms in Wickiup Reservoir could result in transport of cyanobacteria to the Upper Deschutes River.

**Upper Deschutes River.** Irrigation season flows would also decrease under Alternative 4 at full implementation (years 6–20) compared to the no-action alternative more greatly than under the proposed action and Alternative 3, resulting in increased temperature, pH and dissolved oxygen for a short distance in the reach downstream from Wickiup Reservoir. It could also result in increased transport of cyanobacteria and related effects from Wickiup Reservoir if they were to occur in the reservoir. Other water quality effects would be the same as described for the proposed action.

**Middle Deschutes River.** The effects on water quality in the Middle Deschutes River reach north of Tumalo Creek to Culver are expected to be similar to those of the proposed action because this reach experiences considerable groundwater inputs that would offset water quality effects.

**Effect Conclusion:** Modeled changes in streamflows and surface water elevations and variability and related water quality effects under Alternative 4 compared to the no-action alternative would be the same as described for the proposed action for Crane Prairie Reservoir, Crescent Creek, the Little Deschutes River, Tumalo Creek, and Whychus Creek. Effects in Wickiup Reservoir and the Upper and Middle Deschutes River under Alternative 4 in years 1 through 5 compared to the no-action alternative would be the same as under the proposed action in years 11 through 20; effects in the Middle Deschutes would be minor, as described under the proposed action, because of the influx of groundwater. In years 6 through 20, effects on Wickiup Reservoir and the Upper Deschutes River under Alternative 4 would be similar to the proposed action in years 21 through 30 but would be more likely and of greater magnitude. Overall effects would be adverse for the same reasons described for the proposed action. Adverse effects in Wickiup Reservoir and Upper Deschutes River would be of greater magnitude than under the proposed action or Alternative 3.

## WQ-2: Affect Water Quality in Crooked River Subbasin

Modeled changes in streamflows and surface water elevations and variability and related water quality effects under Alternative 4 compared to the no-action alternative would be the same as described for the proposed action for Ochoco Reservoir and Ochoco and McKay Creeks. While decreases in Prineville Reservoir elevations would be slightly greater than under the proposed

action, there still would be no effect on water quality because of the depth of Prineville Reservoir and its high turbidity.

On the Crooked River, although Alternative 4 would result in increased storage season flows during dry years in most reaches, during irrigation season it would result in decreased minimum flows in all reaches and decreased total monthly in most reaches and most water year types throughout the permit term. Therefore, effects on water quality in the Crooked River, especially temperature, pH, and dissolved oxygen under Alternative 4 compared to the no-action alternative, would be adverse. These adverse effects would be greater than under the proposed action.

**Effect Conclusion:** Effects of Alternative 4 on water quality in the Crooked River Subbasin compared to the no-action alternative would be the same as described for the proposed action, except for in the Crooked River. Alternative 4 would result in decreased irrigation season flows in all reaches of the Crooked River over the permit term that would result in adverse effects on water quality. Overall, Alternative 4 would have an adverse effect on water quality because adverse effects in the Crooked River would outweigh beneficial effects on Ochoco and McKay Creeks.

# 3.4 Biological Resources

This section describes the affected environment for biological resources and effects on biological resources that would result from the proposed action and alternatives.

## 3.4.1 Methods

### 3.4.1.1 Vegetation and Wildlife

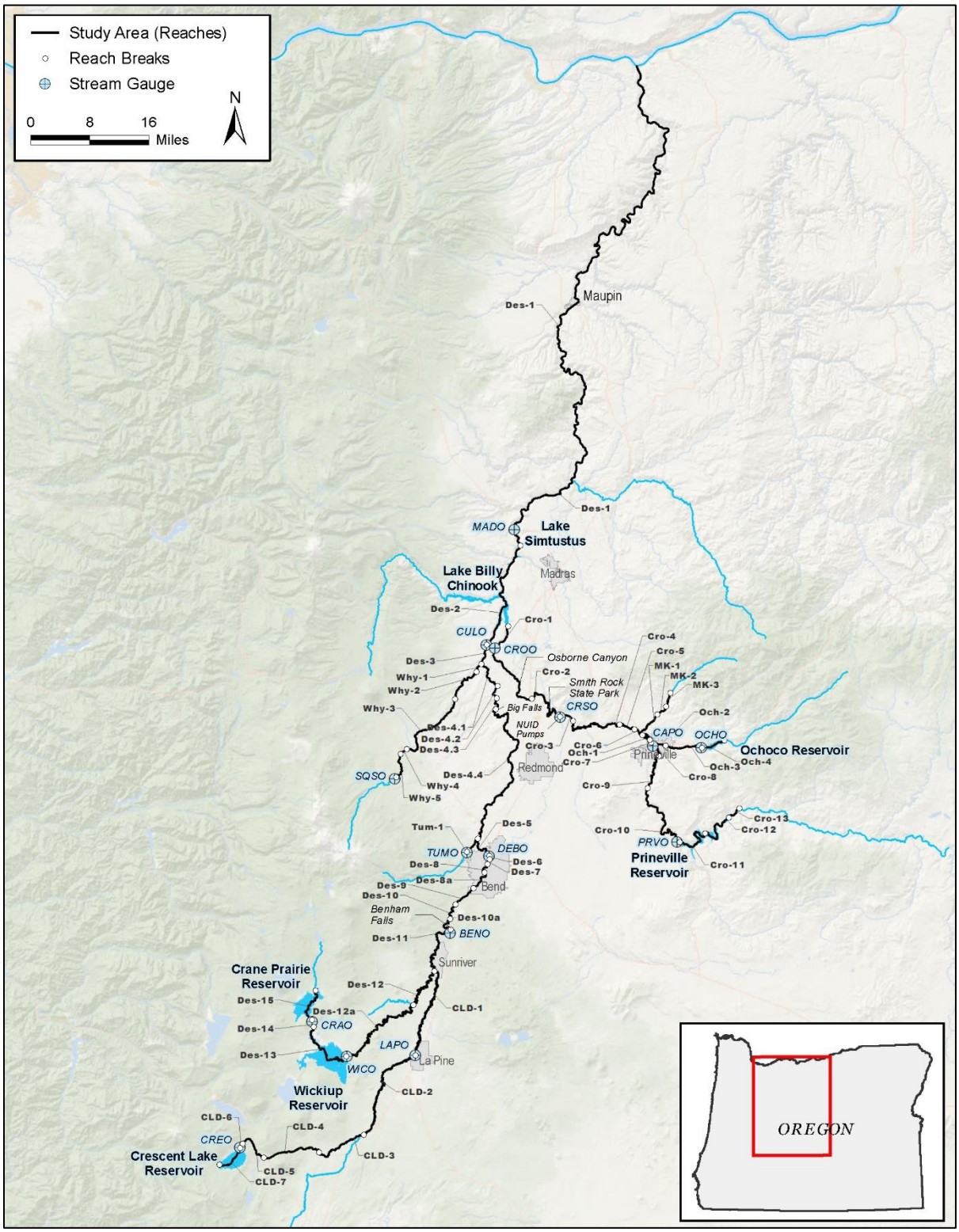
The study area for vegetation and wildlife consists of areas in or near the covered lands and waters and Prineville Reservoir and hydrologically associated lands where vegetation and wildlife could be affected under the proposed action and alternatives. The proposed action and alternatives would affect the hydrology of certain streams and reservoirs in the Deschutes Basin. These changes may, in turn, alter the vegetation and physical conditions within riparian, aquatic, and wetland habitats associated with those streams and reservoirs but do not have the potential to alter adjacent upland habitats that are not hydrologically connected to the affected streams and reservoirs, except to the extent that local conditions may allow changes in the position of the transition between aquatic and upland settings. Accordingly, the study area for vegetation and wildlife includes all aquatic, wetland, and riparian habitats, and adjacent upland areas potentially affected by the proposed hydrologic changes. Based on aerial photograph reconnaissance, it was determined that all such habitats occur within 1 mile of inventoried stream reaches (described below) in the Deschutes Basin, and this metric was used to define the study area for purposes of acreage calculations (Figure 3.4-1).

The analysis of the affected environment relies 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. Additional sources consulted include online sources of data and imagery describing or depicting conditions in the study area. These sources are cited hereafter, as applicable.

The inventory of potentially sensitive species and habitats was developed by consulting representatives of the land management agencies having jurisdiction over the habitats and species occurring in the study area. These included species and habitats identified by Oregon Compass (2018), the Oregon Department of Agriculture (2018a, 2018b), the U.S. Forest Service (USFS) (2016), the Bureau of Land Management (Ashton pers. comm.), the FWS, and the National Marine Fisheries Service. The specific species and habitats subject to detailed consideration in this EIS were determined using a screening tool designed to identify species potentially vulnerable to the hydrologic changes considered as part of the proposed action and alternatives (Appendix 3.4-A, *Plant and Wildlife Technical Supplement*).

As described in Appendix 3.4-A, the analysis did not identify any potentially sensitive plant species. The analysis did identify potential effects on the distribution of weeds. Review of the weed inventory provided by the Oregon Department of Agriculture (2018b) revealed that many different weeds occur in the study area and that more weed species may be expected to invade the study area in the future irrespective of the proposed action and alternatives. Accordingly, the analysis of potential weed effects is not species-specific.

**Figure 3.4-1. Biological Resources Study Area**



For the purposes of the vegetation and wildlife effects analysis, the large and environmentally diverse study area was subdivided into 47 reaches shown and labeled in Figure 1, *River Reaches in the Wildlife Study Area*, and described in Table 4 of Appendix 3.4-A.

The analysis of environmental consequences is based upon information presented in the affected environment and both qualitative and quantitative inference of the known or expected biological consequences of the hydrologic changes under each alternative. Those hydrologic changes are, in turn, inferred from the RiverWare model results described in the water resources analysis (Section 3.2.1, *Water Resources* [*Methods]*). Hydrologic conditions for reaches not available from the RiverWare model output were inferred based on model output for neighboring reaches, aerial photographs, and professional knowledge of basin hydrology, principally as reported by Gannett et al. (2001) and Sherrod et al. (2002). Vegetation and wildlife effects associated with known and anticipated hydrologic changes are described qualitatively.

Modeling results were quantified by determining the mean and variability of water availability within each reach, analyzing daily data aggregated by month for the entire RiverWare 29-year modeling period. Variability in this analysis was represented by the standard deviation. Water year types and their equivalent flow percentile and associated hydrologic conditions are described in Section 3.2, Table 3.2-1. Results for the proposed action and alternatives were compared to those for the no-action alternative.

In this document, the term *wildlife* refers to all vertebrate wildlife species other than Oregon spotted frog. For wildlife species, the analysis generally assumes that habitat availability and quantity are determined by the anticipated extent of riparian and/or wetland vegetation in the study area, which, in turn, are determined by the results of modeled hydrologic changes.[1] Modeling results were aggregated by month because vegetation is not typically responsive to short-duration hydrologic changes.

Effects of the proposed action and alternatives on vegetation and wildlife resources are considered adverse if they would result in any of the following conditions.

- Cause direct mortality of any plant or wildlife species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the Oregon Department of Fish and Wildlife (ODFW) or FWS.
- Permanently reduce the quality and function of habitats, including FWS-designated critical habitats for any plant or wildlife species listed under the Endangered Species Act (ESA), or such habitats used by candidate species for ESA listing, or by sensitive or special-status species in local or regional plans, policies, or regulations, including those subject to ODFW or FWS jurisdiction.
- Permanently reduce the long-term quality and function of any sensitive natural community in the study area (including wetlands and riparian areas), as identified in local, state, or federal regional plans, policies, or regulations.
- Reduce the habitat of a common plant or wildlife species to the extent that a population would be subject to extirpation from the study area.

[1] For some bird species, habitat is also affected by the extent of open water in reservoirs, and for many species, habitat is affected by factors that would not change under the various alternatives, such as topography or land use.

- Interfere substantially with the movement of any native resident or migratory wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites.
- Conflict with goals set forth in an approved recovery plan for a federally listed plant or wildlife species to the extent that the goals could not be achieved.
- Conflict with the provisions of an adopted HCP or other approved local, regional, or state habitat conservation plan.

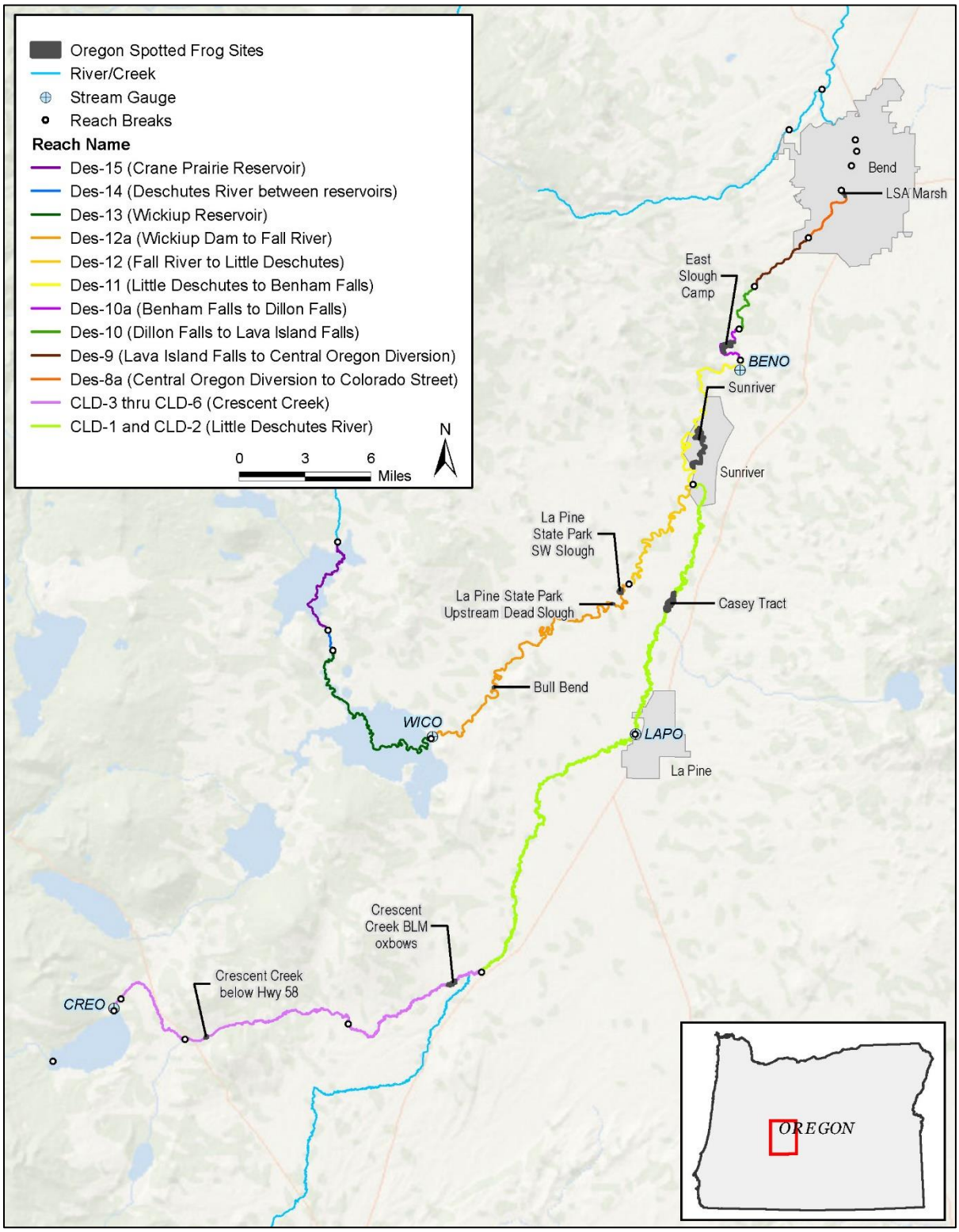
### 3.4.1.2 Oregon Spotted Frog

The study area for Oregon spotted frog includes the portion of the Deschutes Basin that is occupied by this species and could be affected by the proposed action and alternatives. The study area extends from Crane Prairie Reservoir down the Upper Deschutes River to the Old Mill District in Bend, Oregon, which is the location of the lowest occupied site directly influenced by flows in the Deschutes River system (Figure 3.4-2). 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.

To facilitate the analysis of environmental consequences, the study area for Oregon spotted frog was divided into 12 stream and river reaches (Figure 3.4-2). 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 Little Deschutes River portion of the study area.

This analysis utilized 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.

**Figure 3.4-2. Oregon Spotted Frog Study Area Reaches and Sites (Occupied and Breeding)**

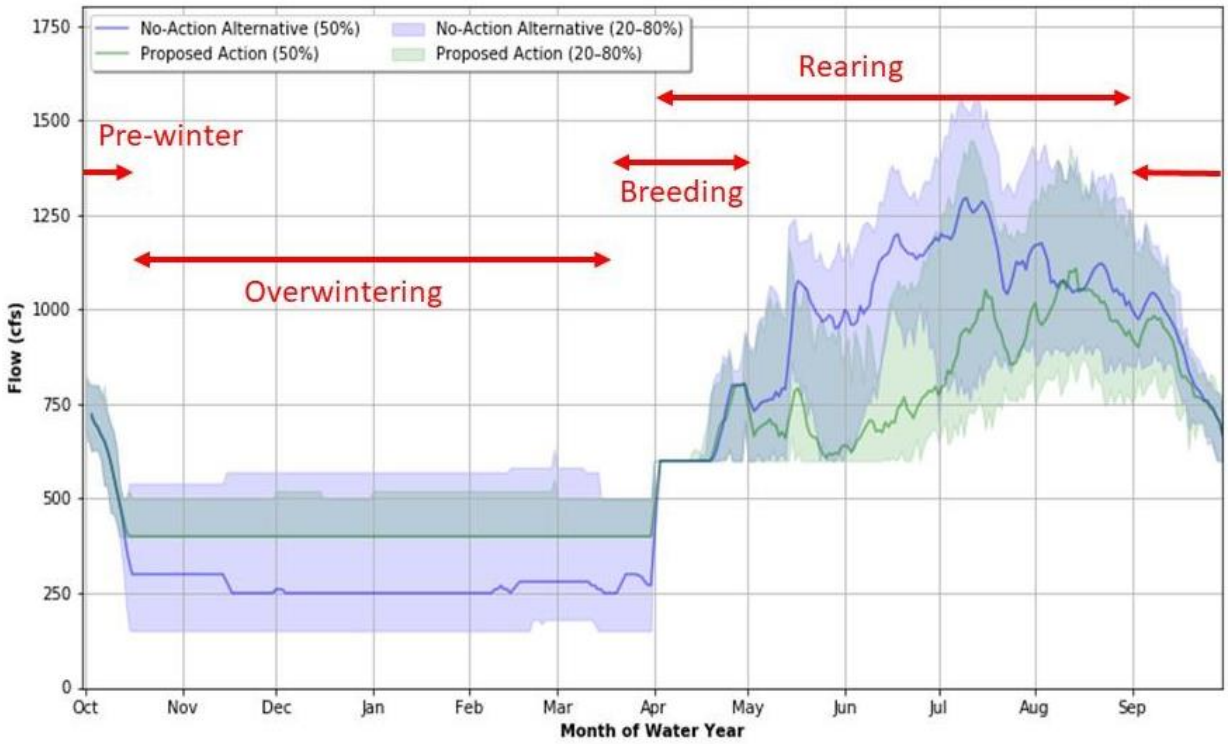


This analysis assesses the effects among the alternatives by comparing how the differing flow regimes might affect the following four key life history periods of Oregon spotted frog.

- Breeding (March 15 through April 30): 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): 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 and are vulnerable to exposure via desiccation, suffocation, and freezing.

These key life history periods are depicted in Figure 3.4-3 on an example hydrograph from the RiverWare model output for a gauge located in the Upper Deschutes River.

**Figure 3.4-3. Oregon Spotted Frog Key Life History Periods and the Flow Hydrograph for the WICO Gauge in the Upper Deschutes River**




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 above. Habitat sensitivity to flow is expressed in the following conditions.

- 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.

The reach-level and site-level impact assessments herein rely on the flow thresholds presented in Table 3 of Appendix 3.4-B, *Oregon Spotted Frog Technical Supplement*, as well as the hydrographs in the *Environmental Consequences* section of the appendix. With some exceptions the flow thresholds presented in Table 3 of Appendix 3.4-B were developed by FWS and are also presented in the Deschutes Project BiOp (see Table 32 in U.S. Fish and Wildlife Service 2017, 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 of Appendix 3.4-B is observed at the gauge, the associated sites experience inundation levels that are deep enough to partially submerge emergent vegetation thereby providing sufficient cover and habitat function for Oregon spotted frogs. In addition to the wetland inundation thresholds in Table 3 in Appendix 3.4-B, this analysis applies 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 Oregon spotted frog 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 of Appendix 3.4-B.

This assessment qualitatively addresses how proposed changes to water management of the system may secondarily affect other known threats to Oregon spotted frog 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 emergent vegetation at Oregon spotted frog breeding sites, and nonnative predators of Oregon spotted frog, such as bullfrog (*Lithobates catesbeianus*), brown bullhead catfish (*Ictalurus nebulosus*) and three-spined stickleback (*Gasterosteus aculeatus*).

Alternatives 3 and 4 include Conservation Measure DR-2: Upper Deschutes River Conservation Fund. This measure is not included in the proposed action and no-action alternative. 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." Chapter 2, *Proposed Action and Alternatives*, and Appendix 2-C, *Rationale for Oregon Spotted Frog Conservation Fund*, describe how the fund would be used to support Oregon spotted frog conservation. Although specific actions to be funded under Conservation Measure DR-2 have yet to be identified, potential effects of the measure on Oregon spotted frog were assessed qualitatively based on the types of projects that it would fund similar to those described in Appendix 2-C. The measure could be used to fund habitat maintenance

work necessary to reduce existing threats to Oregon spotted frogs and maintain population viability. It could also fund enhanced water leasing opportunities to supplement flows in the Deschutes River. Treatment of threats may include controlling reed canary grass and bullfrogs and reducing vegetation encroachment into open water areas of wetlands. This fund could be used to respond to negative trends in Oregon spotted frog habitat or population size and distribution if such trends are detected by the HCP monitoring program during the permit term.

This assessment compares the performance of the proposed action and Alternatives 3 and 4 relative to the no-action alternative and identifies which alternative or group of alternatives would result in the most favorable conditions for Oregon spotted frog and its 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, 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.

### 3.4.1.3 Fish and Mollusks

The study area for fish and mollusks includes the portion of the Deschutes Basin that is occupied by the species and could be affected by the proposed action and alternatives. The study area for fish and mollusks is illustrated in Figure 3.4-1, and the 15 waterbodies are listed in Table 3.4-1. (Figures 11 through 15 in Appendix 3.4-C, Fish and Mollusks Technical Supplement, provide more detailed views of the study area.)

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 relied on hydrologic data predictions for specific reaches and representative sites under the proposed action and alternatives (Figure 1). Flows were primarily evaluated using annual hydrologic data and monthly median flow comparisons. Additional information used were results of habitat and water temperature modeling in support of the HCP as described in this section. A detailed description of methods is provided in Appendix 3.4-C.

RiverWare model simulations for the proposed action and alternatives were generated for a 29-year period (1980–2009). Appendix 3.2-A, Water Resources Technical Supplement, provides an overview of the RiverWare model. 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 analyses were based on information from RiverWare nodes (U.S. Geological Survey or Oregon Water Resources Department gauge locations), or internode locations.

**Table 3.4-1. Waterbodies Included in the Area of Potential Effects for Fish and Mollusks**

| 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, the Little Deschutes River, and the Deschutes River. 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 River at RM 57. Streamflows are largely unregulated as inflows from other sources overwhelm any regulation at Crescent Lake Reservoir. |

| Geographic Area | Waterbody | Description |
|---|---|---|
| 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 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. |
| Middle Deschutes | Middle Deschutes River | The 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 the 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 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 the reregulating 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 57) 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 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 effects. |
| | McKay Creek | Tributary to Crooked River at RM 45. |

RM = river mile.

The effects analysis considered the following types of RiverWare outputs: annual hydrographs of daily streamflow with median, 20% and 80% daily flows; median monthly streamflows by water year; annual and monthly reservoir elevations and volumes; and occasionally shorter time frames of daily streamflows relevant to life histories of evaluated species.

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. However, quantitative modeling was used for the Upper Deschutes and Crooked Rivers. Predicted changes from a quantitative analysis of water quality parameters was completed for the Upper Deschutes River from Wickiup Reservoir to Tumalo Creek using the QUAL2Kw model, described in Section 3.3, *Water Quality*. Water temperature modeling conducted by Portland State University (Berger et al. 2019) was used in the analysis of effects in the Crooked River. Temperature thresholds reported by Berger et al. (2019) for preference, avoidance, stress/disease, delay, and lethality for some species and life stages were considered.

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 for the Draft Deschutes Basin HCP. 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. 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 Portland State University for the 3 years in the RiverWare analysis period (Berger et al. 2019).

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 Oregon Department of Fish and Wildlife (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.

# 3.4.2 Affected Environment

## 3.4.2.1 Vegetation

Because the proposed action and alternatives differ in their direct hydrologic effects, vegetation types considered in this analysis are those having a primary association with aquatic, wetland, and riparian settings. Upland vegetation types have minimal potential to be affected by the proposed action and alternatives because the proposed changes in hydrology would only affect portions of the study area already subject to changes from current water management operations. Because no changes to upland vegetation are expected from the proposed action or alternatives, upland vegetation is not discussed further.

The study area covers 512,750 acres. It includes portions of the Columbia Plateau, Eastern Cascades Slopes and Foothills, and Blue Mountains ecoregions, with most of the Upper Deschutes Basin in the Pumice Plateau Basins section of the Eastern Cascade Slopes and Foothills, and most of the streams from Bend, Sisters, and Prineville downstream to the lower end of Lake Billy Chinook in the Deschutes River Valley section of the Blue Mountains ecoregion (Thorson et al. 2003). The Pumice Plateau Basins section includes extensive wetlands containing willow, aspen, and lodgepole pine, as well as forest, marshland, and wetland meadows. The Deschutes River Valley section includes wetlands and riparian areas that support white alder, black hawthorn, ponderosa pine, and juniper (Thorson et al. 2003). Within these general classifications, a great diversity of aquatic, wetland, and riparian vegetation communities have been described, which are generally characterized by their dominant woody, grass, sedge, or forb plant species (Crowe et al. 2004). No existing inventory of these vegetation communities exists, except for riparian and wetland communities (Oregon Compass 2018); these communities are listed in Table 3.4-2.

Special-status plants in the study area are discussed in Appendix 3.4-A. No state- or federally listed species has a primary association with aquatic, wetland, or riparian settings. USFS reports that 24 sensitive plant species have been documented in riparian habitats at unspecified locations within the study area and are potentially affected by the proposed action. These species are named in Appendix 3.4-A (Ferriel pers. comm.).

**Table 3.4-2. Vegetation Communities in the Study Area**

| Vegetation Community[a] | Acres/Percentage of Study Area[b] | | Source |
|---|---|---|---|
| Emergent Wetland | 9,062 | 1.8% | National Wetland Inventory (U.S. Fish and Wildlife Service 2018) |
| Forested/Shrub Wetland | 6,019 | 1.2% | |
| Pond | 525 | 0.1% | |
| Lake-Associated Wetland | 24,409 | 4.8% | |
| Riverine Wetland | 7,532 | 1.5% | |
| Flowing Water and Riparian | 13,407 | 2.6% | Strategy Habitats (Oregon Department of Fish and Wildlife 2016) |
| Natural Lakes | 4,698 | 0.9% | |
| Wetlands | 69 | 0.0% | |
| Aspen Woodlands | 242 | 0.0% | |
| Late Successional Mixed Conifer Forests | 2,484 | 0.5% | |

[a] Only vegetation communities potentially associated with wetland or riparian settings are included. Other cover types include development, agriculture, and upland vegetation.

[b] Some National Wetland Inventory and Strategy Habitats types overlap.

As described in Appendix 3.4-A, a wide variety of invasive plant species potentially occur in the study area; many of them are potentially associated with aquatic, wetland, or riparian settings. These species are generally widely distributed, and the available mapped inventory (Oregon Department of Agriculture 2018c) is incomplete; thus, the species can reasonably be expected to occur in many locations not currently inventoried.

Table 4 in Appendix 3.4-A describes existing vegetation in each study area stream reach.

### 3.4.2.2 Wildlife

Table 3.4.3 lists the wildlife species considered in this analysis, as identified through the screening process described in Appendix 3.4-A. Table 5 in Appendix 3.4-A identifies the probable distribution of these species within the study area by stream reach based on published data sources. The wildlife species have been assigned to *guilds*, which are groups of species that share ecological attributes that make them similarly vulnerable to the adverse consequences of environmental changes that could occur under the proposed action and alternatives. In general, species are assigned to guilds according to the habitat where the animal primarily forages, reproduces, and/or rests.

**Table 3.4-3. Wildlife Species Considered in this Analysis**

| Guild | Species in Guild |
|---|---|
| Elk-Deer | Elk, mule deer |
| Fish-Eater | 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 | 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 | Great blue heron, neotropical migrant birds, western toad |
| Insect-Eater | Black swift, fringed myotis, gray flycatcher, long-legged myotis, olive-sided flycatcher, pallid bat, silver-haired bat, Townsend's big-eared bat, willow flycatcher, yellow-breasted chat |
| Open-Wetland | Canada goose, greater sandhill crane, long-billed curlew, marbled godwit, tricolored blackbird, trumpeter swan |
| Shallow-Water | 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, tule goose, wood duck |
| Wetland-Aquatic | Cascades frog |

A variety of invasive wildlife species may also be found in wetland and riparian settings of the study area. Of these, the principal species is the bullfrog, a predator of and competitor with Oregon spotted frog, as described in Section 3.4.2.3, *Oregon Spotted Frog*. Some wetlands and waters in the Pumice River Plateau and Deschutes River Valley ecoregions are known to harbor this species.

### 3.4.2.3 Oregon Spotted Frog

The study area encompasses parts of two 4th field hydrologic unit code subbasins: the Upper Deschutes River from Bend to Crane Prairie Reservoir and the Little Deschutes River, from its confluence with the Deschutes River 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.

#### Current Habitat Condition

As described in the Deschutes Project BiOp (U.S. Fish and Wildlife Service 2017, 2019), the current water management operations in the Upper Deschutes River Basin (including the Upper and Little Deschutes River Subbasins) generally result in higher water levels in the summer during the irrigation period and lower water levels during the winter when the reservoirs are used to store water for the coming irrigation season. The high water levels in the summer have supported the development of wetlands that serve as habitat for Oregon spotted frogs; however, the large change in water elevation between the summer irrigation and winter storage seasons means that large portions of the wetlands inundated during summer along the river are drained during the winter. The Deschutes Project BiOp (U.S. Fish and Wildlife Service 2017, 2019) concluded that these seasonal changes in reservoir storage and flow in the rivers and the associated water elevations in the wetlands supporting Oregon spotted frogs negatively affect the species. The greatest effects occur during the breeding season and during overwintering, two vulnerable life history periods for Oregon spotted frogs. The Deschutes Project BiOp (U.S. Fish and Wildlife Service 2017, 2019) concluded that the current management of the Upper Deschutes River Basin for irrigation results in significantly degraded the habitat conditions for Oregon spotted frogs to an extent that results in ongoing incidental take of the species. Overall, Oregon spotted frog and its habitat are experiencing ongoing adverse effects from the seasonal changes in water elevations in the wetlands due to current water management operations combined with ongoing threats identified in the 2014 Final Rule determining the ESA threatened species status of Oregon spotted frog (79 Federal Register [FR] 168:51658-51710).

In the 2014 Final Rule (79 FR 168:51658-51710), FWS identified threats to Oregon spotted frogs in the Deschutes Basin. Specifically, in the Upper Deschutes River Subbasin threats include, but are not limited to wetland loss, reed canarygrass, shrub encroachment, and hydrological changes (water management). In the Little Deschutes River Subbasin, threats include, but are not limited, to 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).

#### Species Description

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). 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). In the Upper Deschutes River basin, breeding typically commences in late March or early April. Egg masses are laid communally in groups of up to several hundred (Licht 1971; Nussbaum et al. 1983; Cook 1984; Hayes 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. When optimum site conditions are available, eggs are deposited in low and sparse aquatic vegetation situated to take advantage of solar exposure that warms the surrounding water. Because of 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 survival increases as tadpoles grow and gain 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 occupy vegetation communities that are a mix of reed canarygrass and native vegetation (Watson et al. 2003, McAllister and Leonard 1997) for basking and cover. Reed canarygrass, a productive invasive grass, can reduce the quality of breeding habitat as it proliferates over time (Kapust et al. 2012).

For overwintering, adults generally require flowing streams or springs 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, Oregon 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).

Oregon spotted frogs are generally limited in their movements, averaging approximately 1,300 to 2,600 feet throughout the year; however, individuals have been shown to disperse up to 1.7 miles (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). Oregon spotted frogs in the Sunriver population routinely make annual migrations of approximately 1,640 to 4,265 feet between a major egg-laying complex and an overwintering site. A recent study by Pearl et al. (2018) including some sites from the Upper Deschutes found that most frogs moved less than 820 feet during the fall, although some showed greater movement distances depending on habitat type.

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 6.2 miles apart. FWS considers Oregon spotted

frog habitat connected for the purposes of genetic exchange when occupied/suitable habitats fall within a maximum movement distance of 3.1 miles (79 FR 168:51658-51710).

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 3.4-2. 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 monitored breeding sites 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 Oregon spotted frogs were distributed throughout the entire reach of the Little Deschutes River, downstream of Crescent Creek (U.S. Fish and Wildlife Service 2017, 2019). 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 is 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 breeding sites) 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).

### 3.4.2.4 Fish and Mollusks

Table 3.4-4 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. Table 3.4-5 lists the geographic extent within the study area by species. Appendix 3.4-C describes extent and life history for these species. Additional information about the covered species is provided in Chapter 5, *Covered Species*, of the Draft Deschutes Basin HCP.

**Table 3.4-4. 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 |
| Nonnative Trout | Brook Trout | *Salvelinus fontinalis* | NA | Introduced |
| Nonnative 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 |

| Taxonomic Group | Species Common Name | Species Scientific Name | Status | Origin |
|---|---|---|---|---|
| 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 3.4-5. Geographic Extent of Fish and Mollusks Evaluated in the EIS**

| 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 Simtustus | 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.

# 3.4.3 Environmental Consequences

## 3.4.3.1 Alternative 1: No Action

This sections describes effects on biological resources under the no-action alternative compared to existing conditions.

### Vegetation

Continuation of current water management 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 historical 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. The effects of invasive species under the no-action alternative would generally be similar to those under existing conditions in terms of weed infestation with the potential for slight improvements in areas of the Upper Deschutes River that experiences less severe seasonal streamflow variation. Weed infestation in Wickiup Reservoir would generally be the same as under existing conditions because of the high seasonal variation in reservoir surface elevations and continuation of large bare areas in the reservoir bathtub ring. Other areas in the study area would experience similar invasive species conditions to existing conditions because no changes or relatively minor hydrological changes would occur in these other areas. However, data are not adequate to identify those locations or to quantify the magnitude of the habitat quality improvement. In the remainder of the study area, seasonal and year-to-year flow variations would be essentially unchanged; therefore, vegetation changes in these areas would not be expected.

Climate change will affect environmental conditions in the study area over the analysis period. Halofsky et al. (2018) forecast that peak winter/spring flows will be higher and summer low flows lower compared to existing conditions. 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 low flow reductions of 40 to 60% are forecast by 2040, approximately 20 years into the analysis period.

Elevated risk of extreme climate events and ecological disturbances has high potential to substantially alter riparian and wetland vegetation in the study area; most of the disturbances would cause elevated mortality in plant communities, resulting in a shift to plant communities of an earlier successional stage. Such plant communities are often less structurally complex, less species diverse, and commonly experience heightened vulnerability to invasion by nonnative plant species. These effects have the potential to trigger a permanent reduction in quality and function of sensitive natural communities such as wetlands and riparian areas.

**Effect Conclusion:** Although continuation of current water management operations under the no-action alternative would have small beneficial effects on vegetation in some reaches along the Upper Deschutes River downstream of Wickiup Reservoir over the analysis period, climate change is anticipated to result in generally adverse effects on vegetation throughout the study area when

compared to existing conditions. Overall, due to the effects of climate change over the analysis period, effects on vegetation under the no-action alternative would be adverse compared to existing conditions by reducing the quality and function of sensitive natural communities such as wetlands and riparian areas.

## Wildlife

Minor potential improvements in the quality of vegetation along the Upper Deschutes River upstream of Bend over the analysis period are not expected to meaningfully improve the condition of wildlife habitat in the study area. Ecological changes associated with forecast climate change, especially increasing frequency and intensity of drought, insect outbreaks, and wildfire, could adversely affect wildlife by reducing the quality of wildlife habitat. These effects would be associated with an increase in vegetation mortality and a generalized shift to earlier successional stages and would particularly affect species that depend upon mature or late-successional riparian forest habitats. Increased frequency and severity of drought and flood and substantial reductions in summer streamflow in streams lacking headwater reservoirs (such as Whychus Creek, Tumalo Creek, and the Little Deschutes River) would adversely affect wildlife using riparian and wetland habitats along those streams. Overall, the timing and magnitude of these effects cannot be determined because of uncertainties in how soon forecast climate changes would occur.

**Effect Conclusion:** Although the continuation of current water management operations and other ongoing projects and programs assumed under the no-action alternative would have little to no effect on wildlife in the study area over the analysis period, compared to existing conditions, climate change could cause adverse effects on wildlife by permanently reducing the quality and function of existing habitats for special-status species (potentially, all wildlife species addressed in this analysis). Therefore, effects on wildlife habitat in the study area under the no-action alternative over the analysis period would be adverse compared to existing conditions.

## Oregon Spotted Frog

Continuation of current water management operations under the no-action alternative, described in Chapter 2, would slightly improve habitat conditions for Oregon spotted frog, as described below.

- Maintaining water elevations that inundate wetlands would support Oregon spotted frogs using Crane Prairie Reservoir as habitat during the breeding and rearing periods.
- Managing the Upper Deschutes River below Wickiup Dam to somewhat reduce seasonal and interannual changes in the hydrograph relative to those experienced during the historical period (i.e., from the beginning of hydrologic records through 2015) could slightly improve Oregon spotted frog breeding conditions by timing flow releases to better coincide with the breeding period and benefit wetland vegetation over time, providing habitat for Oregon spotted frogs.
- Managing Crescent Lake to provide a sustained and improved input of winter flows in Crescent Creek and, to a lesser extent, the Little Deschutes River would support overwintering Oregon spotted frogs given the unpredictable nature of the unregulated sources in this part of the study area.

However, even with these slight improvements, continuation of current water management operations would perpetuate degraded habitat conditions for the species over the analysis period, as described in Section 3.4.2.3, *Oregon Spotted Frog*, under *Current Habitat Condition*, and in the Deschutes Project BiOp (U.S. Fish and Wildlife Service 2017, 2019).

Climate change will affect environmental conditions in the study area over the analysis period. Halofsky et al. (2018) forecast that peak winter/spring flows will be higher and summer low flows lower compared to existing conditions. 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 low flow reductions of 40 to 60% are forecast by 2040, approximately 20 years into the analysis period. Changes in precipitation patterns and precipitation type (e.g., an increasing shift from snow to rain) due to climate change could affect the distribution and composition of wetland vegetation and communities, as well as individual site hydrology which could affect Oregon spotted frog and its habitat. These adverse effects due to climate change could offset the slight improvements detailed above.

**Effect Conclusion:** Although the continuation of current water management operations under the no-action alternative could result in slight improvements to Oregon spotted frog habitat, it is likely to perpetuate degraded habitat conditions for Oregon spotted frog in the basin. Moreover, climate change could result in adverse effects on the distribution and quality of habitat available in the study area. Other adverse impacts would continue unabated (e.g., negative impacts from nonnative predators, and habitat degradation from reed canarygrass). Overall, effects on Oregon spotted frog in the study area would be adverse because of the perpetuation of degraded habitat conditions in the basin and effects of climate change.

## Fish and Mollusks

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[2] 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[3] 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, not adverse, beneficial, or no effect) and 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

[2] 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.

[3] 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 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.

comprehensive manner likely would have an adverse effect on the ability to manage for future changes in climate.

**Effect 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. 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.

### 3.4.3.2 Alternative 2: Proposed Action

This section describes effects on biological resources under the proposed action compared to the no-action alternative. Effects of the proposed action on Oregon spotted frog are considered at full implementation, which would occur in years 21 through 30 of the permit term when minimum fall/winter flows downstream of Wickiup Dam are highest (Table 3.1-1). Effects on fish and mollusks are discussed by geographic area and include only those geographic areas where each species occurs or has the potential to occur.

#### BIO-1: Change Vegetation Communities

Table 3.4-6 summarizes the potential for the proposed action to change vegetation communities within each study area reach over the permit term.[4] Flow and reservoir elevation changes in the Crooked River and its tributaries, the Deschutes River system downstream of Bend, and the Crescent Creek–Little Deschutes River system have little potential to affect riparian or wetland vegetation due to one or more of the following four conditions.

- Flow or reservoir water surface elevation (reservoir level) changes would be minimal.
- Reservoir level changes would affect reservoirs that have very little, low-quality riparian and wetland vegetation.
- Flow or reservoir level changes would occur at a time of year when vegetation is dormant and not responsive to changes in water availability.
- Groundwater entering the river along its banks is a primary source of water for riparian and wetland vegetation, which is thereby less responsive to changes in instream flow.

Therefore, as detailed in Table 3.4.3, effects on vegetation communities in these areas would be not adverse.

[4] The summary in Table 3.4-6 is based on information provided in Table 4 in Appendix 3.4-A.

Increased minimum flows on Ochoco and McKay Creeks under the proposed action (Conservation Measures CR-2 and CR-3) would have small beneficial effects on riparian and wetland vegetation on these creeks compared to the no-action alternative.

Flows would be unchanged in Whychus and Tumalo Creeks under the proposed action. Therefore, the proposed action would have no effect on vegetation communities on Tumalo Creek compared to the no-action alternative.

Substantial changes in vegetation communities may occur in Upper Deschutes River reaches downstream of Wickiup Reservoir. Summer flows would diminish and winter flows would increase. These changes would occur gradually as minimum fall and winter flows below Wickiup Reservoir increase in stages over the permit term(Table 3.1-1). It would take a period of years for the hydrologic changes to occur, and it would take a period of years for the vegetation to respond to the hydrologic changes, with some changes (such as those affecting herbaceous plants) happening within a few years, and others (such as those affecting trees) occurring over the entire permit term and beyond. By the conclusion of the permit term, riparian and wetland vegetation in summer would be more functional, located adjacent to the water rather than below its surface. In winter, vegetation would extend to near the water's edge compared to the no-action alternative, under which vegetation would continue to be a considerable distance from the water, with large expanses of unvegetated mud, sand, and rock. With less seasonal variability in flow, the riparian and wetland vegetation communities would likely be more resilient and stable, thereby achieving improved quality and function. Therefore, reduced seasonal flow variability under the proposed action in Deschutes River reaches upstream of Bend would have a beneficial effect on wetland and riparian vegetation in these reaches. The lower summer flows in these reaches may also reduce the area of wetland vegetation types by lowering summer water levels in the river and adjacent groundwater. However, this change would be minor compared to the improvements in the quality and function of affected wetland vegetation types.

The expected changes described for Upper Deschutes River reaches would not occur in Wickiup Reservoir. In the reservoir (reach Des-13), there would be extreme increases in year-to-year variability in the mean monthly reservoir level. From years 6 to 30 of the permit term, month-to-month variability in pool elevations would progressively increase in all months, with the greatest changes observed from December through July. This increased variability in pool elevations would likely result in occasional runs of multiple years with exceptionally high or exceptionally low pool elevations. This would be expected to result in prolonged episodes of drying or inundation of riparian vegetation, a change which would reduce the long-term quality and function of riparian vegetation around the reservoir**.** This effect is tempered by the paucity and poor condition of existing riparian vegetation around the reservoir, which is a consequence of the existing high year-to-year variability in reservoir elevations; thus, the proposed action would achieve improved riparian conditions at Crane Prairie Reservoir and throughout the Upper Deschutes River but at the cost of a further decline in riparian conditions at Wickiup Reservoir.

Invasive plant species potentially associated with aquatic, wetland, or riparian settings are expected to occur primarily in settings conducive to weed invasion; these include areas of exposed soil and/or areas with relatively high nutrient availability, which are generally areas with high month-to-month variability in streamflow or reservoir levels. Under the proposed action, streamflow variation and variability in reservoir levels would generally either be consistent with or decrease relative to the no-action alternative. Thus, the proposed action would likely maintain current levels of weed infestation in some areas and reduce weed infestation in others, with the exception of Wickiup

Reservoir (reach Des-13; Table 3.4-6). As noted, the reservoir would begin to experience much greater year-to-year variability in mean monthly reservoir levels starting in year 6 and increasing throughout the permit term. The large areas of unvegetated soil exposed during the growing season could become sites for extensive invasive vegetation establishment. However, such sites would be inundated, and thereby extirpated, during periods of anomalously high reservoir elevations. Therefore, any increases in invasive weed cover would likely be temporary.

**Effect Conclusion:** Effects of the proposed action on riparian and wetland vegetation in the study area would be not adverse in most river reaches, provide clear benefits in others, and comprise a mix of beneficial and adverse effects in a few reaches compared to the no-action alternative. Overall, the effect of the proposed action would be beneficial compared to the no-action alternative because seasonal flow changes in the Upper Deschutes River and Crane Prairie Reservoir stabilization would improve habitat conditions over this large area, while only minor and localized vegetation impairments would occur in Wickiup Reservoir.

**Table 3.4-6. Effects on Vegetation Communities by Reach under the Proposed Action Compared to the No-Action Alternative**

| Reach | Effects on Vegetation |
|---|---|
| Des-15 (Crane Prairie Reservoir) | There would be negligible changes in the mean monthly reservoir level of Crane Prairie Reservoir, but throughout the permit term, there would be substantial changes in year-to-year variability in mean monthly values. Variability would decrease substantially in April, May, June, and September and would increase substantially in November and December, with minor changes in other months. Water surface elevations would be more stable, except in November and December, on a year-to-year basis. Ecologically, this change would allow the growth of a more complex and diverse riparian and wetland vegetation community around the shores of the reservoir. |
| Des-14 | Flows would change in a complex manner, with substantial decreases from September through December and in March and April, and substantial increases in February, May, July, and August. Flow variability would generally show moderate changes, with decreases in November through December and an increase in January. However, flow variability in this reach is already high compared to most other Deschutes River reaches. The distribution of riparian vegetation in this reach is mainly defined by topography, which would not change; therefore, no detectable effects on vegetation are likely. |
| Des-13 (Wickiup Reservoir) | There would be small changes in the mean monthly reservoir level of Wickiup Reservoir. However, there would be extreme increases in year-to-year variability. From years 6 to 30 of the permit term, month-to-month variability in reservoir levels progressively increases from December through May, although variability changes little in the other months. The increased variability would likely result in occasional runs of multiple years with exceptionally high or exceptionally low reservoir levels. This would be expected to result in prolonged episodes of drying or inundation of riparian vegetation, a change which would reduce the long-term quality and function of riparian vegetation around the reservoir. This impact is somewhat moderated due to the changes occurring, in large part, outside of the growing season. |
| Des-12a | Changes would be minor through year 5 of the permit term, but thereafter, flows would increase substantially (from over 10 to 37%) in years 6 through 30 from October through March, the lowest flow months. Flow variability in those months would diminish by about 20 to 30%. Flows would diminish by 5 to 25% from May through August, the highest flow months, with unchanged flow variability. These changes would increase channel stability and decrease the extent of unvegetated area exposed during low flows. The cover and resilience of riparian and wetland vegetation would increase, while the extent of bare-soil substrates vulnerable to infestation by weed species would decrease. These would be |

| Reach | Effects on Vegetation |
|---|---|
| | beneficial changes. The reduction in summer peak flows is likely to reduce the total area of riparian and wetland vegetation; however, this change would be minor compared to the improved quality and function of affected riparian and wetland vegetation. |
| Des-12 | Effects would be essentially the same as described for Des-12a, but Des-12 also has a flow contribution from Fall River that is nearly constant year-round at about 150 cfs, which is about one-seventh to one-third of the total Deschutes River flow in Des-12. The Fall River contribution would slightly reduce the magnitude of both beneficial and adverse effects described for Des-12a. |
| Des-11 | Changes would be essentially the same as described for Des-12, but Des-11 also has a flow contribution from the Little Deschutes River, which would experience negligible flow changes; thus, the Little Deschutes River contribution would tend to slightly reduce the magnitude of both beneficial and adverse effects described for Des-12. |
| Des-10a<br>Des-10 | Flow changes would be minor in the first 20 years of the permit term, but by year 21 would increase by 6 to 12% from October through March, the lowest flow months. Flows would diminish (by 2 to 14%) from May through September, the highest flow months. Flow variability would decrease (6 to 20%) from October through March and would increase substantially (31 to 57%) in May and June, with little change in the other months. These changes would generally increase channel stability by reducing the magnitude of seasonal peak flows and would reduce the extent of unvegetated area exposed during low flows. The cover and resilience of riparian and wetland vegetation would increase, while the extent of bare-soil substrates vulnerable to infestation by weed species would decrease. These would be beneficial changes. The reduction in summer peak flows is likely to reduce the total area of riparian and wetland vegetation; however, this change would be minor compared to the improved quality and function of riparian and wetland vegetation previously described. |
| Des-9<br>Des-8a<br>Des-8<br>Des-7 | Starting in year 21, May through July average monthly flow would decrease by up to 19% and November through March flow would increase by up to 13%. November through March flow variability would decrease by up to 26%, and May through June flow variability would increase by up to 61%. The reduced May through July flows and increased flow variability could somewhat increase drought exposure in riparian vegetation, but the increased October through March flows would support denser and more resilient vegetation. Net effects would be approximately neutral. |
| Des-6<br>Des-5 | Initially, flow changes would be minor, but by year 21 of the permit term, flows would increase up to 14% in all months except May and June, when decreases of 13 to 20% would occur; July through September would still be the driest months. Year-to-year flow variability would also change substantially, generally decreasing in June through July and increasing in August through September. Because groundwater inflow is the principal source of moisture for riparian vegetation in this confined desert canyon, vegetation changes would likely be minor to negligible. |
| Des-4 | Changes would be essentially the same as on Des-5, which has similar hydrology (with the addition of Tumalo Creek flows). |
| Des-3 | Changes would be essentially the same as on Des-5, which has similar hydrology (with the addition of Whychus and Tumalo Creek flows). |
| Des-2 | The reservoirs in the Pelton Round Butte Project are regulated for power production purposes and have negligible riparian or wetland vegetation; thus, there would be no effect on riparian or wetland vegetation. |
| Des-1 | Flow changes would be negligible (maximum change 3%) and flow variability would not change substantially. Therefore, no effects on vegetation are expected. |
| CLD-7 | There would be no changes in mean monthly pool elevation and only a minor increase in year-to-year variability in the mean monthly pool elevation. However, because year-to-year |

| Reach | Effects on Vegetation |
|---|---|
| (Crescent Lake Reservoir) | reservoir level variability would remain extremely high, riparian or wetland vegetation would remain minimal. |
| CLD-6 CLD-5<br>CLD-4 | Changes in flows and flow variability in these reaches would be negligible (maximum change of 6% in any month, except for a 26 to 32% decline in October and November in years 1 to 5). These non-growing-season changes have little potential to affect vegetation. Therefore, no effects on vegetation are expected. |
| CLD-3<br>CLD-2<br>CLD-1 | Changes in flows and flow variability in these reaches would be negligible (less than 10% in all months throughout the permit term). Therefore, no effects on vegetation are expected. |
| Tum-1 | Flows in Tumalo Creek would be unchanged. Therefore, there would be no effect on vegetation. |
| Why-5<br>Why-4<br>Why-3<br>Why-2<br>Why-1 | Flows in Whychus Creek would be unchanged; addition of 3 cfs in Conservation Measure WC-1 is assumed under the no-action alternative. Therefore, there would be no effect on vegetation. |
| Cro-13<br>Cro-12<br>Cro-11<br>(Prineville Reservoir) | There would be no changes in mean monthly reservoir level, but there would be increases, from January through August, in year-to-year variability in the mean monthly pool elevation. Because there is minimal riparian and wetland vegetation at the reservoir, these changes have little potential to affect vegetation. |
| Cro-10 | Flow changes would be small over the permit term, no more than 10% in any month, with June increases of up to 10% and July through August decreases of up to 7%. Flow changes of this magnitude are unlikely to produce any detectable change in riparian or wetland vegetation. |
| Cro-9 | There are some substantial short-term flow changes in years 11 through 30 (up to 26%) in June through August. Under the no-action alternative, this reach has some of the most extreme year-to-year flow variations in the study area, so the modeled flow changes would be unlikely to affect riparian or wetland vegetation. |
| Cro-8 | Flow changes would be essentially the same as on Cro-9. However, there is almost no riparian or wetland vegetation on this highly urbanized river reach, so no observable effects on vegetation are likely. |
| Cro-7<br>Cro-6 | Changes would be essentially the same as on Cro-9. |
| Cro-5<br>Cro-4 | Flow changes would be small, with a maximum increase of 12% in June and a maximum decrease of 12% in July, starting at year 21 of the permit term. These reaches have very high year-to-year flow variation under the no-action alternative, so the modeled small flow changes would be unlikely to affect riparian or wetland vegetation. |
| Cro-3 | Flow changes would be small, with a decrease of less than 10% June through September over the permit term, except for a July decrease of 15% in years 21 through 30. The summer flow reductions are unlikely to alter riparian vegetation in this reach because it is primarily supported by groundwater inflows, and there are negligible wetlands. |
| Cro-2<br>Cro-1 | Changes would be essentially the same as Cro-3. |
| MK-3<br>MK-2<br>MK-1 | Modeled flows in McKay Creek would be unchanged, but Conservation Measure CR-3 would eliminate extreme low flows in these reaches. This would tend to increase water available to |

| Reach | Effects on Vegetation |
|---|---|
| | support riparian and wetland vegetation during the growing season years dry enough to trigger Conservation Measure CR-3, with beneficial effects on vegetation. |
| Och-4 (Ochoco Reservoir) | Water surface elevations in Ochoco Reservoir would be unchanged. Therefore, there would be no effect on vegetation. |
| Och-3<br>Och-2<br>Och-1 | Modeled flows in Ochoco Creek would be unchanged, but Conservation Measure CR-2 would eliminate extreme low flows in these reaches. This would tend to increase water available to support riparian and wetland vegetation during the growing season years dry enough to trigger Conservation Measure CR-2, with beneficial effects on vegetation. |

cfs = cubic feet per second

## BIO-2: Change Habitat for Wildlife Species

In areas where no hydrological or vegetation changes would occur under the proposed action compared to the no-action alternative, or where those changes would be negligible in magnitude, corresponding effects on wildlife and habitat would also be negligible or nonexistent. Such areas include the lower reaches of the Deschutes River from its confluence with the Columbia River upstream to and including Lake Billy Chinook (Des-1, Des-2), Prineville Reservoir, all of Whychus, McKay, and Ochoco Creeks, the Little Deschutes River and the lowest reach of Crescent Creek, and Crescent Lake. Accordingly, these areas would experience negligible effects on wildlife and their habitat, relative to the no-action alternative.

Changes that are exclusively hydrologic in nature would only affect wildlife species that depend upon streamflow or reservoir level, independent of vegetation. Those species include birds and bats that belong to the fish-eater, insect-eater, and shallow-water guilds (Table 3.4-3). Exclusively hydrologic changes would occur in the Deschutes River from Bend to Lake Billy Chinook (reaches Des-3 to Des-6), the inflow stream to Wickiup Reservoir (reach Des-14), and Crooked River reaches Cro-1 to Cro-10.

In the Deschutes River from Bend to Lake Billy Chinook (reaches Des-3 to Des-6), there would be July and August flow increases, as well as smaller winter flow increases. These increases would provide increased water surface area for wildlife to forage. Summer increases would be brief and the winter increases would occur are at a time of year when they would not make an appreciable contribution to the food supply of these species, particularly the insect-eater guild. Conditions for all affected guilds would improve slightly.

The Deschutes River between Wickiup and Crane Prairie Reservoirs (reach Des-14) would have complex and diverse flow changes related to the changing relationships in storage between the two reservoirs, with a combination of consequences. In general, this short reach has a high gradient with substantial forest shade, provides limited habitat value, and thus is not likely to be extensively used by the affected guilds, so the expected changes would have little effect on wildlife use of this reach.

The Crooked River from its confluence with the Deschutes River upstream to the North Unit ID pumps (reaches Cro-1 to Cro-3) flows as a narrow stream at the bottom of a deep canyon. Thus, the relatively small flow changes under the proposed action would have little potential to appreciably alter the surface area of water or alter habitat quality or quantity for the fish-eater, insect-eater, and shallow-water guilds. From the North Unit ID pumps upstream to its confluence with McKay Creek (reaches Cro-4 and Cro-5), the Crooked River would have only small flow changes (maximum of

13%) over the permit term and have very high year-to-year variability. Moreover, the June flow increases would tend to be offset by August flow decreases. Therefore, substantial changes in the utility of these reaches for wildlife are unlikely. A similar situation occurs farther upstream, from the McKay Creek confluence (lower end of reach Cro-6) to just below Prineville Reservoir (reach Cro-10), where substantial flow increases for June are offset by July flow decreases, such that substantial changes in the utility of these reaches for wildlife are unlikely.

As described in BIO-1, vegetation changes would likely result from hydrologic changes in the Deschutes River from Bend up into Wickiup and Crane Prairie Reservoirs (reaches Des-7 to Des-13 and Des-15); and in Crescent Creek (reaches CLD-4 to CLD-6). These changes could affect the following species guilds: elk-deer, forest, generalist, open-wetland, and wetland-aquatic.

In the Deschutes River below Wickiup Reservoir, the beneficial effects on vegetation, discussed in BIO-1, would likely improve conditions for wildlife. For instance, the riparian zone would move closer to the river over the permit term, reducing inundation of this vegetation in the summer and distance from the water's edge in the winter. This change would improve riparian forest habitat for species, such as bats, that roost in the forest and forage over the stream and wetlands. In Wickiup Reservoir (reach Des-13), the adverse effects on vegetation described in BIO-1 mean that wildlife use of the reservoir is volatile on a year-to-year and month-to-month basis, and this situation would continue under the proposed action. Conversely, in Crane Prairie Reservoir (reach Des-15), the increased stability of water levels and improved quantity and function of riparian and wetland vegetation described for BIO-1 would be expected to also improve conditions for wildlife; for instance, shallow-water habitat productivity would likely increase, and the improved quality of riparian vegetation would provide improved nesting and foraging opportunities.

In years 6 to 10 of the permit term, Crescent Creek reaches CLD-4 to CLD-6 would experience October and November flow reductions of 20 to 30% and December flow increases of about 20%. These flow reductions would likely lead to some reduction in October and November use of these reaches by the fish-eater and shallow-water guilds (the insect-eater guild is not active at that time of year), but those effects would end after year 10 of the permit term. In the absence of flow changes at other times of the year, there would be no effect on wildlife at other times of the year.

**Effect Conclusion:** Effects of the proposed action on wildlife and its habitat would be not adverse in most river reaches, provide clear benefits in others, and result in a mix of beneficial and adverse effects in a few reaches. Overall, the effect would be beneficial compared to the no-action alternative because stabilization of seasonal flow conditions in the Upper Deschutes River and water levels in Crane Prairie Reservoir would provide spatially extensive, improved habitat conditions for wildlife, while habitat impairments would be localized and limited to Wickiup Reservoir.

## BIO-3: Affect Oregon Spotted Frog Habitat

The results of the effects analysis for Oregon spotted frog are summarized in Table 3.4-7. The full analysis is available in Appendix 3.4-B. Table 3.4-8 shows the direction of effects for each life history stage by reach.

Based on modeled flows, the proposed action is likely to improve conditions for Oregon spotted frog and its habitat compared to the no-action as follows.

- Maintaining water elevations that inundate wetland habitat during the Oregon spotted frog breeding and rearing periods in Crane Prairie Reservoir.

- Managing the Upper Deschutes River below Wickiup Dam with lower flows during the vegetation growing season that would result in the migration of wetland vegetation downslope, closer to the river.
- Managing the Upper Deschutes River below Wickiup Dam to decrease the magnitude of the drop in water elevation during the pre-winter period, thus lessening the travel distance between rearing sites and overwintering locations at sites where frogs move between the two types of habitat.
- Managing the upper Deschutes River below Wickiup dam to increase winter flows such that overwintering habitat are inundated with water and travel distances between the overwintering sights and breeding sites are decreased.

Although flows under the proposed action at full implementation would likely improve conditions for Oregon spotted frogs in most reaches and history stages, it would take 20 years to reach its full implementation. Until then, a highly modified hydrograph would persist. During this time, flows would not adequately support the life history requirements of the Oregon spotted frog in the Deschutes River downstream of Wickiup Reservoir because they would not consistently or adequately inundate Oregon spotted frog wetland habitat during critical life history periods. The proposed action would gradually improve the degraded habitat conditions currently present in the study area.

Other detrimental effects on Oregon spotted frogs would include lower flows and associated water level conditions during the rearing period in most reaches, and during all life history periods in Wickiup Reservoir, as well as the likely expansion of invasive bullfrog and nonnative predatory fish species populations and distributions, which would benefit from the more stable annual flow regime established by the proposed action.

The proposed action also includes effectiveness monitoring and adaptive management plans, detailed in Chapter 7 of the Draft Deschutes Basin HCP, *Adaptive Management and Monitoring*, which contain provisions to monitor Oregon spotted frog and its habitat in the study area during the permit term. If conditions change (e.g., frog egg-laying behavior or timing shifts), there are operational management actions prescribed to modify flow or reservoir storage and water elevation in response to those changes. Adverse effects on the frog that stem from threats other than flow (e.g., invasive and predatory species) could perpetuate throughout the permit term because the proposed action does not include a mechanism to address these threats.

**Effect Conclusion:** During most life history periods and in most reaches considered in this analysis, the proposed action at full implementation (years 21–30) would have a beneficial effect on Oregon spotted frog and its habitat compared to the no-action alternative. These benefits would result from an annual flow regime in most of the reaches that more closely aligns with the natural hydrograph and facilitates conditions that more adequately support the life history requirements of the Oregon spotted frog (i.e., timing of flows to support breeding sites in the spring and availability of more water to support overwintering). Prior to reaching full implementation, the proposed action would perpetuate degraded habitat conditions for Oregon spotted frog in the basin. The proposed action would have an adverse effect in Wickiup Reservoir compared to the no-action alternative during all life history periods due to highly variable water levels caused by irrigation water management activities associated with water storage and drawdown of reservoir levels. The proposed action would also have an adverse effect during rearing in other reaches. Adverse effects on the frog that stem from threats other than flow (e.g., invasive and predatory species) also could perpetuate

throughout the permit term because the proposed action does not include a mechanism to address these threats. Overall, effects on Oregon spotted frog and its habitat under the proposed action are considered beneficial compared to the no-action alternative because improvements to Oregon spotted frog habitat in most reaches and during most life history periods would outweigh anticipated adverse effects in Wickiup Reservoir and during rearing in other reaches.

**Table 3.4-7. Effects on Oregon Spotted Frogs by Reach under the Proposed Action Compared to the No-Action Alternative**

| Reach | Effects |
|---|---|
| CLD-1 CLD-2 (Little Deschutes River) | **Breeding:** Little difference in flow during the breeding season. Within-year variation would be slightly greater, providing slightly less stable wetland inundation and increased risk of egg mass mortality, although the difference may be negligible.<br>**Rearing, pre-winter, overwintering:** Flow and therefore conditions for Oregon spotted frog would be relatively unchanged.<br>**Emergent vegetation:** Inundation levels during the growing season and therefore conditions for Oregon spotted frog would be relatively unchanged.<br>**Invasive species:** Conditions for invasive species and therefore threats to Oregon spotted frog would be relatively unchanged although these species could continue to expand distribution and population if uncontrolled. |
| CLD-3 CLD-4 CLD-5 CLD-6 (Crescent Creek) | **Breeding:** Reaches would experience slightly less flow at the beginning of the breeding season, and a more abrupt increase in flow during the breeding season. Larger changes in flow could displace egg masses and affect survival, although the risk of stranding may be negligible in this reach.<br>**Rearing:** Reaches would consistently experience slightly more water in the system throughout the rearing period, therefore, sites closely associated with the creek hydrology would sustain more wetted area over the growing season, and possibly sustain more habitat to provide cover for tadpoles and juveniles.<br>**Pre-winter:** Reaches would experience a slightly greater decrease in flows during pre-winter, which means water elevations would drop more under the proposed action. This could result in more frogs selecting poor overwintering sites that end up disconnected or above the waterline, reducing frog survival overwinter.<br>**Overwintering:** Reaches would experience reduced minimum flows during the early and late overwintering period, which would maintain less water in the system prior to the arrival of fall rains and could be detrimental to overwintering frogs.<br>**Emergent vegetation:** Inundation levels during the growing season would be higher under the proposed action.<br>**Invasive species:** Reed canarygrass would continue to persist in these reaches. Greater annual fluctuations in flow (more water in summer, less in winter) would result in a less supportive environment for bullfrogs and nonnative fish species known to prey on Oregon spotted frogs. |
| Des-8a (Central Oregon Diversion to Colorado Street) | **Breeding:** Reach would experience slightly fewer days of higher water elevation. Reaches would experience a smaller change in flow as flows ramp up from the winter minimum at the onset of the irrigation season around April 1, which would reduce the risk of displacing egg masses, although known sites in this reach are not known to experience this threat.<br>**Rearing:** Reach would experience fewer days of wetland vegetation inundation and thus potentially less cover for tadpoles and metamorphic frogs, although the effect could lessen over time as vegetation responds to flows. Decreased flows and more year-to-year variability would provide less stability late in the rearing season.<br>**Pre-winter:** Reach would experience smaller decrease, or step-down, in flow through the pre-winter season and thus smaller change in water inundation elevation may result |

| Reach | Effects |
|---|---|
| | in fewer frogs selecting poor overwintering sites that end up disconnected or above the waterline.<br>**Overwintering:** Flows reach higher sustained water elevations more often. The higher sustained water elevations would result in higher levels of vegetation inundation which could protect overwintering Oregon spotted frogs.<br>**Emergent vegetation:** 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.<br>**Invasive species:** Reed canarygrass would continue to persist in this reach. Year-round inundation of wetlands and a more stable river hydrograph are likely to improve conditions for bullfrogs and nonnative fish species known to prey on Oregon spotted frogs. |
| Des-9 (Lava Island Falls to Central Oregon Diversion) | **Breeding:** Reach would experience a slightly smaller change (increase) in flow reducing likelihood of dislodging egg masses, although known sites in this reach are off-channel and not known to experience this threat.<br>**Rearing:** Reach would experience lower flows which 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 effect could lessen over time as vegetation responds to reduced flows.<br>**Pre-winter:** Reach would experience a similar decrease in flow through the pre-winter season, which could result in fewer frogs selecting poor overwintering sites that end up disconnected or above the waterline.<br>**Overwintering:** Higher sustained water levels throughout the overwintering period could result in more consistently wetted overwintering sites and shorter distances for frogs to travel between breeding and overwintering locations.<br>**Emergent vegetation:** 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.<br>**Invasive species:** Reed canarygrass would continue to persist in this reach. Year-round inundation of wetlands and more stable river hydrograph are likely to improve conditions for bullfrogs and nonnative fish species known to prey on Oregon spotted frogs. |
| Des-10<br>Des-10a<br>(Lava Island Falls to Benham Falls) | **Breeding:** Within-year flow variation would be much lower during the breeding period, which would reduce the likelihood of mortality of developing egg masses through displacement during high flows, or desiccation if stranded by low flows. Egg masses at known sites in this reach have been stranded and desiccated but are not known to experience displacement. Displacement can lead to a higher risk of predation or movement to unsuitable habitat for tadpoles.<br>**Rearing:** Reaches would experience fewer days of wetland vegetation inundation, which provides cover for tadpoles and metamorphic frogs although the effect could lessen over time as vegetation responds to lower flows. Reaches would experience greater year-to-year variability in flow, and thus less stability in days of inundation.<br>**Pre-winter:** Reaches would experience a smaller amount of change as flows decrease at the end of the irrigation season, which could result in overwintering frogs in the river being closer to breeding locations (adjacent wetlands).<br>Reaches would experience the same number of days of wetland vegetation inundation, which provides cover for juvenile and adult frogs inhabiting associated sites. |

| Reach | Effects |
|---|---|
| | **Overwintering:** Higher sustained water levels throughout the overwintering period could result in more consistently wetted overwintering sites and shorter distances for frogs to travel between breeding and overwintering locations.<br>**Emergent vegetation:** 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.<br>**Invasive species:** Reed canarygrass would continue to persist in these reaches. Year-round inundation of wetlands and more stable river hydrograph are likely to improve conditions for bullfrogs and nonnative fish species known to prey on Oregon spotted frogs. |
| Des-12a<br>Des-12<br>Des-11<br>(Wickiup Dam to Benham Falls) | **Breeding:** Within-year flow variation would be much lower during the breeding period, which would reduce the likelihood of mortality of developing egg masses through displacement during high flows, or desiccation if stranded by low flows. Displacement can lead to a higher risk of predation or movement to unsuitable habitat for tadpoles.<br>**Rearing:** Reaches would experience approximately 30 fewer days of wetland vegetation inundation. The effect could lessen over time as vegetation responds to lower flows. During rearing, tadpoles and metamorphic frogs are mobile, but need the cover offered by vegetation, so flows that maintain vegetation inundation remain important, although individuals can tolerate more water level fluctuation than egg masses.<br>Reaches would experience greater year-to-year variability in flow, and thus less stability in days of inundation.<br>**Pre-winter:** Reaches would experience a smaller amount of change as flows decrease at the end of the irrigation season. The less drastic change in inundation water elevation means that overwintering frogs in the river would be closer to breeding locations (adjacent wetlands).<br>Reaches would experience fewer days of wetland vegetation inundation.<br>**Overwintering:** Sustained higher winter flows would improve conditions for overwintering 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.<br>**Emergent vegetation:** 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.<br>**Invasive species:** Reed canarygrass would continue to persist in this reach. Year-round inundation of wetlands and more stable river hydrograph are likely to improve conditions for bullfrogs and nonnative fish species known to prey on Oregon spotted frogs. |
| Des-13<br>(Wickiup Reservoir) | Habitat conditions in Wickiup Reservoir would decline based on the following changes:<br>• During a normal year, water volume and elevation would be lower during all key life history periods.<br>• During a dry year, less water would be available during breeding, rearing, and overwintering, but more during pre-winter.<br>• During a wet year, water volume would be relatively unchanged.<br>• During a normal year, water elevation would be lower during all seasons, but especially breeding, rearing, and to a lesser degree overwintering.<br>• During a dry year, these differences are amplified.<br>• During a wet year, slightly higher water elevation would be available during rearing and pre-winter, and slightly lower water elevation during breeding and overwintering. |

| Reach | Effects |
|---|---|
| Des-14 (Deschutes River between reservoirs) | Note: although the results presented here rely on a comparison of flows modeled at the CRAO gauge, portions of this reach are also affected by water storage volumes and management of Wickiup Reservoir.<br>**Breeding:** Flows would fluctuate more throughout this period, which can result in increased egg mass mortality.<br>**Rearing:** Flow would continue to display erratic swings but to a lesser degree.<br>**Pre-winter:** Reach would experience more stable conditions, which could increase the use of this reach at least for dispersal during pre-winter.<br>**Overwintering:** Reach would experience more stable flow conditions, which could result in an increased use of the reach for overwintering. |
| Des-15 (Crane Prairie Reservoir) | Habitat conditions in Crane Prairie Reservoir would improve based on the following changes:<br>• During all water year types (wet, normal, dry), the volume of water would be relatively unchanged during rearing and pre-winter, would increase during breeding, and would increase greatly during overwintering.<br>• Water elevations would increase slightly in winter and during the breeding seasons of normal and wet years.<br>• During breeding season, pool elevation and storage volume stability and vegetation inundation would be relatively unchanged.<br>• During pre-winter, the volume of water in the reservoir would decrease less, which would improve access to overwintering sites by decreasing the travel distances between breeding and overwintering sites.<br>• Volume would be prevented from decreasing below 37,870 acre-feet during the winter compared to 35,000 acre-feet under the no-action.<br>• The rate of fill would be spread out over a longer period as water volumes increase between Nov 1 and April 1 (or earlier) and are held at an upper volume of 48,000 acre-feet. The jump in volume after May 1 would be eliminated. The smoothing of the hydrograph would maintain a more stable water interface with the vegetation and decreased changes in volume. |

cfs = cubic feet per second

**Table 3.4-8. 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

## BIO-4: Affect Bull Trout Habitat

The proposed action would have no effect on bull trout habitat in Whychus[5] 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

[5] 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.

and adding more depth to pool habitat) over the permit term in the portion of the reach accessible to the species.

**Crooked River.** Bull trout are currently encountered at Opal Springs Dam (Lickwar pers. comm.[a]). Foraging subadult and adult bull trout are expected to migrate upstream of Opal Springs Dam with operation of fish passage facilities starting in winter 2019. They may occupy habitats throughout the river up to Bowman Dam during the winter when temperatures are favorable. However, summer daily maximum temperatures exceed the temperature thresholds for subadult and adult bull trout under the no-action alternative, with the exception of the reach downstream of Bowman Dam (Reach CR-10; river mile [RM] 57 to 70) and the Opal Springs reach (CR 1.2 and 1.1) from about RM 4 to the Crooked River confluence with Lake Billy Chinook.

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 be present in the river at the beginning of the irrigation season.

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.

Bull trout would be exposed to a range of water management operations effects under the proposed action, including differences in streamflow across the year affecting the amount of habitat available and water management operations affecting water temperatures during critical life stages. 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. However, during the irrigation season, increased North Unit ID reliance on the Crooked River to compensate for decreased Upper Deschutes water supply under Conservation Measure WR-1 would decrease streamflows downstream of the North Unit ID pumps to Osborne Canyon (Reaches CR-2 through 1.3; RMs 28 to 8) from May through September in a little over half of the years over the permit term. The median flow in July and August in this reach would begin to decrease in years 11 to 20 of the permit term, and in years 21 to 30 there would be a more substantial reduction in median streamflow in a majority of years.

Analysis of water temperature thresholds for bull trout juvenile and subadult life stages suggest an adverse effect of water management on water temperatures in dry and normal water year types[6] in years 21 through 30 of the permit term (Table 10, Appendix 3.4-C). Water management and associated modeled water temperatures in the wet water year show no effect on bull trout juvenile and subadult habitat. However, water management and water temperatures in the dry and normal water years indicate a potential for adverse effects on bull trout that may remain in the Crooked River through the summer in the approximately 62 miles between Bowman Dam and Osborne Canyon (Reaches CR-10 through CR-1.3; RM 70 to 8). Specifically, in the 13-mile long reach immediately downstream of Bowman Dam (Reach CR-10), the number of days that water

[6] Water year types are defined in Table 3.2-1 in Section 3.2, *Water Resources*.

temperatures met the preference threshold decreased by 21 days and the number of days that water temperatures exceeded the stress/disease threshold increased by 19 days. Water temperature results predicted a similar trend of decreasing preference days and increasing stress/disease days in downstream reaches.

The fewer days meeting the water temperature preference threshold and an increase in stress/disease days would be an adverse effect. Together, the possibility of bull trout moving into the Crooked River, the shift in water temperatures, and the frequency of occurrence indicate an adverse effect on bull trout habitat in the Crooked River downstream of Bowman Dam from RM 70 to Osborne Canyon at RM 8.

**Effect Conclusion:** 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. However, overall effects on bull trout habitat would be not adverse because adverse effects on the Crooked River would be limited to summer months (when existing conditions are not favorable to bull trout because of water temperatures) in dry and normal water year types in years 21 through 30 of the permit term in the 62 miles between Bowman Dam (RM 70) to Osborne Canyon (RM 8); conditions would improve on the Middle Deschutes River and Ochoco and McKay Creeks, and would be unchanged in other areas occupied by bull trout (Whychus Creek, the Lower Deschutes River, Lake Billy Chinook, Lake Simtustus, and the 8 miles of Crooked River downstream of Osborne Canyon).

## 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 the Crooked River because temperatures would not be affected during migration windows for subadult

and adult bull trout entering and moving upstream in the fall and leaving the Crooked River in the spring.

**Effect Conclusion:** In the Middle Deschutes River, increased winter streamflows would have a beneficial effect on the ability of subadults and adults to move in and out of the Middle Deschutes River to access foraging habitat. In the Crooked River, migratory life stages would not be affected because water management would not affect habitat conditions or water temperatures during subadult and adult migration periods. In Ochoco and McKay Creeks, increased flows would have small beneficial effects. Overall, the proposed action would have a beneficial effect on bull trout migratory life stages compared to the no-action alternative because of the beneficial effects on the Middle Deschutes River and Ochoco and McKay Creeks.

## 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 and McKay Creeks from increased flows (described under Impact BIO-4). 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.

**Crooked River.** Conservation Measures CR-4, CR-5, and CR-6 would benefit steelhead trout habitat as described for bull trout (Impact BIO-4).

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).

Decreased streamflows and downstream of the North Unit ID pumps to Osborne Canyon (Reaches CR-2 through 1.3; RMs 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.

Habitat model results suggest an adverse effect on summer rearing habitat and inconclusive effects on winter rearing habitat, although higher streamflows are predicted to increase habitat capacity independent of summer water temperatures (Figures 26 and 27, Appendix 3.4-C).

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 (Table 12, Appendix 3.4-C).

In the reach immediately downstream of Bowman Dam (Reach CR-10) the number of days that water temperature exceeded the avoidance temperature threshold for juvenile steelhead trout

increased by 26 days in the modeled wet water year and 4 days in the dry water year related to early season irrigation diversions. In the normal water year the number of avoidance days did not change, but the number of suboptimal days increased by 32 days. In the next downstream reach (Reach CR-9; RM 48 to 57), the number of days water temperature exceeded the avoidance temperature threshold increased by 25 days in the wet water year and 8 days in the normal water year. In the dry water year the number of suboptimal days decreased by 21 days, but the number of stress/disease days increased by 10 days.

**Effect Conclusion:** In the Crooked River, Conservation Measures CR-4, CR-5, and CR-6 would result in beneficial effects on steelhead habitat. However, water management under the proposed action (Conservation Measures WR-1) would result in an adverse effect on water temperatures and juvenile habitat in all water years in years 21 through 30 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. 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 steelhead trout habitat would be adverse in the Crooked River because the potential exists for early season irrigation diversions to affect steelhead trout habitat in years 21 through 30 of the permit term. However, overall effects of the proposed action on steelhead trout habitat compared to the no-action alternative would be not adverse because adverse effects on the Crooked River would be limited to summer months (when existing conditions are not favorable to steelhead trout because of water temperatures) in dry and normal water year types in years 21 through 30 of the permit term in the 62 miles between Bowman Dam (RM 70) to Osborne Canyon (RM 8); conditions would improve on the Middle Deschutes River and Ochoco and McKay Creeks, and would be unchanged in other areas occupied by steelhead trout (Whychus Creek, the Lower Deschutes River, Lake Billy Chinook, Lake Simtustus, and the 8 miles of Crooked River downstream of Osborne Canyon).

## BIO-7: Affect Steelhead Trout Migratory Life Stages

The proposed action would have no effect on steelhead trout migratory life stages in Whychus Creek because streamflows would be unchanged over the permit term compared to the no-action alternative. 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. The proposed action would have small beneficial effects on steelhead trout migratory life stages in Ochoco Creek and McKay Creek from increased flows described for bull trout (Impact BIO-5). Effects in the remaining reaches relevant to the species are described.

**Middle Deschutes.** The proposed action would have no effect on steelhead trout migratory life stages during the irrigation period from April to September because streamflows in the 12.2 miles of river accessible to steelhead trout (Big Falls as RM 132 to Lake Billy Chinook at RM 120) during the irrigation season would be unchanged over the permit term. Small to moderate increases in winter streamflows of approximately 20% outside of the irrigation season, under the proposed action during the last 10 years of the permit term, are insufficient to suggest improved adult and juvenile migration habitat..

**Crooked River.** Higher median streamflows during the storage season (Conservation Measure CR-1) would result in a benefit to steelhead trout migration habitat. There was no evidence that the proposed action streamflows during the irrigation season would adversely affect water temperatures during periods steelhead trout juveniles or adults may be migrating compared to the

no-action alternative for any of water year types analyzed. Water temperatures during migratory periods and temperature thresholds for migratory life stages indicate there would be more days that water temperatures would be in the preferred category under the proposed action. (Tables 13 and 14, Appendix 3.4-C). Overall, because streamflows and water temperatures are relatively unchanged compared to the no-action alternative during the irrigation season, there would be no effect on migratory life stages of steelhead trout in the Crooked River.

**Effect Conclusion:** In all river reaches, there would be no effect on steelhead migratory life stages. In the Middle Deschutes River, increased winter streamflows would be small to moderate and, thus, are expected to have no effect on steelhead migration. In the Crooked River, water temperature changes would also have no effect or possibly small beneficial effects with more preferred days during steelhead trout migration. Overall, the proposed action would have no effect on steelhead trout migratory life stages compared to the no-action alternative because increases in streamflows would not change enough to suggest an effect during steelhead migration life stages.

## BIO-8: Affect Spring Chinook Salmon Habitat

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. The proposed action would have small beneficial effects on spring Chinook salmon habitat in Ochoco Creek from increased flows described for bull trout (Impact BIO-4). 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 would benefit spring Chinook salmon habitat as described for bull trout (Impact BIO-4).

Spring Chinook salmon would be exposed to a range of water management effects under the proposed action in the Crooked River, including seasonal streamflow changes that could affect the amount of habitat available and effects of water management operations that could affect water temperatures during critical life stages (Conservation Measures CR-1 and WR-1). However, habitat model results are inconclusive, suggesting no trend toward better or worsening amount of available habitat. During the irrigation season, increased North Unit ID reliance on the Crooked River to compensate for decreased Upper Deschutes water supply under Conservation Measure WR-1 would decrease streamflows and spring Chinook salmon habitat in the Crooked River downstream of the North Unit ID pumps to Osborne Canyon (Reaches CR-2 through 1.3; RMs 28 to 8) from May through September in a little over half of the years over the permit term.

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 (Table 15, Appendix 3.4-C). Water management operations and associated modeled water temperatures in wet water years shows minimal effect on juvenile Chinook salmon habitat over the permit term as streamflows and water temperatures are relatively unchanged from the no-action alternative.

However, water management and water temperatures for the dry and normal water years in years 21 through 30 (and less so in years 11–20), indicate a potential for adverse effects on Chinook salmon habitat in the approximately 62 miles between Bowman Dam and Osborne Canyon. For example, in the reach immediately downstream of Bowman Dam (Reach CR-10), the number of days that water temperatures met the preference threshold decreased by 21 days, and the number of days water temperatures exceeded the stress/disease temperature threshold increased by 21 days. Water temperature results predicted a similar trend of decreasing preference days and increasing stress/disease days in downstream reaches. In the reach downstream of the canyon reach (Reach CR-9) and in the reach just upstream of Prineville (Reach CR-8; RM 48 to 57) the number of days temperatures met the preference threshold decreased by 21 days and 22 days, respectively compared to the no-action alternative. Effects of water management on water temperature in reaches downstream of Prineville tended to be variable as temperatures were warmer 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 in the normal water year type.

Temperature thresholds were not evaluated for adult holding habitat in the Crooked River. However, more days with warm water temperatures evaluated for summer juvenile rearing suggest a similar adverse effect on adult spring Chinook salmon holding habitat in the Crooked River through the summer.

**Effect Conclusion:** 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. 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 between Bowman Dam (RM 70) and Osborne Canyon (RM 8) 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. However, overall effects on spring Chinook salmon habitat would be not adverse because adverse effects on the Crooked River would be limited to summer months (when existing conditions are less favorable to spring Chinook because of water temperatures) in dry and normal water year types in years 21 through 30 of the permit term in the 62 miles between Bowman Dam (RM70) to Osborne Canyon (RM 8); conditions would improve on the Middle Deschutes River and Ochoco Creek, and would be unchanged in other areas occupied by spring Chinook (Whychus Creek, the Lower Deschutes River, Lake Billy Chinook, Lake Simtustus, and the 8 miles of Crooked River downstream of Osborne Canyon).

## BIO-9: Affect Spring Chinook Salmon Migratory Life Stages

The proposed action would have no effect on spring Chinook 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 spring Chinook salmon migratory life stages

in the Lower Deschutes because the increase in winter streamflows over the permit term would be minor. Effects in the remaining reaches relevant to the species are described.

**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. 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.** Analysis of temperature thresholds for spring Chinook salmon upstream migrating adults from March through June and seaward migrating smolts from February through May suggest no effect of proposed action water management on water temperatures based on modeled streamflows (Table 16 and 17, Appendix 3.4-C). 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 spring Chinook adults may move upstream in the Crooked River in July and August (Hill et al. 2014). Furthermore, radio tracking of spring Chinook salmon 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 indicate 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.

**Effect Conclusion:** In the Crooked River, water management operations under the proposed action compared to the no-action alternative would result in no effect on migrating adult spring Chinook salmon from March to May and migrating spring Chinook salmon smolts but may result in a decline in habitat for adult spring Chinook salmon migrating in July and August depending on water management practices.

Overall effects on spring Chinook salmon migratory life stages would be not adverse because potential adverse effects in Crooked River would be limited to adults attempting to migrate in July and August between Bowman Dam and Osborne Canyon in a limited set of water year types downstream of the North Unit ID diversion during the last 10 years of the permit term

## BIO-10: Affect Sockeye Salmon Habitat

The proposed action would have no effect on sockeye 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. Effects in the remaining reaches relevant to the species are described.

**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 (differences are minor suggesting no effect on streambed scour or channel erosion rates) 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. Eggs would remain in the gravel through the winter. Newly emerged sockeye salmon 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 the 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.

**Effect Conclusion:** In the Middle Deschutes River, increased winter streamflows would be relatively small and would have no effect on sockeye salmon habitat. In the lower portion of the Crooked River used by sockeye salmon, changes in flow would be too small context of the high volume groundwater inflow to result in effects. Overall, the proposed action would have no effect on sockeye salmon habitat compared to the no-action alternative.

## BIO-11: Affect Sockeye Salmon Migratory Life Stages

The proposed action would have no effect on sockeye salmon migratory life stages 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. Effects in the remaining reaches relevant to the species are described.

**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 minor 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.

**Effect Conclusion:** The proposed action would have no effect on sockeye salmon migratory life stages compared to the no-action alternative in any of the modeled water year types.

## 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 or changes would be minor 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 redband trout habitat in Ochoco and McKay Creeks from increased flows described for bull trout (Impact BIO-4). Effects in the remaining reaches relevant to the species are described.

**Crescent Lake Reservoir.** Crescent Lake Reservoir elevations would not change during most of the year. Slightly higher reservoir elevations in the spring would occur when redband trout are accessing tributaries for spawning. However, the minor increase in reservoir elevation in the spring 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.** The proposed action would have small beneficial effects on redband trout habitat from seasonal minimum streamflows under Conservation Measure CC-1, restricted rate of change in streamflows below Crescent Dam under Conservation Measure CC-2, and a limited period of ramp down at the end of irrigation season under Conservation Measure CC-3. Streamflows would be lower in the fall and in early spring and may negatively affect rearing habitat and spawning habitat in the spring. Streamflows would be slightly higher during the summer, which may negatively affect emergent bank vegetation and corresponding habitat structure important to juvenile redband trout. However, the differences would be minor and would have no discernable effect on stream margin vegetation. Streamflows would be more variable during the summer but likely not enough to suggest a negative effect. 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 in the Little Deschutes River. Streamflows in the Little Deschutes River and Big Marsh Creek overwhelm 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 would be less variable over the year, and reservoir volume would be higher throughout most of the year. 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 toward the end of the permit term would negatively affect rearing habitat for juvenile and subadult redband trout and would negatively affect the lake food web (Murphy et al. 2019). Furthermore, the extreme drawdown would result in the entrainment of juvenile redband trout into the unscreened reservoir outlet and displacement of fish 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 possibly improving riparian habitat for juvenile 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, Appendix 3.4-C).

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 (Figure 6, Appendix 3.4-C). 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 phenomena 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, Appendix 3.4-C). 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.

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.

Therefore, despite the improved conditions with higher winter streamflows, lower summer streamflows, and potential for improved riparian conditions in the Deschutes River, the proposed action would have an overall adverse effect on redband trout habitat in the Upper Deschutes River between Wickiup Reservoir and the city of Bend because of increased within year variation in streamflows in the spring and summer during critical non-mobile or less mobile life stages.

**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 (Reach DR-5) 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 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 (Figure 37, Appendix 3.2-A*)*. Any adverse effect of down ramping during this period on redband trout would be the same for all alternatives. Therefore, the proposed action would have an overall beneficial effect on redband trout habitat in the Middle Deschutes River.

**Crooked River.** In the Crooked River, redband trout are abundant in the reach immediately downstream of Bowman Dam (Reach CR-10) because of a consistent supply of cool water from Bowman Dam and in the lower Crooked River reach upstream of Lake Billy Chinook (Reaches CR-1.2 and CR-1.1) because of 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 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; RMs 28 to 8) 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 (Impact BIO-6). The Crooked River downstream of the canyon reach (Reach CR-9) and in the reach just upstream of the city of Prineville (Reach CR-8; RM 48 to 57) 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.

**Effect Conclusion:** The proposed action would have no effect on redband trout habitat in Crescent Lake Reservoir, Crescent Creek, the Little Deschutes River, Whychus and Tumalo Creeks, and the Lower Deschutes, Lake Billy Chinook, Lake Simtustus, and Prineville Reservoir. There would be a beneficial effect on redband trout in Crane Prairie Reservoir, the Upper Deschutes River between Crane Prairie and Wickiup Reservoirs, the Middle Deschutes River, and Ochoco and McKay Creeks. Adverse effects in the Crooked River would be limited to summer months (when existing conditions are not favorable to redband trout because of water temperatures) in dry and normal water year types in years 21 through 30 of the permit term in the 62 miles between Bowman Dam (RM 70) to Osborne Canyon (RM 8); effects would be not adverse in the 8 miles of the Crooked River downstream of Osborne Canyon. Adverse effects on habitat quantity and quality would also occur in Wickiup Reservoir and the Upper Deschutes River between Wickiup Reservoir and the city of Bend. Overall, the proposed action would have an adverse effect on redband trout habitat compared to the no-action alternative because of the importance of the reaches where adverse effects would occur.

## BIO-13: Affect Nonnative Resident Trout Habitat

The proposed action would have no effect on nonnative trout habitat in Whychus Creek, the Lower Deschutes River, Crescent Creek, Little Deschutes River, Crane Prairie Reservoir, Prineville Reservoir, 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. The proposed action would have small beneficial effects on nonnative resident trout habitat in Ochoco and McKay Creeks from increased flows described for bull trout (Impact BIO-4). Effects in the remaining reaches relevant to the species are described below.

**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 between Wickiup Reservoir and Bend.** Increase 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.** Increased winter flows would have a beneficial effect on nonnative brook and brown trout by providing additional habitat for the species between Bend and Lake Billy Chinook.

**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.

**Effect Conclusion:** There would be no effect in several reaches, and there would be small beneficial effects in the Upper Deschutes River, Middle Deschutes River, and Ochoco and McKay Creeks. However, there would be an adverse effect in Wickiup Reservoir due to extreme variation in reservoir elevation and volume and in the Crooked River due to temperature effects. Overall, the effect of the proposed action would be not adverse on nonnative trout habitat compared to the no-action alternative.

## BIO-14: Affect Summer/Fall Chinook Salmon Habitat

Summer/fall Chinook salmon distribution is limited to the Lower Deschutes River downstream of the Pelton-Round Butte Complex. The proposed action would have no effect on summer/fall Chinook salmon habitat in the Lower Deschutes River because the increase in winter streamflows over the permit term would be minor compared to the no-action alternative.

**Effect Conclusion:** The proposed action would have no effect on summer/fall Chinook salmon habitat compared to the no-action alternative.

## 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. Effects in the remaining reaches relevant to the species are described.

**Crane Prairie Reservoir.** Higher reservoir elevations and volumes in fall and winter months may result in improved conditions in the reservoir for kokanee salmon. Overall the proposed action would have no effect on kokanee salmon habitat and migratory life stages in Crane Prairie Reservoir.

**Wickiup Reservoir.** The predicted extreme variation in reservoir elevations over the permit term would affect kokanee habitat in the reservoir. Effects would be less extreme in years 1 through 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 into the Deschutes River.

**Effect Conclusion:** There would be no effect in all reaches except for Wickiup Reservoir, in which there would be an adverse effect due to extremely low reservoir elevations and volumes and extreme seasonal differences. Overall, the proposed action would have an adverse effect on kokanee salmon habitat and migratory life stages because of the effects in Wickiup Reservoir.

## BIO-16: Affect Native Non-Trout and Non-Game Species 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. In the Crooked River, water management could have adverse effects on habitat for these species (except for Pacific lamprey, which is not present in the river) due to differences in water temperature during the summer. Non-game native species are adapted to the cooler temperatures typical in most areas in the study area, so a shift to more warm days under the proposed action at full implementation (years 21–30) would adversely affect these species for reasons similar to those already discussed for other fish species.

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 that 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 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.

The proposed action would have a beneficial effect on non-game species habitat in the Middle Deschutes River between Bend and Lake Billy Chinook because increased winter flows would provide additional habitat for non-game species.

**Effect Conclusion:** The proposed action would have an adverse effect on non-game native species occurring in Wickiup Reservoir due to extreme variation in reservoir elevation and volume and seasonal differences and the Crooked River due to more days with warmer temperature. Effects in

the Upper Deschutes River downstream of Wickiup Reservoir 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. There would be beneficial effects in the Middle Deschutes River during storage season, small beneficial effects in Ochoco and McKay Creeks, and no effect in other areas occupied by these species. Overall, effects of the proposed action on non-game native species would not adverse compared to the no-action alternative.

## BIO-17: Affect Freshwater Mollusk Habitat

The proposed action would have no effect on freshwater mollusk habitat in Whychus Creek, the Lower Deschutes River, or Crane Prairie Reservoir 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. Effects in the remaining reaches where species occur or have the potential to occur are described.

### Crescent Lake Reservoir

- Although reservoir elevations would be lower between August and October, they would be generally higher the rest of the year; therefore, overall, the effect on Crater Lake tightcoil and evening field slug tightcoil habitat would be not adverse.

### Crescent Creek

- Increased summer streamflows would provide additional moist habitat for Crater Lake tightcoil. Flow differences during winter months would have little to no effect on this species because tightcoil often ***aestivate*** under the ground during the winter; therefore, overall effects on Crater Lake tightcoil would be beneficial.
- Unlike snails, slugs generally remain active during cooler months as long as temperatures are slightly above freezing. Therefore, while reduced fall streamflows 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, the effect on evening field slug would be not adverse.
- Reductions in streamflows during fall and spring could adversely interfere with western pearlshell mussel juvenile development and adult maturation; however, increased summer streamflows could be beneficial for maturing western pearlshell mussels and for their glochidia traveling on host salmonid fish. As discussed in Appendix 3.4-C, reductions in streamflows at the end of September and beginning of October could cause stranding of newly settled juveniles and adults. Reduced streamflows in October and November in some years could cause additional mussel stranding or reduced water quality. Increased June streamflows could provide additional habitat and better streamflow conditions during the time period of larval pearlshell attachment and maturation on host fish. The proposed action would have small beneficial effects on freshwater mollusk habitat in Ochoco and McKay Creeks from increased flows described for bull trout (Impact BIO-4). Overall, the effect on western pearlshell mussels would be not adverse.

### Little Deschutes River

- Changes in streamflows would be minimal across an annual cycle, resulting in no additional or improved habitat (perennially moist areas) for Crater Lake tightcoil and evening field slug. Therefore, effects on these species would be not adverse.

- May and June, the critical period of reproduction and juvenile establishment for western pearlshell mussel, are the months that experience the most significant median streamflow increases. Therefore, effects would be beneficial.

**Upper Deschutes**

- 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, the higher streamflows in fall and winter would provide more inundation for Crater Lake tightcoil. For evening field slug, increased base streamflow during fall and winter months in most of the Upper Deschutes would provide additional habitat during this time, and while summer months experience significantly lowered flows, the flow levels are still relatively high enough to avoid seasonal reductions of moist habitats for this species. The effect on Crater Lake tightcoil or evening field slug habitat would be not adverse because although there would be summer streamflow decreases overall, these decreases would not significantly alter habitat for the species over the course of the permit term.
- While 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 of western pearlshell mussel. Effects would be not adverse.

**Wickiup Reservoir**

- Riparian conditions in Wickiup Reservoir are poor and suggest that Crater Lake tightcoil and evening field slug are not present or are located in a few isolated locations; however, increased variation in reservoir elevations would have an adverse effect on the species, if present, because it could cause mortality.

**Middle Deschutes**

- Increased streamflows October through March would creating additional moist habitat for Crater Lake tightcoil and evening field slug habitat and would therefore have a beneficial effect.
- Although streamflows are higher during the winter, streamflows would decrease in the reaches immediately downstream of the DEBO gauge in May and June, the critical period for reproduction and juvenile establishment for western pearlshell mussel. Therefore, effects on western pearlshell mussel would be adverse.
- Higher winter streamflows would be beneficial to western ridged mussels, where they are present in this reach up to Big Falls, Decrease streamflows from June through August, the most critical period reproduction and juvenile settlement, would be very minimal on average and not adverse. Overall, the effect would be not adverse.

**Crooked River**

- 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 North Unit ID 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. Because of the increased frequency of lowered flows in summer months, the effect would be adverse.

- The increased frequency of decreased median monthly flows in summer months could cause drying of potential habitat for evening field slug. This period is also critical for reproduction and juvenile establishment of floater species mussels (May through August) and western ridged mussels (June through August). Therefore, effects would be adverse for these species.
- Variable flow changes through May and June, the critical period of reproduction and juvenile establishment for western pearlshell mussel habitat, would also result in an adverse effect.

**Effect Conclusion:** The proposed action would have no effect on freshwater mollusk habitat in Whychus Creek, the Lower Deschutes River, and Crane Prairie Reservoir. Effects would be not adverse in Crescent Lake Reservoir and the Upper Deschutes River; beneficial, not adverse, or adverse in Crescent Creek, the Little Deschutes River, and the Middle Deschutes River depending on the species; and adverse in Wickiup Reservoir. Overall, effects of the proposed action on mollusk habitat compared to the no-action alternative would be not adverse.

### 3.4.3.3 Alternative 3: Enhanced Variable Streamflows

This section describes effects on biological resources 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. Effects of Alternative 3 on Oregon spotted frog are considered at full implementation , which would occur in years 11 through 30 of the permit term when minimum fall/winter flows downstream of Wickiup Dam are at their highest (Table 3.1-1). Effects on fish and mollusks are discussed by geographic area and include only those geographic areas where each species occurs or has the potential to occur.

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. More detailed data, analysis, and graphics are provided in Appendix 3.4-C.

Changes in streamflows and reservoir elevations and variability would be the same or nearly the same 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-1: Change Vegetation Communities

Changes in streamflows and reservoir elevations and variability under Alternative 3 compared to the no-action alternative would be the same or nearly the same as described for the proposed action (Table 3.4-6) for all reaches.[7] Therefore, effects on vegetation in these reaches would be the same as

[7] Although changes in the Crooked River reaches changes would be of slightly than described for the proposed action in Table 3.4-6, the effects on vegetation would be the same for the reasons described in the table.

described for the proposed action. However, adverse effects on Wickiup Reservoir and beneficial effects along the Upper Deschutes River would occur earlier in the permit term than the proposed action (Table 3.1-1). In Wickiup Reservoir, prolonged episodes of drying or inundation of riparian vegetation would occur earlier than under the proposed action and the change would reduce the long-term quality and function of riparian vegetation around the reservoir. Conservation Measure DR-2 under Alternative 3 would provide a funding mechanism for actions identified in a future OSF recovery plan anticipated in 2021 (Appendix 2-C, *Rationale for Oregon Spotted Frog Conservation Fund*). These actions would address ongoing threats such as reed canarygrass and bullfrogs to Oregon spotted frogs along the Upper Deschutes River that would persist despite improvements in hydrology as described in Impact BIO-3. Implementation of such controls could benefit function and species diversity of riparian and wetland vegetation in treated areas along the Upper Deschutes River under Alternative 3 compared to the no-action alternative.

**Effect Conclusion**: Effects on vegetation communities under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action, except beneficial effects in the Upper Deschutes River would be greater with Conservation Measures DR-2. Both adverse effects in Wickiup Reservoir and beneficial effects in the Upper Deschutes River would occur earlier in the permit term and, therefore, be of longer duration under Alternative 3 than the proposed action (Table 3.1-1). Overall, the effects of Alternative 3 on vegetation communities would be beneficial compared to the no-action alternative because the extensive vegetation improvements in Crane Prairie Reservoir and the Upper Deschutes River would have a greater effect compared to the localized impairments occurring in Wickiup Reservoir.

## BIO-2: Change Habitat for Wildlife Species

Changes in streamflows and reservoir elevations and variability (Table 3.4-6) and related vegetation changes would be same as described for the proposed action for all reaches except for the Crooked River and the Upper and Middle Deschutes River. Therefore, effects on wildlife in these reaches would be the same as described for the proposed action.

Exclusively hydrologic changes in Crooked River reaches Cro-1 to Cro-10 and would be similar to but of slightly greater magnitude than those described for the proposed action. As described for the proposed action, effects on wildlife would be limited in reaches Cro-1 to Cro-5. The further increased flows under Alternative 3 compared to the proposed action downstream of Prineville Reservoir in June would further increase foraging and, for some species, breeding habitat.

As described in BIO-1, modeled changes in Wickiup Reservoir and flows in the Deschutes River reaches downstream of the reservoir and related effects on vegetation are the same as described for the proposed action but would occur earlier in the permit term. Therefore, effects on wildlife in these reaches would be the same as described for the proposed action but would also occur earlier in the permit term.

Conservation Measure DR-2, described in Alternative 3, would provide a funding mechanism for actions identified in a future Oregon spotted frog recovery plan anticipated in 2021 (Appendix 2-C). These actions would address ongoing threats to Oregon spotted frogs along the Upper Deschutes River, such as reed canarygrass infestations and predation by invasive bullfrogs. Implementation of such actions would also benefit wildlife in the affected areas by reducing habitat impairments, such as reduced foraging habitat quality for waterfowl attributable to these invasive species.

**Effect Conclusion**: Effects of Alternative 3 on wildlife and its habitat compared to the no-action alternative would be the same as described for the proposed action, except that Conservation Measure DR-2 would increase beneficial effects by reducing habitat impairments. Both adverse effects in Wickiup Reservoir and beneficial effects in the Upper Deschutes River would occur earlier in the permit term and, therefore, be of longer duration under Alternative 3 than the proposed action (Table 3.1-1). Overall, effects of Alternative 3 on habitat for wildlife would be beneficial compared to the no-action alternative because hydrologic modifications and vegetation improvements in Crane Prairie Reservoir and the Upper Deschutes River would be more substantial and more extensive than habitat impairments, which are limited to Wickiup Reservoir.

## BIO-3: Affect Oregon Spotted Frog Habitat

Modeled changes in flows under Alternative 3 at full implementation compared to the no-action alternative are the same as described for the proposed action but would occur earlier in the permit term. Therefore, flow-related effects (both beneficial and adverse) on Oregon spotted frog habitat would be the same as described for the proposed action but would occur starting in year 11 of the permit term, 10 years earlier than under the proposed action. This decade of flow improvements in most reaches and during most life history periods represents a substantial timeframe for a species that reaches breeding maturity within 1 to 3 years. Frogs would have access to improved habitat conditions in most reaches as the fully implemented flows would result in more consistent and adequate wetland vegetation inundation a decade earlier than they would under the proposed action. Table 3.4-8 shows the direction of hydrology-related effects for each life history stage by reach. Refer to Appendix 3.4-B for the full analysis.

In addition, Conservation Measure DR-2, included under Alternative 3, would provide a funding mechanism for actions identified in a future OSF recovery plan anticipated in 2021 (Appendix 2-C). These actions would address ongoing threats such as reed canarygrass and bullfrogs to Oregon spotted frogs that would persist despite improvements in hydrology. Conservation actions would be site specific to benefit Oregon spotted frog and its habitat by increasing local populations and connectivity between populations. Actions may include but would not be limited to removal of bullfrogs and reed canarygrass, reduction of encroachment of cattails or lodgepole pine, maintenance of existing restoration sites such as Ryan Ranch or Dilman, and implementation of riverine and wetland habitat restoration. The conservation fund may also be used to address new threats to Oregon spotted frog, such as those resulting from climate change.

**Effect Conclusion**: Beneficial and adverse effects related to changes in hydrology under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action, but would occur earlier in the permit term and therefore be of longer duration.

In addition, funding to implement actions to address ongoing threats to and improve habitat for Oregon spotted frog would increase beneficial effects of hydrologic changes and offset adverse effects of those changes. Overall, effects on Oregon spotted frog and its habitat under Alternative 3 would be beneficial compared to the no-action alternative for the reasons described for the proposed action. Because of the addition of the conservation fund, beneficial effects would be of greater magnitude and adverse effects of lesser magnitude than described for the proposed action.

### BIO-4: Affect Bull Trout Habitat

Effects on bull trout habitat under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action for all reaches except the Crooked River reach between the North Unit ID pumps and Osborne Canyon. Adverse effects in this reach 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). Tables 19 through 21 in Appendix 3.4-C present detailed model results. 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 (Table 3.1-1). Overall, effects on bull trout habitat under Alternative 3 would be not adverse compared to the no-action alternative for the reasons described for the proposed action.

### BIO-5: Affect Bull Trout Migratory Life Stages

Effects on bull trout migratory life stages under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action for all reaches, but beneficial effects in the Middle Deschutes River would occur earlier in the permit term and, therefore, have a longer duration under Alternative 3 than the proposed action (Table 3.1-1). Overall, Alternative 3 would have a beneficial effect on bull trout migratory life stages for the reasons described for the proposed action.

### BIO-6: Affect Steelhead Trout Habitat

Effects on steelhead trout habitat under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action for all reaches, except in the Crooked River reach between the North Unit ID pumps and Osborne Canyon where 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). Figures 36 and 37 and Tables 22 and 23 in Appendix 3.4-C present detailed model results. 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 (Table 3.1-1). Overall, effects on steelhead trout habitat under Alternative 3 would be not adverse compared to the no-action alternative for the reasons described for the proposed action.

### BIO-7: Affect Steelhead Trout Migratory Life Stages

Effects on steelhead trout migratory life stages under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action for all reaches. Tables 24 and 25 in Appendix 3.4-C present modeled results. Alternative 3 would have no effect on steelhead trout migratory life stages for the reasons described for the proposed action.

### BIO-8: Affect Spring Chinook Salmon Habitat

Effects on spring Chinook salmon habitat under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action for all reaches, except for in the Crooked River reach between the North Unit ID pumps and Osborne Canyon where 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). Figure 38 and Table 26 in Appendix 3.4-C present detailed model results. Effects in the Crooked River would occur earlier in the permit term and therefore be of longer duration under Alternative 3 than the proposed action (Table 3.1-1). Overall, effects on spring Chinook habitat under Alternative 3 would be not adverse compared to the no-action alternative for the reasons described for the proposed action.

### BIO-9: Affect Spring Chinook Salmon Migratory Life Stages

Effects on spring Chinook salmon migratory life stages under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action for all reaches, but 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 (Table 3.1-1). Tables 27 and 28 in Appendix 3.4-C present detailed model results. Overall, Alternative 3 would have a not adverse effect on spring Chinook migratory life stages for the reasons described for the proposed action.

### BIO-10: Affect Sockeye Salmon Habitat

Effects on sockeye salmon habitat under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action for all reaches. Alternative 3 would have no effect on sockeye salmon habitat for the reasons described for the proposed action.

### BIO-11: Affect Sockeye Salmon Migratory Life Stages

Effects on sockeye salmon migratory life stages under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action for all reaches. Alternative 3 would have no effect on sockeye salmon migratory life stages for the reasons described for the proposed action.

### BIO-12: Affect Redband Trout Habitat

Effects on redband trout under Alternative 3 compared to the no-action alternative would be the same 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. Implementation of Conservation Measure DR-2 under Alternative 3, described in Impact BIO-3, could have additional benefits on redband trout habitat in the Upper Deschutes River between Wickiup Reservoir and Bend; riverine and wetland habitat restoration actions funded through this measure would improve connectivity and functions of river riparian habitats that could contribute to improved river ecosystem function for redband trout in this reach. 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 (Table 3.1-1). 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.

### 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 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 (Table 3.1-1). 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

Alternative 3 would have no effect on summer/fall Chinook salmon habitat compared to the no-action alternative for the reasons 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 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 (Table 3.1-1). 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 native non-trout and non-game fish habitat under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action, except that implementation of riverine and wetland habitat restoration actions funded through Conservation Measure DR-2 under Alternative 3 could increase beneficial effects on these species in the Upper Deschutes River by improving connectivity and functions of river riparian habitats and contributing to improved river ecosystem function. 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 (Table 3.1-1). 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 compared to the no-action alternative would be the same as described for the proposed action except for floater species mussels and western pearlshell mussels in the Crooked River where there would be an adverse effect. 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 under the proposed action (Table 3.1-1). Overall, effects of Alternative 3 on freshwater mollusk habitat compared to the no-action alternative would be not adverse for the reasons described for the proposed action.

### 3.4.3.4 Alternative 4: Enhanced and Accelerated Variable Streamflows

This section describes effects on biological resources 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. Effects of Alternative 4 on Oregon spotted frog are considered at full implementation , which would occur in years 6 through 20 of the permit term when minimum fall/winter flows downstream of Wickiup Dam are at their highest (Table 3.1-1).

Changes in streamflows and reservoir elevations and variability would be the same or nearly the same 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 flows would diminish and winter flows would increase compared to the no-action alternative. 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 (Table 3.1-1), 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-1: Change Vegetation Communities

Changes in streamflows and reservoir elevations and variability under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action (Table 3.4-6) for all of the reaches except for the Crooked River and the Upper and Middle Deschutes River. Therefore, effects on vegetation in these remaining reaches would be the same as described for the proposed action.

In the Crooked River reaches, changes would be of slightly greater magnitude compared to those described for the proposed action in Table 3.4-6, but the effects on vegetation would be the same for the reasons described in the table.

Substantial changes in vegetation communities may occur in Deschutes River reaches upstream of Bend. 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. The hydrologic changes would be implemented in two stages, the first in years 1 to 5 and the second in years 6 to 20 of the permit term. It would take a period of years for the vegetation to respond to the hydrologic changes, with some changes (such as those affecting herbaceous plants) happening within a few years, and others (such as those affecting trees) occurring over the entire permit term, and beyond. The resulting ecological changes would be qualitatively the same as those described for the proposed action, but differing in timing, with changes forecast by year 21 of the proposed action being achieved by year 6 of Alternative 4.

- In reaches Des-7, Des-8, Des-8a, and Des-9, the flow changes under Alternative 4 have average values very similar to changes under the proposed action, but May and June flow variability would be somewhat greater. During low flow years this could slightly increase drought exposure in riparian and wetland vegetation, and during high flow years it could result in vegetation inundation. However, as under the proposed action, the likely outcome is still denser and more resilient vegetation compared to the no-action alternative.
- In reaches Des-10, Des-10a, Des-11, Des-12, and Des-12a, changes would be similar to the proposed action and Alternative 3, but would be of greater magnitude. For example, in Des-12a October through March increases would range from 17 to 47%, May through September reductions 4 to 26%, and flow variability reductions 27 to 51%. These changes would increase channel stability and decrease the extent of unvegetated area exposed during low flows. The cover and resilience of riparian and wetland vegetation would increase, while the extent of bare-soil substrates vulnerable to infestation by weed species would decrease. These would be beneficial changes. The reduction in summer peak flows is likely to reduce the total area of riparian and wetland vegetation; however, this change would be minor compared to the improved quality and function of affected riparian and wetland vegetation.
- The changes described for the proposed action for Wickiup Reservoir (reach Des-13), would be largely the same under Alternative 4, but would begin in year 1 of the permit term (rather than year 11 under the proposed action).
- Upstream of Wickiup Reservoir, Alternative 4 would begin to have the same effects on vegetation by year 6 as described for the proposed action in years 21 to 30.

Effects in the Deschutes River below Wickiup Reservoir would likewise begin sooner under Alternative 4 than under Alternative 3 (in year 1 instead of year 6) and, since Alternative 4 has a shorter permit term than the proposed action or Alternative 3 (20 years instead of 30), fewer long-term changes in vegetation would accrue by the end of the permit term.

Inclusion of Conservation Measure DR-2 under Alternative 4 would provide a funding mechanism for actions to improve conditions for Oregon spotted frog, which could benefit function and species diversity of riparian and wetland vegetation in treated areas along the Upper Deschutes River, as described for Alternative 3.

**Effect Conclusion**: Effects on vegetation communities under Alternative 4 compared to the no-action alternative would be the same as described for the proposed action, except that adverse effects in Wickiup Reservoir and beneficial effects in the Upper Deschutes River related to changes in hydrology would be of greater magnitude. Beneficial effects on function and species diversity of riparian and wetland vegetation would be further increased with implementation of Conservation Measure DR-2. Both beneficial and adverse effects would occur earlier in the permit term but end sooner than under the proposed action or Alternative 3 (Table 3.1-1); the duration of these full implementation effects would be between the proposed action and Alternative 3. Overall, the effects of Alternative 4 on aquatic and riparian vegetation would be beneficial compared to the no-action alternative because the extensive vegetation improvements in Crane Prairie Reservoir and the Upper Deschutes River would have greater effect compared to the localized impairments occurring in Wickiup Reservoir.

## BIO-2: Change Habitat for Wildlife Species

Changes in streamflows and reservoir elevations and variability and related effects on wildlife under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action, except along the Upper Deschutes River (reaches Des-3 to Des-6 and Des-14) and Crooked River (reaches Cro-1 to Cro-10) where effects would be the same but of slightly greater magnitude.

Inclusion of Conservation Measure DR-2 under Alternative 4 would provide a funding mechanism for actions to improve conditions for Oregon spotted frog along the Upper Deschutes River, which could benefit wildlife by reducing habitat impairments, as described for Alternative 3.

**Effect Conclusion:** Hydrology related effects of Alternative 4 on habitat for wildlife compared to the no-action alternative would be the same as described for the proposed action but of greater magnitude in of the Upper Deschutes River and some reaches of the Crooked River. The duration of both beneficial and adverse effects would be between the proposed action and Alternative 3. Overall, effects of Alternative 4 on habitat for wildlife would be beneficial compared to the no-action alternative because of habitat improvements due to hydrologic modifications and vegetation improvements in Crane Prairie Reservoir and the Upper Deschutes River would be more substantial and more extensive than habitat impairments, which are limited to Wickiup Reservoir.

## BIO-3: Affect Oregon Spotted Frog Habitat

Modeled changes in flows under Alternative 4 at full implementation compared to the no-action alternative would be similar to those described for the proposed action—summer flows would diminish and winter flows would increase compared to the no-action alternative—but changes would be of greater magnitude. Accordingly, effects of hydrological changes on Oregon spotted frog and its habitat would be the same as those described for the proposed action except that both the beneficial and adverse effects would be amplified, as described below. Although Alternative 4 would reach full implementation flows by year 6, faster than either the proposed action (which would take 20 years) or Alternative 3 (which would take 10 years), it would only be in place for a 20-year permit term, so full implementation would persist for 15 years, compared to 10 years under the proposed action and 20 years under Alternative 3.

Reach-specific effect differences in the following reaches under Alternative 4 are described with respect to the descriptions in Table 3.4-7, which represent effects under the proposed action compared to the no-action alternative.

- Des-8a
  - Pre-winter: A smaller decrease in flow could better prevent frogs from selecting poor overwintering sites disconnected from the waterline.
  - Overwintering: Higher sustained levels flow levels and less year-to-year variation would further increase vegetation inundation, which could better protect overwintering frogs.
- Des-9
  - Breeding: A smaller increase in flow would be less likely to dislodge egg masses.
  - Rearing: Lower flows could further dry wetlands and expose juvenile frogs to predation.

  - Pre-winter: A smaller decrease in flow could further prevent frogs from selecting poor overwintering sites disconnected from the waterline.
  - Overwintering: A higher sustained water elevation could further increase vegetation inundation, better protecting overwintering frogs.
- Des 10, Des 10-a
  - Breeding: An increase in flow would result in the most days of vegetation inundation, which is beneficial to breeding frogs.
  - Overwintering: A higher sustained water elevation could increase vegetation inundation, which could better protect overwintering frogs.
- Des-11, Des-12, Des-12a
  - Breeding: An increase in flow would result in more days of vegetation inundation, which is beneficial to breeding frogs.
  - Pre-winter: A lesser change in flows as they decrease at the end of irrigation season would allow overwintering frogs to be closer to breeding locations in adjacent wetlands.
  - Overwintering: Higher flows in more sites would result in more consistently wetted overwintering sites and shorter distances between breeding and overwintering locations.
- Des-13
  - A further decline in all habitat conditions in Wickiup Reservoir; refer to Appendix 3.4-B for details.

Table 3.4-8 shows the direction of hydrology-related effects for each life history stage by reach. Refer to Appendix 3.4-B for the full analysis.

In addition, inclusion of Conservation Measure DR-2 under Alternative 4 would provide a funding mechanism for actions to increase local populations of Oregon spotted frog and connectivity between populations by enhancing habitat conditions, as described for Alternative 3.

**Effect Conclusion:** During most Oregon spotted frog life history periods and in most reaches of the Deschutes River occupied by Oregon spotted frogs, Alternative 4 is likely to result in some beneficial effects due to the combination of timing of flows to support breeding sites in the spring, the availability of more water during the winter support Oregon spotted frog life history requirements, and funding to implement actions to benefit the Oregon spotted frog. Alternative 4 would have adverse effects in one reach (Wickiup Reservoir) during all spotted frog life history periods. Overall, effects on Oregon spotted frog and its habitat under Alternative 4 would be beneficial compared to the no-action alternative.

## BIO-4: Affect Bull Trout Habitat

Changes in streamflows and reservoir elevations and variability and, therefore, effects on bull trout habitat under Alternative 4 compared to the no-action alternative 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. Increased storage season flows and associated beneficial effects on bull trout habitat in the Middle Deschutes River and Crooked River would be the same as described for the proposed action but of greater magnitude at full implementation (Table 3.1-1). 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); in the Crooked River they are due to increased minimum flows to 80 cfs under Conservation Measure CR-1. However, 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. Tables 30 through 32 in Appendix 3.4-C present detailed model results.

Beneficial effects in the Middle Deschutes River and beneficial and adverse seasonal effects on the Crooked River would occur earlier in the permit term but end sooner than under the proposed action or Alternative 3; the duration of these full implementation effects under Alternative 4 would be longer than under the proposed action and shorter than under Alternative 3 (Table 3.1-1). Overall, effects on bull trout habitat under Alternative 4 would be not adverse compared to the no-action alternative for the reasons described for the proposed action.

## BIO-5: Affect Bull Trout Migratory Life Stages

Changes in streamflows and reservoir elevations and variability and, therefore, potential effects on bull trout migratory life stages under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all reaches except for the Middle Deschutes River. Beneficial effects on bull trout migratory life stages in the Middle Deschutes River under Alternative 4 would be the same as described for the proposed action but of greater magnitude at full implementation due to further increases in storage season flows in above-normal and wet years. The duration of these beneficial effects would be between the proposed action and Alternative 3 as described for bull trout habitat. Overall, effects on bull trout migratory life stages under Alternative 4 would be beneficial compared to the no-action alternative for the reasons described for the proposed action.

## BIO-6: Affect Steelhead Trout Habitat

Changes in streamflows and reservoir elevations and variability and, therefore, effects on steelhead trout habitat under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all reaches, except the Middle Deschutes River and Crooked River. Increased storage season flows and associated beneficial season effects on steelhead trout habitat in the Middle Deschutes River and Crooked River and adverse effects in summer in all water year types on the Crooked River would be of greater magnitude than described for the proposed action for the reasons described for bull trout in Impact BIO-4. Figures 44 and 45 and Tables 33 and 34 in Appendix 3.4-C present detailed model results. The duration of these beneficial and adverse effects would be between the proposed action and Alternative 3 as described for bull trout habitat (Impact BIO-4). Overall, effects on steelhead trout habitat under Alternative 4 would be not adverse compared to the no-action alternative for the reasons described for the proposed action.

### BIO-7: Affect Steelhead Trout Migratory Life Stages

Changes in streamflows and reservoir elevations and variability and therefore effects on steelhead trout migratory life stages under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action. Tables 35 and 36 in Appendix 3.4-C present modeled results. Alternative 4 would have no effect on steelhead trout migratory life stages compared to the no-action alternative for the reasons described for the proposed action.

### BIO-8: Affect Spring Chinook Salmon Habitat

Changes in streamflows and reservoir elevations and variability and therefore effects on spring Chinook salmon habitat under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all reaches except for the Crooked River. Increased storage season flows and associated beneficial season effects on spring Chinook salmon habitat in the Crooked River and adverse effects in summer in dry and normal water year types on the Crooked River would be of greater magnitude than described for the proposed action for the reasons described for bull trout in Impact BIO-4. Figure 46 and Table 37 in Appendix 3.4-C present detailed model results. The duration of these beneficial and adverse effects would be between the proposed action and Alternative 3 as described for bull trout habitat (Impact BIO-4). Overall, effects on spring Chinook salmon habitat under Alternative 4 would be not adverse compared to the no-action alternative for the reasons described for the proposed action.

### BIO-9: Affect Spring Chinook Salmon Migratory Life Stages

Changes in streamflows and reservoir elevations and variability and therefore effects on spring Chinook salmon habitat under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action. Tables 38 and 39 in Appendix 3.4-C present detailed model results. Overall, effects on spring Chinook salmon under Alternative 4 would be not adverse compared to the no-action alternative for the reasons described for the proposed action.

### BIO-10: Affect Sockeye Salmon Habitat

Changes in streamflows and reservoir elevations and variability and therefore effects on sockeye salmon habitat under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all reaches. Alternative 4 would have no effect on sockeye salmon habitat compared to the no-action alternative for the reasons described for the proposed action.

### BIO-11: Affect Sockeye Salmon Migratory Life Stages

Changes in streamflows and reservoir elevations and variability and therefore effects on sockeye salmon migratory life stages under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all reaches. Alternative 4 would have no effect on sockeye salmon migratory life stages compared to the no-action alternative for the reasons described for the proposed action.

## 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 as described for the proposed action for all reaches except for Wickiup Reservoir, the Upper and Middle Deschutes River, and the Crooked River. Increased storage season flows and associated beneficial season effects on redband trout habitat in the Middle Deschutes River and Crooked River would be of greater magnitude than described for the proposed action for the reasons described for bull trout in Impact BIO-4.

In the Upper Deschutes River, increased winter streamflows and decreased of summer streamflows and associated benefits for redband trout would be the same as described for the proposed action but of greater magnitude at full implementation (Table 3.1-1) due to increased releases from Wickiup Reservoir in above-normal and wet years under this alternative (Conservation Measure WR-1). In addition, implementation of riverine and wetland habitat restoration actions funded through Conservation Measure DR-2, as described under Alternative 3, could have additional benefits on redband trout by improving connectivity and functions of river riparian habitats and contributing to improved river ecosystem function for redband trout in this reach. Adverse effects in Wickiup Reservoir would also be the same 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. In the Crooked River, adverse effects in summer would also be of greater magnitude than described for the proposed action for the reasons described for bull trout in Impact BIO-4.

The duration of these beneficial and adverse effects would be between the proposed action and Alternative 3. Overall, effects on redband trout habitat under Alternative 4 would be adverse compared to the no-action alternative because of the importance of the reaches where adverse effects would occur.

## BIO-13: Affect Nonnative Resident Trout Habitat

Effects on nonnative resident trout habitat under Alternative 4 compared to the no-action alternative would be the same as described for the proposed action in all reaches. Effects in Wickiup Reservoir, the Upper and Middle Deschutes River, and the Crooked River would occur earlier in the permit term but end sooner than under the proposed action or Alternative 3; the duration of these effects would be between the proposed action and Alternative 3.

## BIO-14: Affect Summer/Fall Chinook Salmon Habitat

Alternative 4 would have no effect on summer/fall Chinook salmon habitat compared to the no-action alternative for the reasons described for the proposed action.

## BIO-15: Affect Kokanee Salmon Habitat

Effects on kokanee salmon habitat and migratory life stages under Alternative 4 compared to the no-action alternative would be the same as described for the proposed action in all reaches except Wickiup Reservoir Adverse effects in Wickiup Reservoir would be the same as described for the proposed action but of greater magnitude because within-year variability in reservoir volume and elevation would be of greater magnitude. The duration of these adverse effects would be between the proposed action and Alternative 3. Overall, effects on kokanee salmon habitat under Alternative 4 would be adverse compared to the no-action alternative.

## BIO-16: Affect Native Non-Trout and Non-Game Fish Habitat

Effects on non-game native fish habitat under Alternative 4 compared to the no-action alternative would be the same 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 implementation of habitat restoration activities funded through Conservation Measure DR-2 under Alternative 4 could increase beneficial effects in this reach by improving connectivity and functions of river riparian habitats and contributing to improved river ecosystem function for these species. Adverse effects in Wickiup Reservoir would be the same as described for the proposed action 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 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. Overall, effects on non-game native fish habitat under Alternative 4 would be not adverse compared to the no-action alternative.

## BIO-17: Affect Freshwater Mollusk Habitat

Effects on freshwater mollusk habitat under Alternative 4 compared to the no-action alternative would be the same as described for the proposed action except for floater species mussels and western pearlshell mussels in the Crooked River. There would be no adverse effect on these species 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. The duration of these effects in Wickiup Reservoir, the Upper and Middle Deschutes River, and the Crooked River would be between the proposed action and Alternative 3. Overall, effects on freshwater mollusk habitat under Alternative 4 would be not adverse compared to the no-action alternative.

# 3.5 Land Use and Agricultural Resources

This section describes the affected environment for land use and agricultural resources and effects on land use and agricultural resources that would result from the proposed action and alternatives.

## 3.5.1 Methods

The study area for land use and agricultural resources consists of land use types and agricultural areas in the Deschutes Basin where land use and agricultural resources could be affected under the proposed action and alternatives. For land use, the study area covers five counties: Klamath, Deschutes, Crook, Jefferson, and Wasco Counties. For agricultural land use, the study area focuses on agricultural land that receives irrigation water from the Deschutes River, the Crooked River, and tributaries (including Whychus Creek, Tumalo Creek, and Crescent Creek), which primarily includes Crook, Deschutes, and Jefferson Counties. This includes the Deschutes Basin Board of Control (DBBC) permit applicant irrigation districts (referred to collectively as the *DBBC districts*), as well as other lands (referred to as *Other Irrigated Lands*). The DBBC districts include Arnold Irrigation District (ID), Central Oregon ID, Lone Pine ID, North Unit ID, Ochoco ID, Swalley ID, Three Sisters ID, and Tumalo ID. Other Irrigated Lands receive irrigation water through the following non-DBBC diversions: Walker Basin Canal, People's Canal, Low Line Canal, Crooked River Feed Canal, Rice Baldwin Canal, and the small private canal above the Crooked River Feed Canal. Figure 3.5-1 shows the DBBC districts, counties, and the points of diversion for Other Irrigated Lands.

The affected environment was developed using land use information obtained by reviewing county comprehensive plans and agricultural data received from the DBBC districts, as well as conducting interviews with county planners, city planners, and irrigation district managers. These sources of information are cited as applicable throughout the analysis. Discussions with the city, state, and county planners resulted in a determination that regardless of water availability, current land use would not be changed or effected and, therefore, no further analyses or effect conclusions are addressed.

This analysis focuses on agricultural resources because review of the resource area, including discussions with city and county planners, did not identify potential impacts on other land use types including any conflicts with land use plans or changes in land use. Implementing the proposed action, however, could affect recreation and impacts on agriculture could indirectly affect the local economy; these resource areas are addressed in Section 3.7, *Recreation*, and Section 3.9, *Socioeconomics and Environmental Justice*, respectively.

As highlighted in Section 3.2, *Water Resources*, there is significant annual variability in hydrology in both the Upper Deschutes River and Crooked River Basins. Dry water years result in much lower flows—and therefore reduced water supplies available for diversion—compared to wet water years. To assess effects of the proposed action and alternatives on irrigation water supplies, this analysis focuses on three water year types: wet (80$^{th}$ percentile of water available for diversions), median[1] (50$^{th}$ percentile of water available for diversions), and dry water years (20$^{th}$ percentile of water

[1] The term *median* water year is used in this land use and agricultural resources analysis and has the same meaning as the term *normal* water year used in the water resources analysis and elsewhere in this EIS.

available for diversions).[2] The intent for analyzing effects using these three water year types is to present the range of impacts that could be experienced in most future water years. In future extremely dry water years, impacts of the proposed action and alternatives on irrigation water supplies (and therefore agriculture) may be more severe for the extreme dry water years than presented in this analysis.

The agricultural analysis focuses on the DBBC 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 during three irrigation subseasons of May, June/July, and August/September.

To estimate impacts on acreage, this analysis take a five-step approach.

1. Estimate current crop water demand for irrigation water for each district based on crop mix and annual water use by crop.
2. Identify the DBBC districts and Other Irrigated Lands that are projected to face a change in the availability of diversion.
3. Estimate the agricultural water use efficiency in the Deschutes Basin (a high and low conservation scenario) over the analysis period for affected DBBC districts and Other Irrigated Lands.
4. Estimate crop water supply available to meet crop water demand and identify reductions in crop water supply by alternative for each conservation scenario.
5. Estimate how farmers would respond to shortages in meeting crop water requirements. The estimated effects are expressed in terms of affected 'acres equivalent'. Reduced irrigation water supplies would uniformly affect all acreage in a district (e.g., a 10% reduction in diversion water would decrease water supplies to all irrigated acres by 10%). To convert changes in irrigation water supplies to changes in acreage, the analysis (see Appendix 3.5-A, *Agricultural Uses and Agricultural Economics Technical Supplement*) estimates the affected "acres equivalent," which is the number of acres that could be fully irrigated with the change in irrigation water supplies (e.g., for every 100 acres with the same crop water requirement, a 10% change in irrigation water would translate into an estimated impact of approximately 10 acres equivalent).

To reflect the uncertainty in the type, timing, and magnitude of responses by irrigators (both in increasing efficiency and in responding to shortages), the agricultural analysis uses ranges to estimate the effect of the alternatives on agricultural land use and agricultural production. Methods for analyzing impacts on agricultural resources are further described in Appendix 3.5-A, in the section titled, *Responses to Changes in Agricultural Water Availability*.

Key assumptions used in the agricultural analysis are described in Appendix 3.5-A.

Effects of the proposed action and alternatives on land use and agricultural resources would be considered adverse if they would result in any of the following conditions.

- Conflict with or threaten to violate applicable land use plans, policies, or regulations of an agency.

[2] For example, in dry years, 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, would be as wet or wetter in 2 out of 10 years.

- Create conditions that result in a change in land use that conflicts with existing land uses within or adjacent to the study area.
- Convert any amount of agricultural land to nonagricultural use.
- Cause changes in the environment, which, because of their location or nature, would result in the conversion of substantial amounts of agricultural land to nonagricultural use.

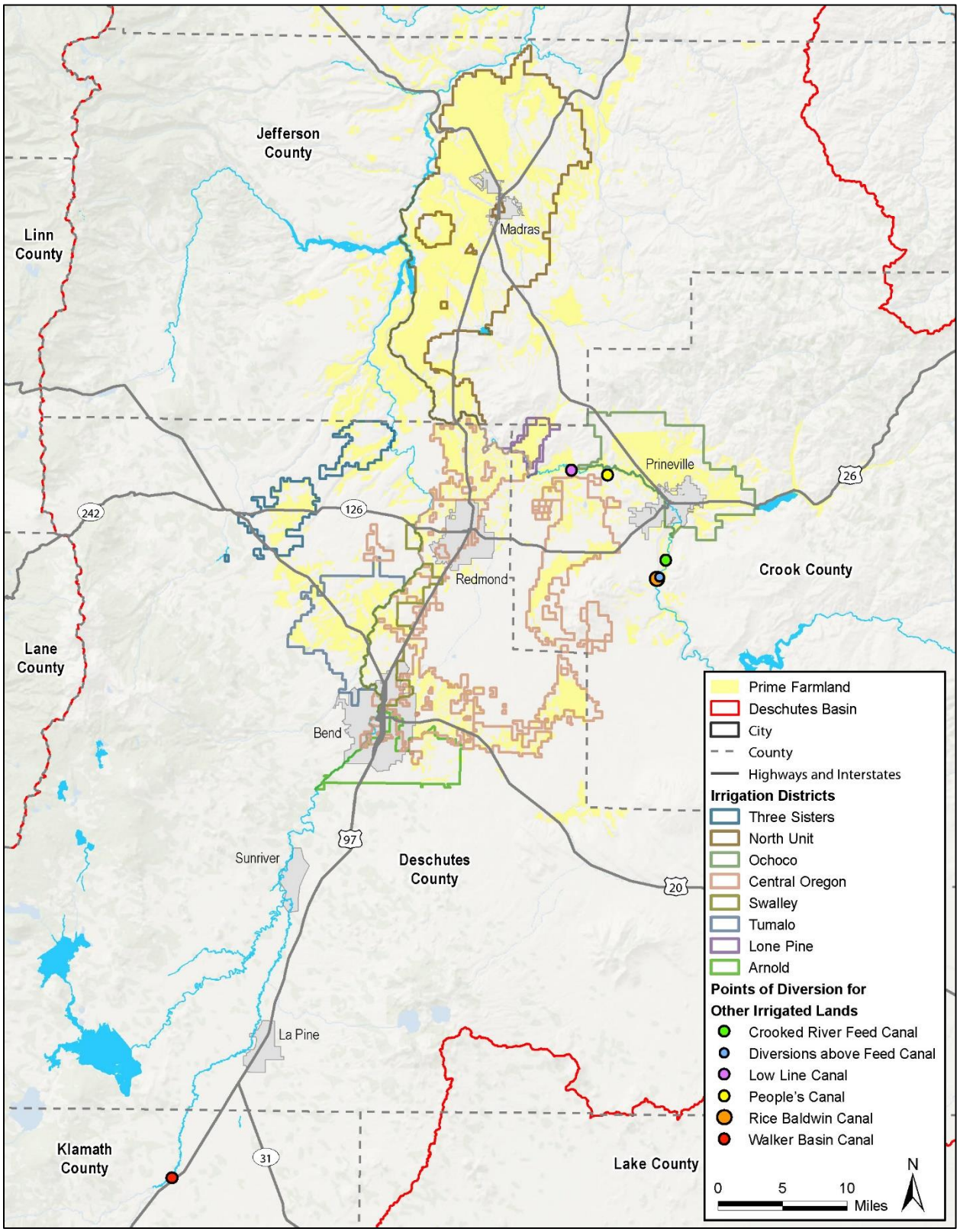
The state of Oregon has maintained a strong policy to protect agricultural land, especially those lands formally designated as exclusive farm use (Oregon Revised Statutes [ORS] 215.243).[3] This policy was adopted by the state legislature in 1973 (Oregon Department of Agriculture 2019).

- Open land used for agriculture is a vital natural and economic asset for all the people of the state.
- Preservation of a maximum amount of agricultural land, in large blocks, is necessary to maintain the agricultural economy of the state and for the assurance of adequate, healthful, and nutritious food.
- Expansion of urban development in rural areas is a public concern because of the conflicts between farm and urban activities.
- Incentives and privileges are justified to owners of land in exclusive farm use zones because such zoning substantially limits alternatives to the use of rural land.

Oregon's Statewide Planning Program has carried out this policy over the years and has effectively slowed the loss of farmland in Oregon. In particular, Statewide Planning Goal 3, “Agricultural Lands,” requires all agricultural lands to be inventoried and preserved by adopting exclusive farm use zones. Local counties are responsible for planning and zoning, subject to approval by the Oregon Department of Land Conservation and Development. Allowable nonfarm uses are incorporated into local zoning regulations.

[3] The purpose of the exclusive farm use zone is to provide areas for continued practice of commercial agriculture. It is intended to be applied in those areas composed of tracts that are predominantly high-value farm soils and generally well-suited for large-scale farming.

**Figure 3.5-1. Agricultural Lands in the Study Area**



# 3.5.2 Affected Environment

## 3.5.2.1 Land Use

A variety of land use types are represented in the study area, including agriculture, recreational areas, forest lands, mining, commercial, industrial, residential, and open spaces. Public lands managed by the federal government represent approximately 80% of total land in the Deschutes Basin. The Bureau of Land Management (BLM) and U.S. Forest Service (USFS) are the primary federal land managers.

Of these land uses, only recreation and agricultural resources would be affected under the proposed action and alternatives. Agricultural resources are addressed in the following sections. Recreation resources are addressed in Section 3.7.

## 3.5.2.2 Agricultural Resources

### Existing Agricultural Land and Crop Types

Agricultural land primarily addressed in this analysis includes pasture managed for grazing and land managed for crops. Existing pasture and crop cropland within the study area are shown in Figure 3.5-1, and acreages are presented in Table 3.5-1.

**Table 3.5-1. Total Agricultural Lands in the Study Area (2017 Census Data)**

| County | Total Land in Farms (acres) | Total Pastureland, all types (acres) | Total Cropland (acres) | % of Land that is Cropland |
|---|---|---|---|---|
| Crook | 799,845 | 746,865 | 49,167 | 6% |
| Deschutes | 134,600 | 89,534 | 30,997 | 23% |
| Jefferson | 792,920 | 674,870 | 77,811 | 10% |
| Total | 1,727,365 | 1,511,269 | 157,975 | 9% |

Source: U.S. Department of Agriculture, National Agricultural Statistics Service 2019a, 2019b.

### Irrigation Districts

Irrigation is a key agricultural production practice due to low precipitation in the region during the crop-growing season. The eight DBBC districts that provide water to agricultural lands in the study area include Arnold ID, Central Oregon ID, Lone Pine ID, North Unit ID, Ochoco ID, Swalley ID, Three Sisters ID, and Tumalo ID. Crop mix among the irrigation districts is similar across the study area, with farmland predominantly planted in hay, pasture, grains, and alfalfa. North Unit ID also supports carrot seed, mint, grass seed, sod, nursery, and vegetables. Other irrigation districts also support similar crops. Table 3.5-2 presents general information on each irrigation district. The location of each DBBC district is shown on Figure 3.5-1.

**Table 3.5-2. Deschutes Basin Board of Control Irrigation Districts**

| Irrigation District | Year Established | Patrons Served[a] | Acres Covered[b] | Crop Types | Water Source(s) |
|---|---|---|---|---|---|
| Arnold | 1905 | 650 | 4,384 | hay, pasture, grains; alfalfa | Deschutes River |
| Central Oregon | 1900 | 3,590 | 44,500 | Hay, pasture, grains; alfalfa; grass seed, sod, nursery; other crops | Deschutes River |
| Lone Pine | 1900 | 19 | 2,369 | Hay, pasture, grains; alfalfa; peppermint and other herbs; other crops | Deschutes River |
| North Unit | 1916 | 980 | 59,000 | hay, pasture, grains; alfalfa; carrot and other seed; peppermint and other herbs; grass seed, sod, nursery; other crops | Deschutes River<br>Crooked River |
| Ochoco | 1916 | 898 | 20,062 | hay, pasture, grains; alfalfa; carrot and other seed; peppermint and other herbs; grass seed, sod, nursery; other crops | Crooked River<br>Ochoco Creek<br>McKay Creek<br>Lytle Creek |
| Swalley | 1899 | 662 | 4,467 | hay, pasture, grains; other crops | Deschutes River |
| Three Sisters | 1891 | 194 | 7,572 | hay, pasture, grains; alfalfa; carrot and other seed; other crops | Whychus Creek (tributary of the Deschutes River) |
| Tumalo | 1900 | 660 | 8,110 | hay, pasture, grains; alfalfa; other crops | Tumalo Creek<br>Deschutes River<br>Crescent Creek |

Sources: Deschutes Basin Board of Control 2019; Vaughn pers. comm.

See Appendix 3.5-A for additional information.

[a] A patron is defined as a single point of water delivery, such as a farm, municipal park, or other irrigator.

[b] Acreage covered by each district is potentially higher than irrigated acreage because not all land may be irrigated or in production.

## Other Irrigated Lands

Other Irrigated Lands (approximately 3,800 acres) receive irrigation water through the non-DBBC irrigation district diversions. These diversions include Walker ID, People's Canal, Low Line Canal, Crooked River Central Canal, Rice Baldwin Canal, and the small private canal above Feed Canal. Private diverters along the Whychus Creek are not included in this analysis because Whychus Creek would not be affected by the proposed action and alternatives. Figure 3.5-1 shows the points of diversion related to Other Irrigated Lands.

## Irrigated Agricultural Land

Acreages of irrigated agricultural lands in the study area are presented by county in Table 3.5-3. The total acreage of irrigated farmland in Crook, Deschutes, and Jefferson Counties is 148,083 acres, with 65% of this farmland managed as harvested cropland.

**Table 3.5-3. Irrigated Agricultural Lands in the Study Area (2017 Census Data)**

| | Irrigated Land | | | % of Total Irrigated Land that is Harvested Cropland |
|---|---|---|---|---|
| County | Total Irrigated Land (acres) | Harvested Cropland (acres) | Pastureland and Other Land (acres) | |
| Crook | 67,573 | 30,421 | 37,152 | 45% |
| Deschutes | 36,029 | 23,983 | 12,046 | 67% |
| Jefferson | 44,481 | 41,831 | 2,650 | 94% |
| Total | 148,083 | 96,235 | 51,848 | 65% |

Sources: U.S. Department of Agriculture; National Agricultural Statistics Service 2019a, 2019b.

The proportions of agricultural lands in the study that are irrigated are presented in Table 3.5-4. This table shows that 88% of harvested cropland in the three-county study area is irrigated while just 3% of pastureland is irrigated.

**Table 3.5-4. Proportion of Agricultural Lands Irrigated in the Study Area (2017 Census Data)**

| | Harvested Cropland | | | Pastureland and Other Land | | |
|---|---|---|---|---|---|---|
| County | All (acres) | Irrigated (acres) | % Irrigated | All (acres) | Irrigated (acres) | % Irrigated |
| Crook | 35,972 | 30,421 | 85% | 746,865 | 37,152 | 5% |
| Deschutes | 25,356 | 23,983 | 95% | 89,534 | 12,046 | 13% |
| Jefferson | 48,092 | 41,831 | 87% | 674,024 | 2,650 | <1% |
| Total | 109,420 | 96,235 | 88% | 1,510,423 | 51,848 | 3% |

Sources: U.S. Department of Agriculture, National Agricultural Statistics Service 2019a, 2019a.

The 2017 estimate provided by the U.S. Department of Agriculture identifies 148,083 acres of irrigated acreage in the three-county study area (Table 3.5-3). This roughly corresponds to the most recent data on existing average irrigated crop acreage by irrigation district and crop type, which estimates 141,000 acres of irrigated lands in the study area (Table 1 in Appendix 3.5-A).

The actual irrigated acreage varies year by year based on factors such as market conditions (which may result in a transition to lower water use crops or higher water use crops), on-farm management practices, and water year type. Of particular importance to this analysis, water supply fluctuates for most irrigation districts based on water year type, with dry water years resulting in lower acreage and/or yields in some districts. In dry water years under existing conditions, approximately 26,400 acres of hay/pasture/grains and alfalfa could be affected and would need to be deficit irrigated or fallowed[4] compared to median water years (Table 2 in Appendix 3.5-A).

[4] Deficit irrigation is irrigating with less water than the crop water requirement. Fallowing of land is when the land is inactive (i.e., left unseeded or uncultivated) for one or more seasons.

## Irrigation Water Supply

Under existing conditions, irrigation water supply fluctuates based on water year type, with dry water years resulting in lower acreage and/or yields in many irrigation districts. The reduction in water supply in dry water years under existing conditions is higher than it has been historically due to increased releases of storage water to enhance wintertime flows for the Oregon spotted frog required under the Deschutes Project Biological Opinion (U.S. Fish and Wildlife Service 2017, 2019). Existing conditions for Tumalo ID in particular are lower than historical conditions. Under the Biological Opinion, Tumalo ID increased its minimum release into Crescent Creek from 6 cubic feet per second (cfs) to between 20 and 30 cfs. Under existing conditions, the irrigation districts that face reduced irrigation water supplies and associated reduced acreage/deficit irrigation (due both to historical hydrology and changes in water management associated with the Biological Opinion) include Arnold ID, Lone Pine ID, North Unit ID, Three Sisters ID, Tumalo ID, and potentially Ochoco ID (Table 2 in Appendix 3.5-A ). RiverWare modeling results also show a shortage to Central Oregon ID under existing conditions; however, this shortage is very small relative to the district's 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.). Although Central Oregon ID's water shortages are small, the shortages occur at a critical time of year for the district (i.e., during the shoulder season) (Vaughn pers. comm.).

## Water Demand and Use Efficiency

The majority of water demand (approximately 86% of all irrigated lands) is consumed by hay/pasture, alfalfa, and grain crops (Table 5 in Appendix 3.5-A). The annual per-acre water demand for hay/pasture, alfalfa, and grain crops varies by DBBC district and Other Irrigated Lands, ranging from 2.3 acre-feet/year (AFY) for Lone Pine ID to 2.8 AFY for North Unit ID (Table 6 in Appendix 3.5-A). See Appendix 3.5-A for additional information on existing water demand calculations (Tables 3 and 4 in Appendix 3.5-A).

Agricultural water use efficiency is a key factor determining 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 AFY of water but canal conveyance efficiency is 55% and on-farm irrigation efficiency is 70%, then to ensure 3 AFY of water reaches the crop, the diversion requirement is 7.8 AFY, or more than double the crop water requirement.[5]

In recent years, irrigation districts and farmers in the Deschutes Basin have been making significant investments in improving agricultural water use efficiency. These include a number of irrigation district piping projects that eliminate seepage from district canals (in the stretches of canal that have been piped) and on-farm conversion to more efficient sprinkler and drip irrigation technologies.[6] As a result of these projects, the volume of diversion water required for a given level

[5] The calculation is 3.0 AFY / 0.55 / 0.70 = 7.8 AFY.

[6] As discussed in detail in Appendix 3.5-A, this analysis assumes irrigation districts are able to obtain outside funding and permits and approvals for the proposed projects (which have yet to be obtained for most projects), or that district patrons fully fund both the piping and on-farm improvements (which would likely limit the projects to be completed and/or slow the timeline of completion). On-farm efficiency improvements are outside the control of the irrigation districts and are voluntary measures that may be adopted by district

of crop production has been decreasing over time. See the section titled *Agricultural Water Use Efficiency* in Appendix 3.5-A for additional information on water use efficiencies related to the piping of irrigation district canals and on-farm irrigation and conveyance of water.

### Farmer Responses to Crop Water Shortages

As noted in Table 3.5-4, approximately 83% of harvested cropland in the agricultural study area is irrigated. Irrigation is required because of low precipitation in the region during the crop-growing season. Farmers respond to a reduction in water supplies by changing farm acreage and crop production. Responses include reducing harvested acreage due to fallowing of lands or crop failure, or reducing crops yields due to deficit irrigation (i.e., irrigating less than crop water requirement). Growers could also transition to crops that require less water; however, for this analysis, the future crop mix and acreage is assumed to remain similar to the current cropping pattern.

See the section titled *Farm Response to Crop Water Shortages* in Appendix 3.5-A for additional information describing how farms respond to a reduction in water supplies available for crops.

## 3.5.3 Environmental Consequences

### 3.5.3.1 Alternative 1: No Action

The amount of water available for diversion under the no-action alternative would be similar to existing conditions for median water years. As such, the average acreage irrigated by each irrigation district under the no-action alternative is expected to be very similar to the acreage presented above in Table 3.5-4 and Table 1 in Appendix 3.5-A. However, the water available to crops in dry water years under the no-action alternative is anticipated to increase over time compared to existing conditions because of on-farm and district-wide water conservation through the piping of canals and increased irrigation efficiency. Water use efficiencies may lead to increased acreage and/or crop yields in dry water years in the future. In particular, water use efficiency is expected to benefit (i.e., provide water savings) for Arnold ID, Lone Pine ID, North Unit ID, and Tumalo ID.[7] Table 3.5-5 shows the potential increase in the proportion of existing acreage that would receive full irrigation under the no-action alternative in dry water years throughout the 30-year permit term, compared to existing conditions in dry water years. Table 17 and Table 21 of Appendix 3.5-A provide additional information on water availability and potential increase in fully irrigated agricultural acreage, respectively. The section titled *Agricultural Water Use Efficiency* in Appendix 3.5-A also provides additional information on water use efficiencies related to the piping of irrigation district canals and on-farm irrigation and conveyance of water.

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patrons. This analysis assumes each irrigation district would conserve water in a manner consistent with their most recent written proposals. For Tumalo ID, 100% of conserved water would be dedicated to instream flow, whereas for Swalley ID, Lone Pine ID, and Arnold ID, 75% of conserved water would be dedicated to instream flow, and 25% would go back to the district. Proposed conserved water projects may be subject to additional constraints, either by funders, or by the State of Oregon as part of their review of a proposed Allocation of Conserved Water for consistency with pertinent State of Oregon statutes and administrative rules.

[7] Other irrigation districts would benefit from water use efficiencies as well; although these districts may not experience water savings, they would benefit from reduced power (pumping) costs and lower management and maintenance costs.

Regarding acreage under existing conditions, it is important to note that water supplies under existing conditions, particularly in dry water years, are lower than historical conditions due to the 2016 Settlement Agreement for the Oregon spotted frog. Existing conditions water supplies (and associated fully irrigated acreage) for Tumalo ID in particular are lower than historical conditions, but other districts with reductions in water supplies under existing conditions compared to historical conditions due to the Settlement Agreement include Central Oregon ID and North Unit ID. As such, particularly for Tumalo ID, the estimated potential increase in acres equivalent under No Action compared to Existing Conditions shown in Table 3.5-5 is not necessarily an increase from historic acreage, but may rather indicate a return to historic conditions.

**Table 3.5-5. Potential Increase in Acres Equivalent under the No-Action Alternative Compared to Existing Conditions, Dry Water Year (Acres Equivalent)**

| Year | Arnold ID | Lone Pine ID | North Unit ID | Tumalo ID | All Other Districts and Irrigated Lands | Total All Irrigated Lands |
|---|---|---|---|---|---|---|
| Existing Conditions | 2,600 | 1,800 | 36,200 | 1,100 | 72,800 | 114,500 |
| 2020 | 100 to 300 | 300 to 400 | 800 to 1,900 | 200 to 300 | 0 | 1,200 to 2,700 |
| 2025 | 200 to 1,400 | 600 | 2,300 to 6,800 | 800 to 1,500 | 0 | 3,700 to 10,100 |
| 2030 | 300 to 1,400 | 600 | 3,900 to 11,400 | 1,500 to 2,900 | 0 | 6,200 to 16,100 |
| 2040 | 300 to 1,400 | 600 | 6,400 to 14,300 | 2,900 to 2,900 | 0 | 10,100 to 19,000 |
| 2049 | 300 to 1,400 | 600 | 8,700 to 16,000 | 2,900 to 2,900 | 0 | 12,400 to 20,700 |
| % Change | 4 to 54% | 17 to 33% | 2 to 44% | 18 to 264% | 0% | 1 to 18% |

ID = Irrigation District.

Notes: The range of values represents a comparison between the low and high conservation scenarios; a range is not shown when the low and high scenario values are the same. Table 21 in Appendix 3.5-A provides additional detail.

As detailed in Section 3.2, climate change could affect the amount and timing of water available for diversion to irrigate agricultural lands. Effects of climate change could include decreased snowpack, earlier snowmelt, earlier runoff, and potentially slightly more precipitation. Upper Deschutes River tributaries are likely to experience more rain and less snowfall with a warming climate. Tributaries in the study area, especially tributaries that are more influenced by surface water runoff and less so by groundwater hydrology, are likely to become flashier, with earlier annual runoff and lower summer flows.

**Effect Conclusion:** Under the no-action alternative, the water available to crops in dry water years is anticipated to increase over time compared to existing conditions because of on-farm and district water conservation through the piping of canals and increased irrigation efficiency. This would result in a net benefit to agricultural lands by increasing the amount of water available for irrigation

and would not result in a conversion of agricultural lands to other land uses.[8] Therefore, effects on agricultural land use under the no-action alternative would be not adverse.

### 3.5.3.2 Alternative 2: Proposed Action

This section describes the effects of the proposed action on land use and agricultural resources compared to the no-action alternative.

#### LUAG-1: Change Irrigated Agricultural Acreage

Under the proposed action, water supply conditions would change for several irrigation districts. The section titled *Water Available for Diversion under the Proposed Action and Alternatives* of Appendix 3.5-A details how water availability for crops would change under the proposed action in each irrigation district compared to the no-action alternative, during median and dry water years, under the low and high water conservation scenarios.

Potential reductions in water supply would be greatest for Arnold ID (0–56% reduction), Lone Pine ID (0–21% reduction), and North Unit ID (0–23% reduction). For these districts, water supply reductions resulting from the proposed action in dry water years would exacerbate the existing water supply shortage. Central Oregon ID, Tumalo ID, and Other Irrigated Lands are projected to experience up to a 1% decrease in water supply (Table 7 of Appendix 3.5-A).[9] Reduced water supplies could affect irrigated lands by resulting in the fallowing or deficit irrigation of these lands.

Table 3.5-6 summarizes the estimated maximum change in acres equivalent (i.e., the change in the number of acres that could be fully irrigated throughout the season due to the change in irrigation water supplies) under the proposed action compared to the no-action alternative, for median and dry water years. The acres equivalent in Table 3.5-6 and the following tables are the maximum as they represent the highest number of acres equivalent that may be affected during any irrigation sub-season (May, June/July, and August/September) during a particular water year type. As presented in detail in Appendix 3.5-A, the affected acres equivalent in mid- to late-summer (as represented in Table 3.5-6) is much higher than the affected acres equivalent in the spring/early summer or fall. The range represents impacts under both the high water conservation scenario (which typically relates to fewer acres affected) and low water conservation scenario (which typically relates to more affected acres). Under the proposed action, across all irrigated lands over the 30-year permit term in a median water year, fallowing/deficit irrigation could affect from 0 acres equivalent (high conservation scenario) to 6,800 acres equivalent (low conservation scenario). During a dry water year, affected acres equivalent could range from 400 acres (high conservation scenario) to 11,700 acres (low conservation scenario).

[8] Agricultural land is protected by Oregon policy ORS 215.243. Statewide Planning Goal 3, "Agricultural Lands," requires all agricultural lands to be inventoried and preserved by adopting exclusive farm use zones. Allowing nonfarm uses must be incorporated into local planning and zoning regulations, which are subject to approval by the Oregon Department of Land Conservation and Development.

[9] Effects are small for these users because Central Oregon ID has senior natural flow rights; Tumalo ID effects are primarily related to Crescent Reservoir, for which storage generally improves under the Proposed Action; Other Irrigated Lands includes Walker Basin, which has senior natural flow rights for the Little Deschutes River, and a number of private diversions and ditch companies on the Crooked River, which have a combination of live flow water rights and stored water from Prineville Reservoir.

Table 3.5-6 focuses on Arnold ID, Lone Pine ID, and North Unit ID, as these districts would be most affected by water shortage under the proposed action, especially during dry water years. In median water years, under the high conservation scenario, there would be no impacts on the equivalent of irrigated acreage for any district or Other Irrigated Lands. Under a low conservation scenario, North Unit ID would have the affected acres equivalent throughout the permit term and Arnold ID would have a small amount of equivalent acres affected in the second half of the permit term. The remaining irrigation districts and Other Irrigated Lands would not be affected in median water years (Tables 24 and 25 of Appendix 3.5-A).

In dry water years, fallowing/deficit irrigation would affect North Unit ID more than Arnold ID under both the low and high conservation scenarios. Tumalo ID would have some affected acres equivalent near the beginning of the permit term under the low conservation scenario, but would not have an affected acres equivalent for the remainder of the permit term under either scenario. The remaining irrigation districts would have no affected acres equivalent under either the low conservation or high conservation scenarios in dry water years; however, Other Irrigated Lands would experience a small amount of equivalent acres affected (less than 5% reductions) throughout the permit term under both scenarios (Tables 24 and 25 of Appendix 3.5-A).

Agricultural land is protected by Oregon policy ORS 215.243. Statewide Planning Goal 3, "Agricultural Lands," requires all agricultural lands to be inventoried and preserved by adopting exclusive farm use zones. Allowing nonfarm uses must be incorporated into local planning and zoning regulations, which are subject to approval by the Oregon Department of Land Conservation and Development. Although the proposed action may result in increased fallowing or deficit irrigation of irrigated lands, this would not affect current land use laws and zoning for agricultural lands. Therefore, implementing the proposed action would not in and of itself convert agricultural land from agricultural use to non-agricultural use.

**Effect Conclusion:** Reduced water supply under the proposed action would result in increased fallowing or deficit irrigation of irrigated lands in the study area. These changes are not expected to result in a conversion of agricultural lands to other land uses because agricultural lands are protected by Oregon policy ORS 215.243. Therefore, effects on agricultural land use under the proposed action would be not adverse. Section 3.9, *Socioeconomics and Environmental Justice*, addresses how increased fallowing or deficit irrigation of irrigated lands could affect the local economy.

**Table 3.5-6. Estimated Maximum Affected Acres Equivalent under the Proposed Action Compared to the No-Action Alternative, Median and Dry Water Years (Acres Equivalent)**

| | Arnold ID | | Lone Pine ID | | North Unit ID | | Tumalo ID | | All Other Districts / Other Irrigated Lands | | Total All Irrigated Lands | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | **Median** | **Dry** | **Median** | **Dry** | **Median** | **Dry** | **Median** | **Dry** | **Median** | **Dry** | **Median** | **Dry** |
| 2020 | 0 | -1,600 to -1,500 | 0 | -300 | 0 | 1,500 to 700 | 0 | -200 | 0 | 0 | 0 | -400 to -1,300 |
| 2025 | 0 | -1,500 to -1,100 | 0 | -200 to -300 | -2,100 to 0 | -4,500 to -4,500 | 0 | 0 | 0 | 0 | -2,100 to 0 | -6,300 to -6,000 |
| 2030 | 0 | -800 to -1,400 | 0 | -200 to -500 | -3,400 to 0 | -7,300 to -7,300 | 0 | 0 | 0 | 0 | -3,400 to 0 | -8,400 to -9,300 |
| 2040 | -200 to 0 | -1,000 to -1,500 | 0 | -200 to -500 | -6,600 to 0 | -9,600 | 0 | 0 | 0 | 0 | -6,800 to 0 | -10,900 to -11,700 |
| 2049 | -200 to 0 | -1,000 to -1,500 | 0 | -200 to -500 | -4,300 to 0 | -8,800 to -9,600 | 0 | 0 | 0 | 0 | -4,500 to 0 | -10,100 to -11,700 |
| % Change | 0 to -5% | -20 to -56% | 0% | -8 to -21% | 0 to -13% | 2 to -23% | 0% | 0 to -15% | 0% | 0% | 0 to -5% | 0 to 9% |

ID = Irrigation District.

Notes: The range of values represents a comparison between the low and high conservation scenarios; a range is not shown when the low and high scenario values are the same. Tables 24 and 25 in Appendix 3.5-A provide additional detail.

### 3.5.3.3 Alternative 3: Enhanced Variable Streamflows

This section describes the effects of Alternative 3 on land use and agricultural resources compared to the no-action alternative.

#### LUAG-1: Change Irrigated Agricultural Acreage

Changes in water availability for crops under Alternative 3 compared to the no-action alternative would be similar to but greater than (more irrigated acres affected) those described for the proposed action. Additionally, these changes would occur earlier in the permit term, especially during dry water years.

Similar to the proposed action, potential reductions in water supply under Alternative 3 compared to the no-action alternative would be greatest for Arnold ID (0–52% reduction), Lone Pine ID (0–33% reduction), and North Unit ID (0–29% reduction). Central Oregon ID, Tumalo ID, and Other Irrigated Lands would experience up to a 1% decrease in water supply (Table 8 of Appendix 3.5-A). These reduced water supplies could affect irrigated lands by resulting in the fallowing or deficit irrigation of these lands.

Table 3.5-7 summarizes the estimated maximum proportion of existing acreage that would receive full irrigation under Alternative 3 compared to the no-action alternative for median and dry water years. Under Alternative 3, across all irrigated lands over the permit term in a median water year, fallowing/deficit irrigation could affect from 0 acres (high conservation scenario) to 11,400 acres (low conservation scenario). During a dry water year, the affected acres equivalent could range from 9,800 acres (high conservation scenario) to 13,900 acres (low conservation scenario).

Table 3.5-7 focuses on Arnold ID, Lone Pine ID, and North Unit ID, as these districts are would be most affected by water shortages under Alternative 4, especially during dry water years. In median water years, under the high conservation scenario, only North Unit ID would have an affected acres equivalent; under the low conservation scenario, North Unit ID would have an affected acres equivalent throughout the permit term (greater than under the proposed action) and Arnold's affected acres equivalent would be the same as under the proposed action but would commence sooner. The remaining irrigation districts and Other Irrigated Lands would not be affected in median water years (Tables 28 and 29 of Appendix 3.5-A).

**Table 3.5-7. Estimated Maximum Affected Acres Equivalent under Alternative 3 Compared to the No-Action Alternative, Median and Dry Water Years (Acres)**

| | Arnold ID | | Lone Pine ID | | North Unit ID | | Tumalo ID | | All Other Districts / Other Irrigated Lands | | Total All Irrigated Lands | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | **Median** | **Dry** | **Median** | **Dry** | **Median** | **Dry** | **Median** | **Dry** | **Median** | **Dry** | **Median** | **Dry** |
| 2020 | 0 | -1,200 to -1,100 | 0 | -700 to -700 | -2,500 to -3,600 | -9,400 | 0 | -200 | 0 | 0 | -2,500 to -3,600 | -11,400 to -11,500 |
| 2025 | 0 | -1,700 to -1,300 | 0 | -400 to -500 | -600 to -5,100 | -7,600 | 0 | 0 | 0 | 0 | -600 to -5,100 | -9,800 to -9,500 |
| 2030 | -200 to 0 | -1,000 to -1,500 | 0 | -200 to -500 | -3,700 to -11,20 0 | -11,800 | 0 | 0 | 0 | 0 | -3,700 to -11,40 0 | -13,100 to -13,900 |
| 2040 | -200 to 0 | -1,000 to -1,500 | 0 | -200 to -500 | -800 to -8,700 | -11,800 | 0 | 0 | 0 | 0 | -800 to -8,900 | -13,100 to -13,900 |
| 2049 | -200 to 0 | -1,000 to -1,500 | 0 | -200 to -500 | -0 to -6,400 | -11,000 to -11,800 | 0 | 0 | 0 | 0 | 0 to -6,600 | -12,300 to -13,900 |
| % Change | 0 to -5% | -25 to -52% | 0% | -8 to -33% | 0 to -21% | -18% to -29% | 0% | 0 to -15% | 0% | 0 | 0 to 8% | -8% to -12% |

ID = Irrigation District.

Notes: The range of values represents a comparison between the low and high conservation scenarios; a range is not shown when the low and high scenario values are the same. Tables 28 and 29 in Appendix 3.5-A provide additional detail.

In dry water years, Arnold ID, Lone Pine ID, and North Unit ID would be affected under both conservation scenarios throughout the permit term; however, North Unit ID would have a higher affected acres equivalent compared to Arnold ID and Lone Pine ID under both the low conservation and high conservation scenarios. Tumalo ID would have some affected acres equivalent near the beginning of the permit term under the low conservation scenario but would not have an affected acres equivalent for the remainder of the permit term under either scenario. The remaining irrigation districts would have no equivalent affected acreage under either the low conservation or high conservation scenarios in dry water years; however, Other Irrigated Lands would experience a small affected acres equivalent throughout the permit term under both scenarios (Tables 28 and 29 of Appendix 3.5-A).

As explained for the proposed action, agricultural land is protected by Oregon policy ORS 215.243. Therefore, implementing Alternative 3 would not in and of itself convert agricultural land to other non-agricultural land uses.

**Effect Conclusion:** Reduced water supply under Alternative 3 compared to the no-action alternative would result in increased fallowing or deficit irrigation of irrigated lands in the study area. Increased fallowing or deficit irrigation would be similar to but greater than that described for the proposed action. These changes are not expected to result in a conversion of agricultural lands to other land uses because agricultural lands are protected by Oregon policy ORS 215.243. Therefore, effects on agricultural land use under Alternative 3 would be not adverse. Section 3.9, *Socioeconomics and Environmental Justice*, addresses how increased fallowing or deficit irrigation of irrigated lands could affect the local economy.

### 3.5.3.4 Alternative 4: Enhanced and Accelerated Variable Streamflows

This section describes the effects of Alternative 4 on land use and agricultural resources compared to the no-action alternative.

#### LUAG-1: Change Irrigated Agricultural Acreage

Changes in water availability for crops under Alternative 4 compared to the no-action alternative would be similar to but greater than (more irrigated acres affected) those described for the proposed action and Alternative 3. Additionally, these changes would occur earlier in the permit term, especially during dry water years.

Similar to the proposed action and Alternative 3, potential reductions in water supply under Alternative 4 compared to the no-action alternative would be greatest for Arnold ID (0–86% reduction), Lone Pine ID (0–38% reduction), and North Unit ID (13–35% reduction). Central Oregon ID, Tumalo ID, and Other Irrigated Lands would experience up to a 2% decrease in water supply (Table 9 of Appendix 3.5-A). These reduced water supplies could affect irrigated lands by resulting in the fallowing or deficit irrigation of these lands.

Table 3.5-8 summarizes the estimated maximum proportion of existing acreage that would receive full irrigation under Alternative 4 compared to the no-action alternative for median and dry water years. Under Alternative 4, across all irrigated lands over the 30-year permit term in a median water year, fallowing/deficit irrigation could affect from 6,800 acres (high water conservation scenario) to 18,900 acres (low water conservation scenario). During a dry water year, the affected acres equivalent could range from 13,400 acres (high water conservation scenario) to 16,400 acres (low

water conservation scenario). The affected acres equivalent would vary over time and would potentially be higher in early years of implementation because fall/winter instream flow requirements for the Upper Deschutes River would outpace the ability of the irrigation districts to conserve water, even under the most aggressive (high conservation) assumptions. Also, impacts associated with Alternative 4 would be more severe in median years than in dry years, effectively turning median years into dry years from the perspective of the irrigators. This means Alternative 4 effectively increases the frequency of years when the irrigation districts have insufficient water.

Table 3.5-8 focuses on Arnold ID, Lone Pine ID, and North Unit ID as these districts are would be most affected by water shortages under Alternative 4, especially during dry water years. In median water years, under a high conservation scenario, only the North Unit ID would have an affected acres equivalent throughout the permit term. In median water years under a low conservation scenario, both Arnold ID and North Unit ID would be affected by Alternative 4 water shortages throughout the permit term, although Lone Pine ID would be affected near the beginning of the permit term under the low conservation scenario. The remaining irrigation districts and Other Irrigated Lands would not be affected in median water years (Tables 32 and 33 of Appendix 3.5-A).

In dry water years, fallowing/deficit irrigation would affect Arnold ID, Lone Pine ID, North Unit ID, and Tumalo ID throughout the permit term under both low and high conservation scenarios; however, North Unit ID would have a higher affected acres equivalent compared to Arnold ID, Lone Pine ID, and Tumalo ID under both the low and high conservation scenarios. The remaining irrigation districts would have no affected acres equivalent under either the low conservation or high conservation scenarios in dry water years; however, Other Irrigated Lands would experience a small affected acres equivalent throughout the permit term under both scenarios (Tables 32 and 33 of Appendix 3.5-A).

As explained above under the proposed action, agricultural land is protected by Oregon policy ORS 215.243. Therefore, implementing Alternative 4 would not in and of itself convert agricultural land to other non-agricultural land uses.

**Effect Conclusion:** Reduced water supply under Alternative 4 compared to the no-action alternative would result in increased fallowing or deficit irrigation of irrigated lands in the study area. Increased fallowing or deficit irrigation would be similar to but greater than that described under the proposed action and Alternative 3. These changes are not expected to result in a conversion of agricultural lands to other land uses because agricultural lands are protected by Oregon policy ORS 215.243. Therefore, effects on agricultural land use under Alternative 4 would be not adverse. Section 3.9, *Socioeconomics and Environmental Justice*, addresses how increased fallowing or deficit irrigation of irrigated lands could affect the local economy.

**Table 3.5-8. Estimated Maximum Affected Acres Equivalent under Alternative 4 Compared to the No-Action Alternative, Median and Dry Water Years (Acres)**

| | Arnold ID | | Lone Pine ID | | North Unit ID | | Tumalo ID | | All Other Districts / Other Irrigated Lands | | Total All Irrigated Lands | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | **Median** | **Dry** | **Median** | **Dry** | **Median** | **Dry** | **Median** | **Dry** | **Median** | **Dry** | **Median** | **Dry** |
| 2020 | 0 to -500 | -2,500 to -2,300 | 0 to -100 | -800 | -12,500 to -13,600 | -9,900 to -10,700 | 0 | -100 | 0 | 0 | -12,500 to -14,200 | -13,400 to -14,000 |
| 2025 | 0 to -400 | -2,400 to -3,100 | 0 | -400 to -600 | -14,000 to -18,500 | -12,000 to -13,100 | 0 | -200 | 0 | 0 | -14,000 to -18,900 | -15,800 to -16,400 |
| 2030 | 0 to -200 | -2,500 to -2,700 | 0 | -200 to -600 | -9,400 to -16,900 | -12,000 | 0 | -200 to -300 | 0 | 0 | -9,400 to -17,100 | -15,300 to -15,400 |
| 2039 | 0 to -200 | -2,500 to -2,700 | 0 | -200 to -600 | -6,800 to -14,600 | -12,000 | 0 | -300 | 0 | 0 | -6,800 to -14,800 | -15,300 to -15,500 |
| % Change | 0 to -13% | -68 to -86% | 0 to -4% | -8 to -38% | -13 to -35% | -24 to -34% | 0% | -7 to -11% | 0% | 0% | -5 to -13% | -11 to -14% |

ID = Irrigation District.

Notes: The range of values represents a comparison between the low and high conservation scenarios; a range is not shown when the low and high scenario values are the same. Tables 32 and 33 in Appendix 3.5-A provide additional detail.

# 3.6 Aesthetics and Visual Resources

This section describes the affected environment for aesthetics and visual resources and effects on aesthetics and visual resources that would result from the proposed action and alternatives.

## 3.6.1 Methods

Aesthetic and visual resources are all objects (artificial and natural, moving and stationary) and features (e.g., landforms and waterbodies) visible on a landscape. These resources add to or detract from the scenic quality of the landscape. A visual impact is an intrusion or perceptible contrast that affects the scenic quality of a viewshed. A visual impact can be perceived by an individual or group as either positive or negative, depending on personal factors or environmental conditions.

The study area for aesthetics and visual resources consists of areas with views of areas that could experience direct effects (the direct effects study area) and areas that could experience indirect effects (the indirect effects study area) under the proposed action and alternatives. The direct effects study area includes the lands and waters directly affected by operation and maintenance of covered facilities: the covered lands and waters as well as Prineville Reservoir and lands hydrologically associated with the reservoir. The indirect effects study area includes the agricultural lands that could be indirectly affected by changes in irrigation water availability under the proposed action or alternatives.

The description of the condition and quality of existing aesthetic and visual resources in the study area considered visual character in the contexts of the Deschutes Basin landscape, regulations and guidance, and viewers' perceptions.

The analysis of effects included review of changes in streamflow and reservoir water surface elevation (reservoir level) presented in Section 3.2, *Water Resources,* and related changes in vegetation (Section 3.4, *Biological Resources*), rural landscapes (Section 3.5, *Land Use and Agricultural Resources*), and recreational experiences (Section 3.7, *Recreation*).

Effects of the proposed action and alternatives on aesthetics and visual resources would be considered adverse if they would result in any of the following conditions.

- Substantial alteration of viewsheds, including changes to existing terrain, vegetative cover, or other natural or built features, and introduction of incompatible visual elements.
- Substantial alteration of existing visual quality of a site and/or the region or elimination of visual resources.
- Substantial obstruction of or permanent reduction of visually important features.

For purposes of this analysis, substantial alteration of the existing visual quality or character is defined as when construction or operational activities would result in a reduction in the visual quality and/or introduce dominant visual elements that, based on the landscape type and viewer sensitivity, would result in noticeable to very noticeable changes that do not blend and are not in keeping or are incompatible with the existing visual environment. These changes could be viewed by sensitive receptors (i.e., residents, recreationists) and from public viewing areas.

For purposes of this analysis, adverse visual changes occur when the changes result in long-term (persisting for 2 years or more) visual changes that substantially degrade the existing visual quality or character. Incompatibility with federal, state, or local plans, policies, or regulations dealing with the subject of aesthetics and visual impacts also has the potential to result in adverse effects. However, incompatibility alone would not result in an adverse effect. If, however the incompatibility relates to an applicable plan, policy, or regulation adopted to avoid or mitigate visual effects, then an incompatibility might be indicative of a related adverse effect under NEPA.

## 3.6.2 Affected Environment

### 3.6.2.1 Visual Character

The Deschutes Basin is defined by the Cascade Range to the west, the Blue Mountains to the east, and the Mutton Mountains in the north-central portion. The Deschutes Basin has a dynamic visual landscape of pine- and juniper-covered mountain ranges; undulating foothills and buttes; flat to rolling valleys covered with grasslands, sagebrush, and a patchwork of agricultural fields; and a complex network of waterways, lakes, and reservoirs that wind through the landscape to create corridors and canyons of all sizes. These features are also characteristic of the study area.

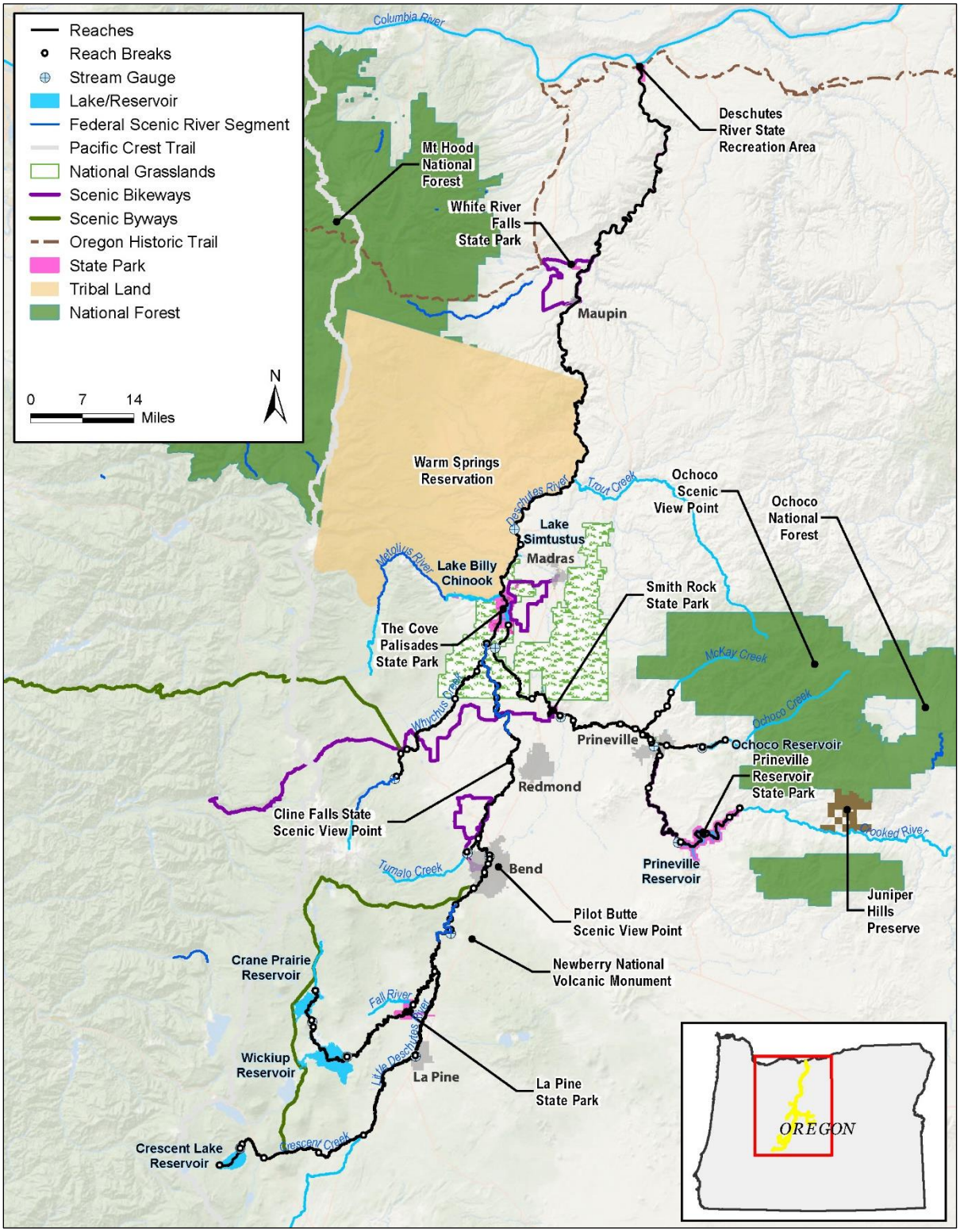
This dynamic landscape provides high-quality scenic views, which have been the subject of federal actions to create national forests, scenic designations, and natural areas that protect large areas of land. Many such areas are in or intersect with the study area, including the Deschutes and Ochoco National Forests; Cross River National Grassland; Newberry National Volcanic Monument; portions of the National Historic Trail; the Pacific Crest National Scenic Trail; and Juniper Hills Preserve (Figure 3.6-1).

Federal and state scenic byways include the Cascade Lakes, McKenzie Pass-Santiam Pass, and Oregon Outback National Scenic Byways. Designated state bikeways in the study area are Sherar's Falls, Madras Mountain Views, Sisters to Smith Rock, McKenzie Pass, Twin Bridges, and Crooked River Canyon. Federal Wild and Scenic River segments classified as scenic include portions of the Deschutes and Metolius Rivers and Whychus Creek. Oregon State Scenic Waterways include portions of the Upper and Lower Deschutes Rivers and portions of the Metolius River. State parks in the study area include La Pine, Tumalo, Prineville Reservoir, Smith Rock, The Cove Palisades, and White River Falls State Parks. State scenic viewpoints in the study area include the Ochoco, Pilot Butte, and Cline Falls State Scenic Viewpoints. The Warm Springs Reservation comprises a large area of the study area.

Numerous public recreational facilities in the study area include such features as boat docks, beaches, campgrounds, multi-purpose trails, and overlooks. These features allow indirect and direct visual access to lands and waters in the direct effects study area. In addition, private recreational features allow indirect and direct visual access to these lands and waters, such as from the golf courses located along waterways.

Panoramic scenic vista views are offered over grasslands areas and from elevated vantage points and include views over the natural landscape and toward the many hills, buttes, mountains, valleys, plains, and flats. Waterways, where present, contribute to these scenic views.

**Figure 3.6-1. Major Visual Resources in the Deschutes Basin**



Population in the study area is largely centralized along major transportation corridors such as the smaller towns of La Pine and Madras along State Route (SR) 97; Sisters along SR 20; Bend and Redmond, which are larger cities along SR 97; and Prineville along SR 26. In the national forests, few residential areas provide views of waters in the direct effects study area. However, low-density residential areas have water views along the north shore Crescent Lake; along Crescent Creek as it approaches La Pine; along the middle portions of Tumalo Creek; along the Upper Deschutes River downstream of Wickiup Dam, downstream of Burgess Road, and as the river approaches La Pine and Three Sisters; near Jasper Point at the Prineville Reservoir; in Crooked River downstream of Ochoco Creek; in Ochoco Creek upstream of the city of Prineville; McKay Creek; and the Lower Deschutes River from Pelton Dam to the confluence of Shitike Creek, at the confluence of Dry Creek, north of the confluence of Trout Creek, at the end of South Junction Road, and in Kaskela, North Junction, and Dant.

Overall, the visual quality of lands with limited or no development range from moderately high to high because of the natural setting, vividness of views, and visual coherence associated with those views. Lands in more developed areas have a visual quality that is moderate because of activities and structures associated with developed and agricultural land uses. However, areas of moderately high visual quality exist in developed and agricultural landscapes where landscape composition and visual integrity contribute to higher-quality views.

### 3.6.2.2 Affected Viewers

Affected viewers are defined by their relationship to the study area, their visual preferences, and their sensitivity to changes associated with the proposed action and alternatives. Visual preferences define the study area's visual quality, which serves as the baseline for determining the nature and magnitude of visual impacts. Two overarching groups of viewers are affected by a project: neighbors and users. *Neighbors* are those people who have views *of* an affected area because they are adjacent to it. *Users* are those people who are within the boundaries of an affected area and have views *from* the affected area. There are many types of viewers (Federal Highway Administration 2015:5-6–5-10); those who would be affected by this project and their sensitivities are identified in Table 3.6-1.

**Table 3.6-1. Summary of Affected Viewer Groups and Associated Sensitivities**

| Viewer Group | Sensitivity | Reasoning |
|---|---|---|
| Residential viewers | High | Longer-term exposure to affected views; an invested interest and sense of ownership over nearby visual resources. |
| Recreational viewers | High | Short- and long-term exposure to affected views; high value attached to natural environment, appreciation of the visual experience, and strong sense of ownership over such resources. |
| Road travelers | Moderate to Moderately High | Short-duration views, except on straighter roadway stretches; regular commuters shifts attention to traffic conditions while recreational travelers have a higher visual sensitivity and a high regard for the natural environment and a holistic visual experience. |
| Industrial, Commercial, Agricultural, Government, & Educational Viewers | Moderate | Semi-permanent views of affected visual resources; generally focused on tasks at hand (i.e., working or shopping). |

## 3.6.3 Environmental Consequences

Beneficial and adverse direct and indirect impacts on aesthetic and visual resources would occur when the proposed action and alternatives cause visible, physical changes to the landscape or alter access to the landscape and its views. Direct impacts from the proposed action and alternatives would include larger-scale changes to vegetation patterns, surface water levels in reservoirs and waterways, and bathtub rings. Changes in visual access are likely to occur where lower water surface elevations would prevent access to waterways for recreational boating and kayaking, where lower elevations would allow more shoreline/beach access along waterways, and where higher elevations would cover part or all of a visual resource. Indirect impacts would result in changes to the visual character and quality of agricultural lands that would occur from changes in irrigation regimes or flooding.

In much of the study area, the proposed action and alternatives would not cause visual changes to the landscape or to visual access because operational changes would be within the normal operating range of the no-action alternative, resulting in no direct or indirect effects. Therefore, this analysis focuses on those areas where direct and indirect effects could occur.

### 3.6.3.1 Alternative 1: No Action

Continuation of existing water management operations under the no-action alternative could result in a small improvement in the extent of riparian and wetland vegetation over the permit term in some locations along the Deschutes River upstream of Bend, as described in Section 3.4.3.1. This could translate into a slight increase in visual quality in these areas.

Forecasted climate change effects on the amount and timing of precipitation (i.e., snow or rain, described in Section 3.2, could have seasonal effects on reservoir and river levels. Less precipitation in the form of snowfall could result in very low reservoir levels, which would expose soils, silts, and mineral deposits, making bathtub rings visually apparent for longer periods, and as described in Section 3.7, reduce recreational access and opportunities. Reduced water availability in drier years could cause irrigators to reduce water application on agricultural fields, thereby reducing crop vegetation and potentially resulting in more of a patchwork appearance of green and brown fields. In contrast, more precipitation in the form of rain could cause flash flows, flooded lands, and damaged vegetation due to flash flows.

Extreme weather events predicted to increase with climate change could result in catastrophic disturbances that would drastically alter the visual landscape. Large-scale visual changes and landscape scarring could result from flooding, mudslides, wildfire, and insect outbreaks that destroy vegetation and force a shift to plant communities in an earlier successional state. These changes would alter the visual character of the landscape and would degrade visual quality for many years.

**Effect Conclusion:** Although the continuation of current water management operations could have slightly beneficial effects on visual quality in portions of the Upper Deschutes, changes in precipitation related to forecasted climate change could result in adverse effects on visual quality related to reduced quality and extent of vegetation, reduced recreation access and opportunity, and reduced irrigation. Elevated risk of extreme weather events could affect water management operations and cause extended periods of consecutive very dry or wet years that could result in substantial alteration of viewsheds, visual quality, and access to visual resources. However, the visual character and quality of the Deschutes Basin would continue to provide an abundance of high-quality views and dynamic visual environments that would be enjoyed by viewers in the study area.

Overall, effects on visual character and quality in the study area would be not adverse under the no-action alternative.

### 3.6.3.2 Alternative 2: Proposed Action

Effects of the proposed action are compared to the no-action alternative.

#### AES-1: Change Visual Character and Quality of Lands and Waters in the Direct Effects Study Area

Changes to water surface elevations in reservoirs and waterways under the proposed action compared to the no-action alternative, described in Section 3.2, are the primary mechanism for altering the visual character and quality of lands and waters in the direct effects study area (Impacts WR-2 and WR-4). These changes would occur where there is a substantial seasonal deviation from the no-action alternative or where long-term changes would create noticeable shifts in the visual landscape compared to the no-action alternative.

##### Large-Scale Changes to Vegetation Patterns

As described in Section 3.4, changes in vegetation patterns under the proposed action compared to the no-action alternative are most likely to occur in Deschutes River reaches upstream of Bend (Table 3.4-3). Summer flows would diminish and winter flows would increase compared to the no-action alternative. Over the permit term, riparian and wetland vegetation in summer would be located adjacent to the water rather than below its surface. In winter, vegetation would extend to near the water's edge instead of distant from the water, greatly reducing expanses of bare substrate (i.e., unvegetated mud, sand, and rock). The more established and resilient wetland and riparian vegetation would create visual diversity and more habitat for wildlife viewing opportunities. These visual changes would be subtle at Crane Prairie Reservoir, where a smaller window of reduced water levels in August would allow vegetation to establish in currently unvegetated areas.

The exception is Wickiup Reservoir, where prolonged episodes of drying or inundation of riparian vegetation would likely result in a reduction in the long-term quality and function of riparian vegetation around the reservoir (Table 3.4-3). Established wetland and riparian vegetation would die off, reducing visual diversity and habitat that is available for wildlife viewing opportunities. High levels of water would cover large areas of wetland and vegetation so that vegetation would be under water for extended periods and low levels of water would expose bare substrate for longer periods of time.

##### Bathtub Rings

Bathtub rings occur in reservoirs when low water surface elevations expose soils, silts, and mineral deposits below the vegetation line. Distinct rings can form during long dry periods and remain intact after levels rise. When the water recedes again, distinct striations signify various periods of low water surface elevations. Under the proposed action, water surface elevations in Crescent Lake, Crane Prairie, Ochoco, and Prineville Reservoirs would remain similar to the no-action alternative or seasonal fluctuations would appear to be within the normal spectrum of operation under the no-action alternative and bathtub rings would not stand out noticeably.

Lower water surface elevations at Crane Prairie Reservoir during the summer under the proposed action compared to the no-action alternative would expose bathtub rings during periods of high

recreational use, a subtle effect. Wetland and riparian vegetation would establish over the permit term and would act to conceal visible bathtub rings and create visual diversity and wildlife viewing opportunities. At Wickiup Reservoir, exceptionally high and low water surface elevations compared to the no-action alternative would cause prolonged episodes of drying or inundation with noticeable bathtub rings that would be more visible when water levels recede. In addition, bathtub rings would be more pronounced because these prolonged shifts in exceptionally high or water elevations would degrade the quality of wetland and riparian vegetation so that there is not as much vegetative cover to hide the bathtub rings.

#### Changes in Visual Access

Changes in seasonal river and creek flows under the proposed action compared to the no-action alternative, described in Section 3.2, would not be sufficient in magnitude to affect visual access in the following areas: the Deschutes River downstream of Bend, the Crooked River, Whychus Creek, McKay Creek, Ochoco Creek, and the Crescent Creek–Little Deschutes River system. Noticeable change in visual access would be limited to the Deschutes River and reservoirs upstream of Bend, where very high flows during the spring and summer and very low flows during fall and winter under the no-action alternative would be altered. Under the proposed alternative, lower water surface elevations in the summer would prevent access to fast- flowing waters for rafting. However, most white-water rafting occurs in reaches where changes in flow would be minimal. In addition, the lower water levels in the Deschutes River, upstream of Bend, would still be conducive for paddling and floating on the river and swimming in the river so that recreational uses—and visual access—on this stretch of river would be maintained.

As described in in Section 3.7, changes in reservoir levels in Crane Prairie, Crescent Lake, Prineville, and Ochoco Reservoirs would be less than are projected to occur at Wickiup Reservoir and are not expected to noticeably reduce recreational opportunities or experiences.

**Effect Conclusion:** Changes in the alteration of viewsheds and visual quality under the proposed action compared to the no-action alternative would be limited to the Deschutes River upstream of Bend. Improved wetland and riparian vegetation would have beneficial effects on visual quality along the Deschutes River reaches and to a lesser degree at Crane Prairie Reservoir and adverse effects at Wickiup Reservoir. Reduced access to boat ramps and recreational use areas at Wickiup Reservoir related to lower water levels during the summer months would also represent an adverse effect. The overall effect on visual character and quality of the lands and waters in the direct effects study area under the proposed action would be not adverse compared to the no-action alternative.

### AES-2: Change Visual Character and Quality of Agricultural Lands

Indirect impacts on visual character and quality of agricultural lands under the proposed action, compared to the no-action alternative, would result from landscape-level changes because of changes in irrigation water application, described in Section 3.5. Effects would occur in normal and dry water years as a result of reduced water application. Lands affected by reduced water application may be fallowed, irrigated less than full crop water demand, or shifted to less water-intensive crops. As described in Section 3.5, agricultural lands are not expected to be converted to other land use types as a result of reduced water supply. In normal water years, up to approximately 20%[1] more agricultural lands in Arnold and North Unit Irrigation Districts could be affected by

[1] Assumes implementation of a low level of water conservation projects by the districts.

reduced water supply compared to the no-action alternative. In dry water years, up to approximately 50%[2] more agricultural lands could be affected in Arnold, North Unit, and Lone Pine Irrigation Districts.

Fallowing of some agricultural lands currently occurs for various reasons in all of the districts, with selected fallowed fields not irrigated while surrounding lands are irrigated, creating a patchwork appearance in seasonal field coloring. If reduced irrigation water supply results in increased crop fallowing, this would reduce the amount of visible greenery in the affected districts, particularly in dry years. The primary crops that would be affected would be alfalfa, grains, and hay and pasture. With no or reduced irrigation, the affected fields would either not be planted in the fall, or would not grow as robustly and would brown earlier in the growing season in drier water years.

In summary, in drier years, reduced irrigation application (compared to the no-action alternative) could increase the acres of non-vegetated or brown fields in the existing patchwork appearance in seasonal field coloring that already occurs with standard agricultural practices. Lastly, as shown in Table 3.5-1 in Section 3.5, there are 1,727,365 acres of pasture and cropland in the study area. Of this, only 148,083 acres are irrigated, which accounts for 9% of all pasture and cropland in the study area. Therefore, reduced irrigation in normal and dry years is not anticipated to result in a notable change to the visual landscape because irrigated pasture and croplands make up such a small percentage of lands in the study area and the visual changes that would occur as a result of reduced irrigation fall within the spectrum of standard agricultural practices.

Irrigation water supplies for urban water uses (primarily turf grass) would be equally affected by reduced diversions as agricultural water uses. However, urban water users are expected to have access (at higher cost) to alternative water supplies. To the extent that urban water users reduce water usage or modify landscaping (including but not limited to planting drought tolerant turf and landscape plants or reducing irrigated areas), then aesthetics may shift for urban irrigation water users. However, the agricultural economic analysis (Section 3.9) models all reductions in water supply as solely affecting forage/grain crop production such that urban/suburban water users may be kept whole through in-district water trading or other mechanisms with no effect on aesthetics.

**Effect Conclusion:** Visual effects on irrigated croplands under the proposed action compared to the no-action alternative would only occur in normal and dry years and would not be notable, and other water users, including residential developments and golf courses, would not be affected. Therefore, the change in visual quality associated with irrigated lands under the proposed action would be not adverse compared to the no-action alternative.

### 3.6.3.3 Alternative 3: Enhanced Variable Streamflows

#### AES-1: Change Visual Character and Quality of Lands and Waters in the Direct Effects Study Area

Changes to water surface elevations in reservoirs and waterways and associated effects on visual character and quality of the lands and waters in the direct effects study area under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action, except that beneficial effects on the Upper Deschutes River would be further increased, as described below. Both beneficial and adverse effects related to changes in hydrology under Alternative 3

[2] Assumes implementation of a low level of water conservation projects by the districts.

would occur earlier in the permit term than under the proposed action (Table 3.1-1), so would be of greater duration.

Conservation Measure DR-2, included under this alternative, would provide a funding mechanism for actions identified in a future OSF recovery plan anticipated in 2021 (Appendix 2-C, *Rationale for Oregon Spotted Frog Conservation Fund*). These actions would address ongoing threats to Oregon spotted frogs along the Upper Deschutes River that would persist despite improvements in hydrology, as described in Impact BIO-3 (Section 3.4, *Biological Resources*). Implementation of such actions could benefit function and species diversity of riparian and wetland vegetation in treated areas along the Upper Deschutes River under Alternative 3 compared to the no-action alternative. Therefore, beneficial effects in this reach would be greater than under the proposed action. Overall, the effects on visual character and quality of lands and waters in the direct effects study area would be not adverse compared to the no-action alternative.

#### AES-2: Change Visual Character and Quality of Irrigated Lands

Changes in irrigation water application and associated effects on the visual character and quality of the irrigated lands under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action but would occur earlier in the permit term (Table 3.1-1) and would therefore have a longer duration under Alternative 3 compared to the no-action alternative. The change in visual character and quality of irrigated lands under Alternative 3 would be not adverse compared to the no-action alternative.

### 3.6.3.4 Alternative 4: Enhanced and Accelerated Variable Streamflows

#### AES-1: Change Visual Character and Quality of Lands and Waters in the Direct Effects Study Area

Changes to water surface elevations in reservoirs and waterways and associated effects on visual character and quality of the lands and waters in the direct effects study area under Alternative 4 compared to the no-action alternative would be similar to those described for the proposed action, but the changes would be of greater magnitude. Both adverse and beneficial effects would occur earlier in the permit term than under the proposed action or Alternative 3 but would end sooner due to the shorter permit term (Table 3.1-1).

Inclusion of Conservation Measure DR-2 included under Alternative 4, as described under Alternative 3, would also increase visual diversity and thereby have beneficial visual effects in the Upper Deschutes River.

Overall, effects on visual character and quality of lands and waters in the direct effects study area under Alternative 4 would be not adverse compared to the no-action alternative.

#### AES-2: Change Visual Character and Quality of Irrigated Lands

Changes in irrigation water application and associated effects on visual character and quality of the irrigated lands under Alternative 4 compared to the no-action alternative would be similar to those described for the proposed action (i.e., during normal and dry water years, cropland may be fallowed, irrigated less, or water may be shifted to less water-intensive or higher-value crops). However, both beneficial and adverse effects under Alternative 4 would be of greater magnitude and would occur earlier in the permit term and end sooner than under the proposed action and

Alternative 3 (Table 3.1-1). The change in visual character and quality of irrigated lands under Alternative 4 would be not adverse compared to the no-action alternative.

# 3.7 Recreation

This section describes the affected environment for recreation and effects on recreation that would result from the proposed action and alternatives.

## 3.7.1 Methods

The study area for recreation consists of recreational areas in or near the covered lands and waters, as well as Prineville Reservoir and lands hydrologically associated with the reservoir where recreation resources could be affected by the proposed action and alternatives. This area primarily includes water-based recreation sites and river reaches that could be affected by changes in water management operations.

Information regarding recreational uses, opportunities, and experiences in the study area was obtained from existing Bureau of Land Management (BLM), U.S. Forest Service (USFS), and Bureau of Reclamation (Reclamation) management plans, as cited below. In addition, recreational information from Oregon State Parks (Oregon State Parks 2018a, 2018b) and the *Deschutes National Forest Recreation Guide* (U.S. Forest Service 2018) was used to identify important recreational uses in the study area.

Potential effects on recreational opportunities and experiences were evaluated based on the surface water analysis in Section 3.2, *Water Resources*. Specifically, changes in reservoir water surface elevations (reservoir levels) and streamflows that would occur under the proposed action and alternatives have the greatest potential to affect recreation. Additional interdisciplinary considerations were based on information in Sections 3.3, *Water Quality*, 3.4, *Biological Resources*, 3.6, *Aesthetics and Visual Resources*, and 3.9, *Socioeconomics and Environmental Justice*.

Effects of the proposed action and alternatives on recreation would be considered adverse if they would result in any one of the following conditions.

- Closure or reduced suitability for use of a well-established and well-used recreation facility, such as boat ramps or shore-based parks.
- Substantial long-term reduction of recreation opportunities and experiences, such as reduced areas or seasonal days available for a particular type of recreation (e.g., whitewater rafting, fly-fishing).
- A conflict with designated values, purposes, and management plan requirements, as defined in Wild and Scenic River designations or reduced eligibility of undesignated river reaches for potential future designation as Wild and Scenic Rivers.

## 3.7.2 Affected Environment

The Deschutes River Basin provides a wide range of recreational opportunities (Bureau of Land Management 1992a, 2018a; Bureau of Reclamation 2003; U.S. Forest Service 2018; Oregon State Parks 2018a). These opportunities are of very high economic, social, and cultural value for local communities as well as the region. Recreation-related businesses form a major component of the regional economy and employment, including guide services, restaurants, lodging, and retail (White 2017). In addition, the abundance of recreational opportunities draws not only many visitors but

also many people who choose to make the Deschutes River Basin their home. Outdoor recreation within the basin is an industry and a popular pursuit. It is also a way of life for local residents and an important component of the local sense of identity, place, and community. As described in Section 3.9, the region continues to experience rapid population growth, and the demands and needs for recreational opportunities are high and are expected to increase.

Water management changes under the proposed action and alternatives are primarily water-related; therefore, the main recreational uses examined here are water-related, including use of reservoirs and river and stream corridors.

### 3.7.2.1 Recreation Sites and Facilities

The following reservoir and river-based recreation opportunities occur in the affected area.

#### Reservoirs

Reservoirs are popular recreational destinations in the Deschutes River Basin. They provide a wide range of recreational opportunities such as fishing, motorized and nonmotorized boating, camping, hiking, swimming, wading, and picnicking. The environmental setting of these water features provides public enjoyment of wildlife, vegetation, and the aesthetic beauty of water and adjacent shorelines and vegetation (Section 3.6). These recreational uses and the associated enjoyable experiences that attract returning visitors are important to local economies and residents. Reservoir fishing was identified in public scoping comments as being particularly important to local economies and to local residents as part of an outdoor lifestyle.

Variations in reservoir levels are common and are a major aspect of reservoir-based recreation in the Upper Deschutes River Basin. At high water levels (near full), reservoirs can provide the experience of a natural lake. At lower levels, broad expanses of exposed sands and soils create a much different experience that is potentially lower in aesthetic value and associated recreational experiences. Low levels are common in most of the reservoirs during summer and early fall, particularly during dry years. However, even at low levels, reservoirs continue to provide opportunities for most uses. In some cases, very low levels reduce opportunities such as vehicle access to shorelines and boat ramps. At very low levels, traditional recreational uses, such as fishing, can be temporarily eliminated (Oregon Department of Fish and Wildlife 2018). Even with these constraints during low reservoir levels, recreation remains an important value of all reservoirs in the study area.

#### Rivers and Streams

For many recreational users, the primary recreational attraction of the Deschutes River Basin is found along popular rivers and streams. The landscape and regional identity are defined by these rivers and streams, and their beauty was sufficient for Congress in 1988 to designate much of the Deschutes River and other rivers in the Deschutes Basin as Wild and Scenic Rivers (described in Section 3.7.2.2 below).

The Deschutes River Basin is a nationally recognized fly-fishing hotspot, known for both the quality of the fishing as well as the scenic beauty (Oregon State Parks 2018a). Additional attractions and destinations—including Mount Bachelor, the city of Bend, numerous golf courses, and many local communities and visitor-based businesses—provide a wide range of opportunities, services, and experiences for recreational users. The Deschutes River is also regionally known for its whitewater

sports (e.g., rafting, kayaking), with most rapids located in the Lower Deschutes (Oregon State Parks 2018a). The Meadowcamp run (3 miles) on the Upper Deschutes River located within the city of Bend is popular throughout the summer. The Crooked River is also a well-known for whitewater rafting from Lone Pine Bridge to Lake Billy Chinook (28.6 miles), although sufficient flows are limited to brief periods in the spring.

Other important river- and stream-based recreational uses include swimming, scenic viewing, birding and wildlife watching, hiking, backpacking, running, mountain biking, equestrian trails, hunting, and camping (Bureau of Land Management 1992a).

Under current water management operations, flows in the Deschutes River upriver of Bend are high during the irrigation season and low during other times, including winter when water is retained in reservoirs for storage. The high flows can provide favorable boating but can interfere with activities such as wading for fly-fishing. Low flows can reduce or eliminate fishing and other flow-based recreational opportunities and can reduce overall visual experience due to exposed sediment. A similar flow regime occurs in Crooked River, and low winter flows have been reported to significantly reduce fish populations, including a notable decline in redband trout in the winter of 2015–2016 (Oregon Department of Fish and Wildlife 2016). However, fishing conditions (e.g., wading, boating) on the Crooked River are not significantly affected by flows and fishing occurs year-round.

### 3.7.2.2 Wild and Scenic Rivers

#### National Wild and Scenic River

The Deschutes River contains 174.4 miles of designated National Wild and Scenic River, designated in 1988 (National Wild and Scenic Rivers System 2018; Bureau of Land Management 2018b, 2018c, 2018d). Thirty-one miles are classified as a Scenic River Area and 143.4 miles are classified as a Recreational River Area. Specific reach designations are as follows.

- 40.4 miles of the Upper Deschutes from Wickiup Dam to the northern boundary of Sunriver (north of Bend), classified as Recreational River Area (administered by USFS).
- 11 miles of the Upper Deschutes from the northern boundary of Sunriver to Lava Island Camp, classified as Scenic River Area (administered by USFS).
- 3 miles of the Upper Deschutes from Lava Island Camp to the Bend Urban Growth boundary, classified as Recreational River Area (administered by USFS).
- 20 miles of the Middle Deschutes, from Odin Falls to the upper end of Lake Billy Chinook, classified as Scenic River Area (administered by BLM).
- 100 miles of the Lower Deschutes from the Pelton Reregulating Dam to the confluence with the Columbia River, classified as Recreational River (administered by BLM).

Wild and Scenic Rivers are designated based on Outstandingly Remarkable Values (ORVs). ORVs of the Upper Deschutes include cultural, fish, geologic, historic, recreational, scenic, wildlife, and botanical. ORVs of the Middle Deschutes include cultural, fish, geologic, recreational, scenic, wildlife, hydrologic, botanical, ecological, and wilderness. ORVs of the Lower Deschutes include cultural, fish, geologic, recreational, scenic, wildlife, and botanical.

The flow of the Upper Deschutes River has been highly regulated for agricultural use for over 80 years. Such use results in flows that are much higher during irrigation water releases than would naturally occur and much lower flows when water is being stored in Wickiup Reservoir. High flows have altered the river channel and banks and both high and low flows have altered recreational opportunities and experiences (U.S. Forest Service 1996), including flows too high or too low for optimal recreational uses.

The Lower Crooked River contains 17.3 miles of designated National Wild and Scenic River, designated in 1988 (National Wild and Scenic Rivers System 2018). Management is divided into two segments: 9.3 miles from Ogden wayside to river mile 8 (managed under the Middle Deschutes Wild and Scenic River Management Plan; Bureau of Land Management 1992a) and 8 additional miles—known as the Chimney Rock segment—between Bowman Dam and State Scenic Highway 27-mile marker 12 (Bureau of Land Management 1992b). Both segments are classified as Recreational River Areas. ORVs of the Lower Crooked River are scenic and recreational. Compared to historical conditions, flows on the Crooked River are lower during winter and higher during summer, reflective of the storage and release of irrigation water.

Crescent Creek contains 10 miles of National Wild and Scenic River designated in 1988 (National Wild and Scenic Rivers System 2018). The creek is classified as Recreational River Area and managed by the Deschutes National Forest. The designated area is from southwest corner of Section 11, T24S, R6E to the west section line of Section 13, T24S, R7E. The ORV of Crescent Creek is scenic. A tributary to Crescent Creek, Big Marsh Creek, is also designated a National Wild and Scenic River (managed by the Deschutes National Forest), and includes 15 miles designated as Recreational River Area, with ORVs being geologic and scenic.

Crescent Creek flows are regulated by the Tumalo Irrigation District, with similar effects to those that occur on the Upper Deschutes River, with low flows common during fall and winter when the Crescent Lake is recharged for summer irrigation withdrawal. High flows during the irrigation season are moderate but may exceed 230 cubic feet per second during specific times during June through September (U.S. Forest Service 2015).

Whychus Creek contains 15.4 miles of National Wild and Scenic River designated in 1988 (National Wild and Scenic Rivers System 2018), managed by the Deschutes National Forest, including 6.6 miles classified as Wild and 8.8 miles classified as Scenic. ORVs include geologic, hydrologic, fish, scenic, cultural–prehistory, and cultural–traditional use. The designated area is from its source to the gauging station 800 feet upstream from the intake of McAllister Ditch. Designated reaches are above irrigation diversions for the Three Sisters Irrigation District and are not affected.

## Oregon Scenic Waterways

The following portions of the Deschutes River are classified as State Scenic Waterways, which support world-famous recreation opportunities and scenic river areas (Oregon State Parks 2018c).

- **Upper Deschutes River**
  - Recreational river area: Harper Bridge (Deschutes County Road—FAS 900) at approximately river mile 190.6 and extending downstream approximately 5 miles to the point at which the river intersects the Deschutes National Forest boundary at approximately river mile 184.8.
  - Scenic river area: From Wickiup Dam stream gauge downstream to General Patch Bridge.

- Scenic river area: From Deschutes National Forest Boundary to Bend Urban Growth Boundary.

- **Middle Deschutes River**
  - Recreational River Area: From the northern urban growth boundary of Bend at approximately river mile 161 downstream to Tumalo State Park at approximately river mile 158.
  - Scenic river area: From Deschutes Market Road at approximately river mile 157 downstream to the south boundary of the wilderness study area at approximately river mile 131, excluding the Cline Falls Dam and powerhouse section between the Oregon Route 126 bridge and river mile 144 and the Crooked River Ranch River Community Area.
  - Natural river area: From the south boundary of the wilderness study area at approximately river mile 131 to the Lake Billy Chinook stream gauge at approximately river mile 120, excluding the Crooked River Ranch River Community Areas as described in the River Community section.
- **Lower Deschutes River**
  - Recreational river area: From the Deschutes River intersection with the northerly extension of the common section line of Section 29 and Section 30, Township 9 South, Range 13 East, of the Willamette Meridian, (T 9S, R 13E, W.M.), Jefferson County, downstream approximately 96 miles to the Columbia River. Excludes the right bank shoreline (as seen when facing downstream) and adjacent lands opposite the city of Maupin, as its boundaries were established on December 3, 1970.

## 3.7.3 Environmental Consequences

### 3.7.3.1 Alternative 1: No Action

Under the no-action alternative, the continuation of existing water management operations would result in little to no change in existing recreational use and experiences compared to existing conditions. Future development may include increased recreational facilities, including golf courses, resorts, trails and boat launches, while residential development may displace some areas currently used for recreation. Projected local and regional population growth would increase demand for and use of recreational areas.

Extreme climate events, such as drought, and ecological disturbances, such as flooding, wildfire, and insect outbreaks, are expected to increase over the analysis period. The timing of these changes is uncertain, but summer low flow reductions of 40 to 60% are forecast by 2040, approximately 20 years into the analysis period. Reduced flows could reduce recreational opportunities and experiences throughout the Deschutes River Basin because fewer seasonal days may be available for water-based recreation (e.g., whitewater rafting, river and reservoir fishing).

**Effect Conclusion**: Continuation of existing water management operations would not affect recreation, but climate change would likely reduce recreational opportunities, and future development and population growth may displace some areas currently used for recreation and create increased demand for and use of existing recreational areas. Overall, the study area is expected to continue to provide plentiful, high-quality recreational opportunities, and effects on recreation in the study area would be not adverse.

### 3.7.3.2 Alternative 2: Proposed Action

Effects of the proposed action are compared to the no-action alternative.

#### REC-1: Change Recreational Opportunities or Quality of Experiences in and Along Rivers, Creeks, and Reservoirs

Seasonal changes in reservoir levels and river and creek flows, as described in Section 3.2, would directly affect in-water recreational opportunities and experiences. In addition, surface water changes would indirectly affect recreation because of effects on water quality, shoreline vegetation, associated wildlife habitats, fish habitat and productivity, land use patterns, and the visual setting.

**Reservoir Levels**

As detailed in Section 3.2, changes in reservoir levels are projected to be most pronounced at Wickiup Reservoir. Median water surface elevations at Wickiup Reservoir would become more variable as less water is stored year-round compared to the no-action alternative. Increased variability in water levels would start in year 6 and increase over the permit term as minimum fall/winter flow releases from the reservoir increase. Effects would be greatest in years 21 through 30, when 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. Average median annual water surface elevations would be approximately 8.5 feet lower over the permit term. Low water levels are expected to occur more often and to start earlier and last longer. These effects would be greatest during dry years.

Increased low water events at Wickiup Reservoir would adversely affect recreational uses and opportunities through reduced aesthetic values of steep, exposed and unvegetated lakebed and reduced access to boat ramps and associated boating opportunities and enjoyment. Popular boat ramps at Gull Point and other shoreline campgrounds and boat ramps at Wickiup Reservoir that become inaccessible during low water levels under existing conditions in the fall could be inaccessible earlier in the season and for longer periods.

In addition to effects on access, populations of Wickiup Reservoir's recreationally important fish—including kokanee, coho salmon, redband trout, brook trout, brown trout, and mountain whitefish—could be adversely affected because increased variability in surface water elevation over the permit term would increase the frequency and severity of low water events. According to the Oregon Department of Fish and Wildlife (2018), the effects of low water events on Wickiup Reservoir's fish population are uncertain. During low water events, some fish may die, some may escape the reservoir through the unscreened outlet into the Deschutes River, and others may migrate upstream at the upper end of the reservoir. Mortality could reduce populations and trophy sized fish, whereas fish escaping downstream may live but would not reenter the reservoir and may adversely affect fish and aquatic communities in the Deschutes River through predation and competition. Since these effects on fisheries are occurring under existing conditions and would continue under the no-action alternative, it is difficult to estimate the degree to which the proposed action would exacerbate these effects and the potential for an adverse effect on recreational fisheries. Biological effects of Wickiup fisheries are discussed further in Section 3.4 (Impacts BIO-13, BIO-15, and BIO-16).

As described in Section 3.2, changes in reservoir levels at Crane Prairie, Crescent Lake, Prineville, Ochoco, and Lake Billy Chinook Reservoirs would be less than are projected to occur at Wickiup Reservoir and are not expected to noticeably reduce recreational opportunities or experiences.

- Crane Prairie Reservoir average median and maximum water surface elevations over the permit term would be approximately 0.5 feet higher during the storage season (November 1 through March 31) and 0.5 feet lower during the irrigation season (April 1 through October 31).
- Crescent Lake Reservoir surface elevations would rise a small amount year round, with approximately 0.7 feet higher maximum levels during the storage season and 0.5 feet higher during the irrigation season.
- Prineville Reservoir levels would decrease through irrigation season and early in winter storage, with average median and maximum water surface elevations approximately 0.6 feet lower during the storage season and 0.1 feet lower during the irrigation season.
- Ochoco Reservoir levels median and maximum water surface elevations would be similar to the no-action alternative over the permit term.
- Lake Billy Chinook would not be affected by the proposed action.

### Seasonal River and Creek Flows

Changes in flows, as described in Section 3.2, would not be sufficient in magnitude to adversely affect recreational opportunities and experiences in the following areas: the Deschutes River downstream of Bend, the entire Crescent Creek–Little Deschutes River system, the Crooked River, and all of Whychus, McKay, and Ochoco Creeks.

Changes in flows would be most noticeable to recreational users of the Deschutes River from Wickiup Reservoir downstream to Bend, where annual flow cycles would level off over the permit term compared to the wide variations that would continue to occur under the no-action alternative, including very high flows during the spring and summer irrigation season and very low flows during fall and winter. Reducing high summer flows would reduce some opportunities for whitewater and swift-water rafting. However, as described in Section 3.7.2, *Affected Environment*, most whitewater rafting occurs in the lower reaches of the Deschutes River, where changes in flow would be minimal. Changes to flows would also be minimal within the Meadowcamp run of the Middle Deschutes in Bend.

Overall, changes in river flows would not adversely affect recreation and would likely beneficially affect recreational opportunities and experiences by providing more constant, predictable, and safer streamflows and improved ecological function and associated recreational benefits, including more naturally appearing shoreline vegetation (Section 3.6) and enhanced fish and wildlife habitat (Section 3.4). As described in Section 3.6, muddy river shorelines exposed under the no-action alternative during low water would be reduced over time by more stable river levels and an increase in natural shoreline vegetation, which would increase overall aesthetic values and associated recreational experiences.

As described in Section 3.4 (Impact BIO-12), projected increases in warm water conditions during summer would adversely affect redband trout in the Crooked River, and variable streamflows in May and June would affect juvenile redband trout habitat in the Upper Deschutes River. Although redband trout may be affected by flow variation in the Upper Deschutes River during some drier years, flow increases during winter months would be beneficial. Water temperatures in the Crooked

River reach immediately downstream of Bowman Dam (CR-10, Figure 3.4-1), where the most abundant populations of redband trout exist, would likely continue to support this important recreational fishery in most years. However, potential effects on Crooked River redband trout in this reach and the reach upstream of the city of Prineville related to increased water temperatures would be adverse in a minority of years.

**Effect Conclusion**: The proposed action would result in more natural and consistent flows and improved aesthetics. In the Upper Deschutes River Basin, recreational opportunities and experiences are likely to benefit from more stable flows and river levels and increased native shoreline vegetation and potential benefits to recreationally important fish populations due to more consistent flows. Most reservoirs would have little noticeable changes in water levels or associated recreational opportunities and experiences. Wickiup Reservoir is the one exception, where low water events may occur more frequently or with more severity; this could result in adverse effects related to additional days of poor or eliminated access to boat ramps and shoreline campgrounds and reduced aesthetic values and fishing opportunities and experiences. Some adverse effects would occur on the recreationally popular redband trout in Wickiup Reservoir and in areas of the Upper Deschutes and Crooked Rivers. Overall, effects on recreation in rivers and streams would be not adverse because of the general improvement of most recreation opportunities in the study area.

### REC-2: Conflict with Existing and Future Wild and Scenic River Designations

The proposed action would result in more natural flow regimes and associated natural vegetation and shoreline conditions on the Upper Deschutes River. Effects on flow regimes on other designated Wild and Scenic Rivers are not expected to be sufficient to alter Outstanding Remarkable Values (ORVs). Based on conclusions presented in other resource sections of this EIS, the proposed action would have no adverse effects on ORVs of designated Wild and Scenic reaches in the study area, including botanical (Section 3.4.3.2), cultural/historic (Section 3.10.3.2), fish (Section 3.4.3.2), wildlife (Section 3.4.3.2), recreational, or scenic values (Section 3.6.3.2). Geologic values were not identified as a project issue to be addressed in this EIS and would not be affected by the proposed action.

The proposed action would also not modify scenic or natural resource values that could reduce the eligibility of undesignated reaches to be designated as Wild and Scenic Rivers because more natural and consistent flows and enhanced ecological function would be provided.

**Effect Conclusion**: The overall effect of the proposed action on designated Wild and Scenic River reaches would be beneficial compared to the no-action alternative due to more natural flow regimes and associated natural vegetation and shoreline.

## 3.7.3.3 Alternative 3: Enhanced Variable Streamflows

### REC-1: Change Recreational Opportunities or Quality of Experiences in and Along Rivers, Creeks, and Reservoirs

Changes to reservoir levels and streamflows and associated effects on recreational opportunities and experiences under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action. Although the effects and the intensity of those effects—both adverse effects in Wickiup Reservoir and adverse and beneficial effects in the Upper Deschutes River—would be the same as under the proposed action, the duration of these effects would be greater because they would occur earlier in the permit term (Table 3.1-1). Overall, effects on

recreation in rivers and streams would be not adverse for the same reasons identified for the proposed action.

### REC-2: Conflict with Existing and Future Wild and Scenic River Designations

Changes to streamflows and associated effects on the values and uses of Wild and Scenic Rivers under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action, with more natural and consistent flows and enhanced ecological function on the Upper Deschutes River. Although the effects and the intensity of those effects would be the same as under the proposed action, the duration of these effects would be greater because they would occur earlier in the permit term under Alternative 3 than under the proposed action (Table 3.1-1). The overall effect on designated Wild and Scenic River reaches under Alternative 3 would be beneficial compared to the no-action alternative.

## 3.7.3.4 Alternative 4: Enhanced and Accelerated Variable Streamflows

### REC-1: Change Recreational Opportunities or Quality of Experiences in and Along Rivers, Creeks, and Reservoirs

Changes to water surface elevations in reservoirs and waterways and associated effects on recreational opportunities and experiences under Alternative 4 compared to the no-action alternative would be similar to those described for the proposed action but would be of greater magnitude. Adverse effects in Wickiup Reservoir would be more adverse and beneficial effects in the Upper Deschutes River would be more beneficial than described under the proposed action. Because increased fall and winter releases from Wickiup Reservoir would occur earlier in the permit term under Alternative 4 than under the proposed action or Alternative 3 (Table 3.1-1), these effects would also occur earlier in the permit term. However, because Alternative 4 has a shorter overall permit term, the duration of effects would be shorter. Therefore, although associated effects on recreational opportunities and experiences would be the same as described for the proposed action, they would be of greater intensity and shorter duration than under the proposed action or Alternative 3. Overall, effects on recreation in rivers and streams would be not adverse for the same reasons described for the proposed action.

### REC-2: Conflict with Existing and Future Wild and Scenic River Designations

Changes to streamflows and associated effects on the values and uses of Wild and Scenic Rivers under Alternative 4 compared to the no-action alternative would be the same as described for the proposed action, with more natural and consistent flows and enhanced ecological function in the Upper Deschutes, but the improvements would be of greater intensity than under the proposed action and Alternative 3. They would also occur earlier in the permit term than under the proposed action or Alternative 3 but would end sooner (Table 3.1-1). Therefore, although associated effects on Wild and Scenic Rivers be the same as described for the proposed action, they would be of greater intensity and shorter duration than under the proposed action or Alternative 3. The overall effect on designated Wild and Scenic River reaches under Alternative 4 would be beneficial compared to the no-action alternative.

# 3.8 Tribal Resources

This section describes the affected environment for tribal resources and effects on tribal resources that would result from the proposed action and alternatives.

For the purposes of this analysis, ***tribal resources*** refers to treaty-reserved, or otherwise federally protected, rights to tribal fishing, hunting and gathering practices, and pasturing of stock including access to areas associated with a tribe's treaty rights. These resources may include plants, animals, fish, or other materials used for commercial, subsistence, and ceremonial purposes. Tribal resources includes all natural resources, including water and harvestable fisheries, relevant to treaty and federally recognized tribes with ceded lands and usual and accustomed stations in the study area (Article 1, Treaty with the Tribes of Middle Oregon, 12 Stat. 963, 1859).

Description of the affected environment for cultural resources and effects on cultural resources that would result from the proposed action and alternatives are described in Section 3.10, *Cultural Resources*.

## 3.8.1 Methods

The analysis of environmental consequences focuses on treaty-reserved rights, including fishing, hunting, and food gathering rights, and access to usual and accustomed stations or places where tribal resources or access to tribal resources could be affected under the proposed action and alternatives.

The study area includes ceded lands of the Confederated Tribes of the Warm Springs Reservation of Oregon (Warm Springs Tribes), including areas along the Deschutes River up to Bend (including Lake Simtustus, and Lake Billy Chinook), Metolius River, the Crooked River and tributaries, Prineville Reservoir, Whychus Creek, and Tumalo Creek (Article I, Treaty with the Tribes of Middle Oregon, 12 Stat. 963 1859).

The study area also includes ceded lands of the Klamath Tribes beginning at Bend and extending south to include the Upper Deschutes River and Crane Prairie and Wickiup Reservoirs, Crescent Creek and Crescent Lake Reservoir, and the Little Deschutes River (Article I, Treaty between the United States and the Klamath and Moadoc Tribes and Yahooskin Bank of Snake Indians, October 14, 1864, 16 Stat. 707, [1864 Treaty]).

The description of the affected environment relies on the best available information in existing publications describing tribal treaty rights, tribal sovereignty, and traditional use of natural resources by tribes in the study area.

The analysis of environmental consequences is based on descriptions of current and traditional uses of natural resources in the study area, information presented in the affected environment, and the results of the analyses for fish, vegetation, and wildlife described in Section 3.4, *Biological Resources*, and water resources described in Section 3.2, *Water Resources.*

Potential effects of the proposed action and alternatives on tribal resources would be considered adverse if they would result in any of the following conditions.

- Reduced abundance and productivity of populations of salmon, steelhead, and other aquatic species harvested within the tribes ceded lands and at usual and accustomed stations for tribal subsistence, ceremonial, and economic purposes.
- Reduced abundance and productivity of wildlife and plant species within the tribe's ceded lands and usual and accustomed stations for tribal subsistence, ceremonial and economic purposes.
- Reduced (1) success of salmon and steelhead reintroduction, or (2) opportunities to create self-sustaining and harvestable populations returning to tributaries upstream of the Pelton-Round Butte Complex (steelhead trout, Chinook salmon, and sockeye salmon).
- Restricted access to treaty-reserved and traditional and cultural natural resources.
- Reduced ability of the Warm Springs Tribes to exercise their Tribal Reserved Water Right for off-reservation uses.

## 3.8.2 Affected Environment

The tribal resources in the study area include ceded lands and usual and accustomed stations of the Confederated Tribes of Warm Springs, Treaty of 1855 with the Tribes of Middle Oregon. This encompasses all of the study area, from the Columbia River south to the 44th parallel, and usual and accustom stations south of the 44th parallel. (Article I, Treaty with the Tribes of Middle Oregon, 12 Stat. 963 1859). South of the 44th parallel, the study area includes ceded lands in (Article I, 1864 Treaty, 16 Stat. 707 1866).

Usual and accustomed stations of both tribes are found throughout the study area. Traditional uses of natural resources by tribal members are described in the following sections.

### 3.8.2.1 Confederated Tribes of the Warm Springs Reservation of Oregon

The Confederated Tribes of the Warm Springs Reservation of Oregon is a federally recognized confederation of three tribes in Oregon (Confederated Tribes of Warm Springs 2019). The Confederated Tribes of Warm Springs entered into the "Treaty the Tribes of Middle Oregon, 1855" with the United States on June 25, 1855. The treaty reserved the exclusive right of tribal members to take fish in the streams running through and bordering the Warm Springs Reservation and reserved the rights of tribal members to fish, hunt, gather roots and berries and medicines, and pasture their stock on unclaimed lands in the ceded lands and usual and accustomed stations on unclaimed lands. Warm Springs Tribes ceded lands include approximately 10 million acres; ceded lands and usual and accustomed stations are present outside of the ceded lands. The Warm Springs Reservation in Central Oregon encompasses 640,000 acres between the Deschutes River and the crest of the Cascade mountain range; and the Metolius River and Deschutes River are streams running within and bordering the Reservation (Figure 3.6-1).

The Warm Springs Tribes include Warm Springs, Wasco, and Paiute people. The Wasco bands on the Columbia River were the eastern-most group of Chinookan-speaking Indians. Although they were principally fishermen (salmon most notably), their frequent contact with other Indians throughout the region provided for abundant trade. The Warm Springs bands who lived along the Columbia's tributaries spoke Sahaptin. Unlike the Wascoes, the Warm Springs bands moved between winter and summer villages, and depended more on game, roots, and berries. Salmon was also an important staple for the Warm Springs bands and, like the Wascoes, they built elaborate scaffolding over waterfalls which allowed them to harvest fish with long-handled dip nets. The Paiutes lived in

southeastern Oregon and spoke a Shoshonean dialect. The lifestyle of the Paiutes was considerably different from that of the Wasco and Warm Springs bands. Their high-plains existence required that they migrate further and more frequently for game, and fish was not the most important part of their diet. Although Paiute territories historically included a large area from southeastern Oregon into Nevada, Idaho and western Utah, the Paiute bands, which eventually settled at Warm Springs, lived in the area of Lake, Harney, and Malheur Counties in Oregon (Confederated Tribes of the Warm Springs 2019).

Warm Springs Tribes co-manages fisheries in the Deschutes River Basin, Columbia River Basin, Fifteenmile Creek Basin, John Day River Basin, and Hood River Basin.

The Warm Springs Tribes entered into a water rights settlement agreement with the State of Oregon and U.S. Government on November 17, 1997. The settlement secured water on reservation and waters bordering the reservation.

#### 3.8.2.2 Klamath Tribes

The Klamath Tribes is a federally recognized confederation of three tribes in the Klamath Basin in southcentral Oregon: the Klamaths, the Moadocs, and the Yahooskin (Klamath Tribes 2019). The Klamath Tribes signed the 1864 Treaty.

Treaty-reserved rights of the Klamath Tribes to harvest game, fish, and gather edible roots and berries are limited to reservation lands set forth in the 1864 Treaty and do not extend to ceded lands in the Upper Deschutes. This analysis assumes members of the Klamath Tribes maintain a cultural connection to the portion of the Deschutes Basin within their ceded lands.

#### 3.8.2.3 Non-Covered Terrestrial Wildlife and Vegetation

Descriptions of the affected environment for terrestrial wildlife and vegetation are presented in Section 3.4. Wildlife and vegetation types considered in this analysis are those having a primary association with aquatic, wetland, and riparian settings. Wildlife species considered in the analysis have been assigned to *guilds*, which are groups of species that share ecological attributes that make them similarly vulnerable to the adverse consequences of environmental changes that could occur under the proposed action and alternatives. Wildlife guilds not associated with aquatic, wetland, and riparian settings for foraging, reproducing, or resting were not included in the analysis.

Vegetation types potentially affected by the proposed action and alternatives include those having a primary association with aquatic, wetland, and riparian settings. Upland vegetation types have minimal potential to be affected because the proposed changes in hydrology would only affect portions of the study area already subject to changes from current water management operations. Because no changes to upland vegetation are expected from the proposed action or alternatives, upland vegetation is not evaluated in this analysis.

#### 3.8.2.4 Covered Fish Species

Covered fish species include spring Chinook and sockeye salmon, steelhead trout, and bull trout. Descriptions of the affected environment for these species are presented in Section 3.4.

Spring Chinook salmon, sockeye salmon, and steelhead were a significant part of the traditional harvest of fish by the Warm Springs Tribes and remain an important fishery by tribal members. Within the study area, Tribal members annually harvest for subsistence purposes spring Chinook

salmon and steelhead trout in the Deschutes River and tributaries downstream of the Pelton-Round Butte Complex.

Beginning in 2008, the Warm Springs Tribes and Oregon Department of Fish and Wildlife initiated a reintroduction plan for spring Chinook, sockeye, and steelhead in the Deschutes River upstream of the Pelton Round Butte Complex (Oregon Department of Fish and Wildlife and Confederated Tribes of Warm Springs 2008). Reintroduction is an ongoing long-term project with the goal to create self-sustaining and harvestable populations of these species in this portion of the basin.

#### 3.8.2.5 Non-Covered Fish and Mollusk Species

Non-covered fish species include fall Chinook salmon, redband trout, kokanee salmon, mountain whitefish, sucker species, Pacific lamprey, mollusks, and non-native trout. Descriptions of the affected environment for these species are presented in Section 3.4.

All native species described in Section 3.4 were historically part of the diet of members of the Warm Springs Tribes and other tribes in the region and harvested throughout the study area.

Pacific lamprey, although extirpated above the Pelton–Round Butte Complex, remains an important species for subsistence and is harvested annually in the Lower Deschutes River by members of the Warm Springs Tribes.

Freshwater mussels were an important food of tribes in the region and the shells were used for beads and other fasteners. Fall Chinook salmon is an important subsistence food species harvested from the Lower Deschutes River by members of the Warm Springs Tribe (Confederated Tribes of the Warm Springs 2019).

Subsistence and ceremonial harvest of covered and non-covered species continues to be important for the tribes. The continued persistence of these species is important to the tribes and their treaty-reserved rights and sovereign interests in the study area.

## 3.8.4 Environmental Consequences

### 3.8.4.1 Alternative 1: No Action

#### Fish, Fish Habitat and Fishing Sites

Although 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 habitats compared to existing conditions, continued implementation of restoration of streamflow and habitat restoration projects assumed under the no-action alternative would result in some overall improvements to these habitats. Streamflow restoration projects developed by the Deschutes River Conservancy would result in some isolated improvements in habitat for fish and mollusks. Habitat restoration projects planned and restoration strategies considered in the Deschutes River, Little Deschutes River, Crooked River, Whychus Creek, and Tumalo Creek also would likely result in improved, but unquantifiable, conditions for fish species. Improvements would occur through the following means.

- The fish passage structure at Opal Springs Dam in the Crooked River, which is anticipated to be operational beginning late fall or early winter 2019, will remove a barrier to resident and

anadromous fish species to the Crooked River that has been in place since 1982 and will support the reintroduction of steelhead trout and Chinook salmon in this area.

- The protection and restoration of riparian and floodplain habitats through riparian plantings, removal of bank hardened structures, and reconfiguration of channels to reconnect floodplains would provide improved habitat for juvenile and adult life stages (Upper Deschutes Watershed Council 2002, 2003, 2008, 2014; Crooked River Watershed Council 2008)Continuation of existing water management rules and agreed minimum streamflow requirements (e.g., Crooked River) would improve habitat for fish and mollusks in some portions of the study area.
- Recent and reasonably foreseeable water conservation projects, described in Chapter 2, would increase instream flows below irrigation diversions in the Deschutes River and Tumalo Creek (Farmers Conservation Alliance 2018a, 2018b).

The continuation of existing restoration and protection strategies under the no-action alternative could result in the improvements to fish habitat and support reintroduction of salmon and steelhead above the Pelton-Round Butte Complex. However, projected changes in climate change could result in adverse effects on the distribution and quality of habitat available in the study area. Halofsky et al. (2018) forecast that peak winter/spring streamflows will be higher and summer low streamflows lower compared to existing conditions as a result of climate change. 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 low streamflow reductions of 40 to 60% are forecast by 2040, approximately 20 years into the analysis period. Changes in precipitation patterns and precipitation type (e.g., a shift from snowpack to rain) due to climate change could affect fish habitats, affecting abundance, productivity, and distribution of these fish and mollusk species.

The resulting outcome (adverse, beneficial, or no effect) and magnitude of this combination of effects on fish and mollusks cannot currently be forecast reliably. However, not addressing water management and effects of climate change on streamflows in a comprehensive manner likely limit the ability to manage for future changes in climate and, thus, would have an adverse effect on fish and mollusks habitats. This would adversely affect the persistence, abundance, and distribution of fish in the study area and, thus, result in an overall adverse effect on tribal fisheries resources in certain portions of the study area. It is likely the no-action alternative would not adversely affect harvest of spring Chinook salmon, fall Chinook salmon, and steelhead trout from the Lower Deschutes River because there it is likely there would be little change in conditions in this portion of the study area (Deschutes River mainstem downstream of Pelton-Round Butte). The effects likely would be most adverse in the Crooked River and Upper Deschutes River, portions of the study area where irrigation demands would conflict most with future climate and habitat for fish and mollusks.

## Vegetation

Continuation of current water management 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 historical 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. However, data are not adequate to identify those locations or to quantify the magnitude of the habitat quality improvement. In the remainder of the study area, seasonal and year-to-year flow variations would be essentially unchanged; therefore, vegetation changes in these areas would not be expected.

Ecological changes associated with forecast climate change, especially increasing frequency and intensity of drought, insect outbreaks, and wildfire, could adversely affect riparian and wetland vegetation. These effects would be associated with an increase in vegetation mortality and a generalized shift to earlier successional stages Overall, the timing and magnitude of these effects cannot be determined because of uncertainties in how soon forecast climate changes would occur.

### Wildlife

Minor potential improvements in the quality of vegetation along the Upper Deschutes River upstream of Bend over the analysis period are not expected to meaningfully improve the condition of wildlife habitat in this portion of the study area. In the remainder of the study area, seasonal and year-to-year flow variations would be essentially unchanged; therefore, effects on wildlife in these areas would not be expected.

Ecological changes to riparian and wetland vegetation associated with forecast climate change would particularly affect species that depend upon mature or late-successional riparian forest habitats. Increased frequency and severity of drought and flood and substantial reductions in summer streamflow in streams lacking headwater reservoirs (such as Whychus Creek, Tumalo Creek, and the Little Deschutes River) would adversely affect wildlife using riparian and wetland habitats along those streams.

**Effect Conclusion:** Climate change is anticipated to result in generally adverse effects on vegetation throughout the study area when compared to existing conditions. Overall, due to the effects of climate change over the analysis period, effects on vegetation under the no-action alternative would be adverse compared to existing conditions. Although the continuation of current water management operations and other ongoing projects and programs assumed under the no-action alternative to restore habitats for fish and wildlife would have small beneficial effects in some parts of the study area, climate change is anticipated to have an overall adverse effect on fish and wildlife by permanently reducing the quality and function of existing habitats of many of the species that are considered a tribal resource. Similarly, throughout the study area, climate change is anticipated to have generally adverse effects on vegetation. Overall, due to the effects of climate change over the analysis period, effects on fish, wildlife, and vegetation tribal resources under the no-action alternative would be adverse because they would permanently reduce the quality and function of existing habitats.

## 3.8.4.2 Alternative 2: Proposed Action

This section describes effects on fish and mollusks under the proposed action compared to the no-action alternative.

### TR-1: Affect Fish Populations Harvested by Tribes

The following is a summary of the effect conclusions for fish potentially harvested by tribal members. Section 3.4 provides a detailed summary of effects, and Appendix 3.4-C, *Fish and Mollusks Technical Supplement*, provides detailed data, analysis, and graphics.

There would be minor differences in streamflows in the Lower Deschutes River (downstream of the Pelton-Round Butte Complex). Therefore, habitat conditions for salmon and steelhead harvested by the Warm Springs Tribes originating from the mainstem and tributaries in the Lower Deschutes River would be relatively unchanged.

The proposed action would have beneficial storage season effects on habitat for bull trout, steelhead trout, and spring Chinook salmon, but would have adverse irrigation season effects in some reaches at full implementation (years 21–30) depending on annual water management practices. Both the beneficial and adverse effects would be due to shifts in release of water from Prineville Reservoir affecting water temperatures downstream of Bowman Dam.

The extreme change in Wickiup Reservoir elevation and volume at full implementation would result in adverse effects on kokanee and trout habitat and populations in Wickiup Reservoir.

In the Upper Deschutes River downstream of Wickiup Reservoir, habitat conditions for redband trout would improve over the permit term during the storage season from October to March. However, greater variability in streamflows in May would adversely affect habitats for redband trout spawning, egg incubation, and fry and abundance of redband trout potentially harvested by tribal members.

Increased winter streamflows in the Middle Deschutes River in the portion of river immediately downstream of Bend later in the permit term would have a beneficial effect on redband trout habitat and redband trout potentially harvested by tribal members. The greatest beneficial effect would be in the portion of the river upstream of significant groundwater influences.

Overall, there would be no effect on access to treaty-reserved tribal resources in the Lower Deschutes River. There would be no effect on the ability of tribal members to access fishing areas in this area because increased winter streamflows would be minor. However, access to fish populations in Wickiup Reservoir would be adversely affected because of the increased drawdown of the reservoir in some years, which would affect access to the reservoir and have an adverse effect on reservoir fish populations.

**Effect Conclusion:** The proposed action would have no effect on fish habitat the Lower Deschutes River and salmon and steelhead harvested by tribal members from the Lower Deschutes River compared to the no-action alternative. The proposed action would have beneficial effects on redband trout habitat and redband trout potentially harvested by tribal members in the Middle Deschutes River. On the Crooked River, beneficial storage season effects would be outweighed by adverse irrigation season effects in some reaches on habitat for bull trout, steelhead trout, and spring Chinook salmon. In the Upper Deschutes River downstream of Wickiup Reservoir, the proposed action would have beneficial effects on redband trout habitat during storage season but adverse effects during spawning, egg incubation, and fry emergence that could affect abundance of redband trout potentially harvested by tribal members. Extreme changes in Wickiup Reservoir elevation and volume at full implementation would result in adverse effects on kokanee and trout habitat and populations in Wickiup Reservoir. Overall, the effect on tribal fish resources would be not adverse because the primary species and populations harvested by tribal members are in Lower Deschutes River.

## TR-2: Affect Reintroduction of Salmon and Steelhead into Habitats Upstream of the Pelton-Round Butte Complex

The proposed action would have beneficial storage season effects on habitat for steelhead trout and spring Chinook salmon. However, shifts in release of water from Prineville Reservoir and increased reliance of North Unit ID pumps would result in increased water temperatures during the irrigation season in the 62-mile reach between Bowman Dam and Osborne Canyon. These changes in water temperatures would have adverse effects on juvenile steelhead trout and spring Chinook and migrating and holding adult spring Chinook in this reach that would outweigh the storage season benefits, especially at full implementation (years 21–30). These effects are described in more detail in Section 3.4 under Impacts BIO-6 through BIO-9. The adverse temperature effects on habitat in some years would result in higher mortality of fish released into the crooked river for reintroduction and higher mortality of progeny fish spawning in nature. Together, these effects would impede reintroduction success and potentially result in reintroduction failure by reducing brood year success during critical early stages of reintroduction.

Minor differences in streamflows in other areas of the study area for reintroduction of salmon and steelhead would have no effect on fish habitat and success of reintroduction of these species.

**Effect Conclusion:** Beneficial storage season effects of the proposed action on the Crooked River compared to the no-action alternative would be outweighed by adverse irrigation season effects that would impede reintroduction success and potentially result in reintroduction failure by reducing brood year success during critical early stages of reintroduction 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. Therefore, overall, the proposed action would have an adverse effect on spring Chinook salmon and steelhead trout reintroduction compared to the no-action alternative.

## TR-3: Affect Wildlife and Plant Species Harvested by Tribes

In areas with no hydrological or vegetation changes or where those changes would be negligible in magnitude, the corresponding effects on wildlife and plant species would also be negligible or nonexistent. Such areas include the Lower Deschutes River from its confluence with the Columbia River upstream to and including Lake Billy Chinook; the Deschutes River downstream of Bend; Wychus Creek; Tumalo Creek; Prineville Reservoir; the Crooked River; McKay and Ochoco Creeks; and Crescent Lake Reservoir, Crescent Creek, and Little Deschutes River. Therefore, there would be no effects on wildlife and vegetation communities potentially harvested by tribal members in these areas.

In the Deschutes River below Wickiup Reservoir, the beneficial effects on vegetation, discussed in detail in Section 3.4, would likely improve riparian conditions for wildlife and plant species of cultural and harvest interest to tribal members. Therefore, reduced seasonal flow variability under the proposed action in the Deschutes River between Wickiup Reservoir and Bend would have a beneficial effect on wetland and riparian vegetation and wildlife species potentially harvested by tribal members.

In Wickiup Reservoir, the adverse effects on vegetation associated with extreme variability in reservoir elevation and volume, described in more detail in Section 3.4, means wildlife use of the

reservoir would decline. Conversely, in Crane Prairie Reservoir, the increased stability of water levels and improved quantity and function of riparian and wetland vegetation would be expected to also improve conditions for wildlife and wetland plant species potentially harvested by tribal members.

**Effect Conclusion:** The proposed action would have no effect on wildlife and plant species potentially harvested by tribal members compared to the no-action alternative over most of the study area. Beneficial effects would be expected in Crane Prairie Reservoir and the Deschutes River between Wickiup Reservoir and Bend. An adverse effect would be expected in Wickiup Reservoir; however, wildlife and plant species are impaired under current water management operations. Overall, effects of the proposed action on wildlife and plant species potentially harvested by tribal members would be not adverse compared to no-action alternative.

### TR-4: Affect Warm Springs Tribes' Off-Reservation Reserved Water Right

Changes in streamflows in the study area that could affect the ability of the Warm Springs Tribes to exercise their reserved off-reservation water right described in the 1997 *Confederated Tribes of The Warm Springs Reservation Water Rights Settlement Agreement* are specific to the portion of the study area adjacent to the reservation. This includes the Lower Deschutes River and Lake Billy Chinook. Under the proposed action, winter streamflows would increase slightly, and summer streamflows would be unchanged.

**Effect Conclusion:** The proposed action would have no effect on the Warm Springs Tribes' ability to exercise their reserved off-reservation water right compared to no-action alternative.

## 3.8.4.3 Alternative 3: Enhanced Variable Streamflows

### TR-1: Affect Fish Populations Harvested by Tribes

Effects on fish populations harvested and potentially harvested by tribal members under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action, except that beneficial effects in the Upper Deschutes River would be greater with implementation of habitat restoration activities funded through Conservation Measure DR-2. 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 under the proposed action (Table 3.1-1). Overall, effects of Alternative 3 on tribal fish resources would be not adverse compared to the no-action alternative because the primary species and populations harvested by tribal members are in the Lower Deschutes River.

### TR-2: Affect Reintroduction of Salmon and Steelhead into Habitats Upstream of the Pelton-Round Butte Complex

Effects on reintroduction of salmon and steelhead under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action, except that adverse effects in the Crooked River reach between the North Unit ID pumps and Osborne Canyon would be of slightly lesser magnitude due to instream protection of uncontracted releases under this alternative in

Conservation Measure CR-1.[1] Adverse effects would occur earlier in the permit term under Alternative 3 and, therefore, be of longer duration under Alternative 3 than under the proposed action (Table 3.1-1). Overall, Alternative 3 would have an adverse effect on spring Chinook salmon and steelhead trout reintroduction compared to the no-action alternative for the reasons described for the proposed action.

### TR-3: Affect Wildlife and Plant Species Harvested by Tribes

Effects on wildlife and plant species harvested and potentially harvested by tribal members under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action, except that beneficial effects in the Upper Deschutes River would be greater with implementation of habitat restoration activities funded through Conservation Measure DR-2. Beneficial effects in the Upper Deschutes River and adverse effects in Wickiup Reservoir would occur earlier in the permit term and would, therefore, be longer in duration than the proposed action. Overall, effects of Alternative 3 on wildlife and plant species potentially harvested by tribal members would be not adverse compared to the no-action alternative.

### TR-4: Affect Warm Springs Tribes' Off-Reservation Reserved Water Right

Alternative 3 would have no effect on Warm Springs Tribes' off-reservation reserved water right compared to the no-action alternative for the reasons described for the proposed action.

## 3.8.4.4 Alternative 4: Enhanced and Accelerated Variable Streamflows

### TR-1: Affect Fish Populations Harvested by Tribes

Effects on fish populations harvested and potentially harvested by tribal members under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action for all reaches except for Wickiup Reservoir and in the Upper and Middle Deschutes River where both beneficial and adverse effects would be of greater magnitude. The duration of these beneficial and adverse effects would be between the proposed action and Alternative 3. Overall, effects on fish populations harvested and potentially harvested by tribal members under Alternative 4 would be not adverse compared to the no-action alternative because the primary species and populations harvested by tribal members are in the Lower Deschutes River.

### TR-2: Affect Reintroduction of Salmon and Steelhead into Habitats Upstream of the Pelton-Round Butte Complex

Effects on reintroduction of salmon and steelhead under Alternative 4 compared to the no-action alternative would be the same as described for the proposed action, except that beneficial and adverse effects on the Crooked River would be of slightly greater magnitude, as described in Section 3.4 (Impacts BIO-6 through BIO-9).[2] Effects would occur earlier in the permit term under Alternative

[1] Adverse effects are based on water supply modeling results that show 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.

[2] Adverse effects are based on water supply modeling results that show that early irrigation season diversions from the Crooked River would increase as water supply availability on the Deschutes River declines. The frequency of

4. The duration of these beneficial and adverse effects would be between the proposed action and Alternative 3. Overall, Alternative 4 would have an adverse effect on Chinook and steelhead reintroduction compared to the no-action alternative for the reasons described for the proposed action.

### TR-3: Affect Wildlife and Plant Species Harvested by Tribes

Effects on wildlife and plant species harvested and potentially harvested by tribal members under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action, except for Wickiup Reservoir and in the Upper and Middle Deschutes River where both beneficial and adverse effects would be of greater magnitude. The duration of these beneficial and adverse effects would be between the proposed action and Alternative 3. Overall, effects of Alternative 4 on wildlife and plant species potentially harvested by tribal members would be not adverse compared to no-action alternative.

### TR-4: Affect Warm Springs Tribes' Off-Reservation Reserved Water Right

Alternative 4 would have no effect on Warm Springs Tribes' off-reservation reserved water right compared to the no-action alternative for the reasons described for the proposed action.

this outcome would depend on specific, annual water supply management decisions and water supply availability that are not captured fully by modeling results.

# 3.9 Socioeconomics and Environmental Justice

This section describes the affected environment for socioeconomics and environmental justice and socioeconomic and environmental effects that would result from the proposed action and alternatives.

## 3.9.1 Methods

This section analyzes the effects on socioeconomic values and environmental justice that are expected to occur as a result of the changes to natural resources described in previous resource sections. Socioeconomic values are broadly defined to include measures of change in social or economic well-being related to how people use and interact with natural resources and the environment. This includes resource uses and values related to agriculture, recreation, water supply, energy production, aesthetics, species preservation, quality of life, and public health.

The study area for socioeconomic resources and environmental justice is three Central Oregon counties: Deschutes, Jefferson, and Crook. The people residing in or visiting these three counties are expected to experience the majority of socioeconomic and environmental justice effects under the proposed action and alternatives. There may be social and economic effects experienced in other counties, but these are either expected to be relatively indirect and/or minor economic effects. For example, changes in agricultural production may result in some minor indirect effects on businesses in other counties supplying central Oregon agriculture. Similarly, residents in other areas of Oregon or the Pacific Northwest (or Nation) may value conservation of the covered species in the study area and their well-being may thus be affected by the proposed action and alternatives. While the focus is on socioeconomic values within the study area, where applicable, the analysis notes where socioeconomic values may be affected outside the study area.

The approach to the analysis of socioeconomic effects is as follows.

1. Identify changes to natural resource management and natural resource availability and quality that may affect socioeconomic values and environmental justice populations.
2. Identify potentially affected socioeconomic values.
3. Qualitatively and quantitatively describe the change in socioeconomic values, based on the change in natural resource availability/quality, the affected social groups, and the anticipated magnitude of effect. Some types of socioeconomic values, particularly those associated with economic activity and market prices such as agricultural production, are more easily quantified than other values (such as cultural and social values associated with recreation and species preservation). Values that are quantitatively analyzed in this section are not more important than values that are qualitatively discussed. Detailed methodology for the quantitative analysis of agricultural resources and the associated effects on agricultural socioeconomic values is presented in Appendix 3.5-A, *Agricultural Uses and Agricultural Economics Technical Supplement*. Results from this analysis focus on the economic contribution of agricultural production in terms of the direct, indirect, and induced jobs and income supported under

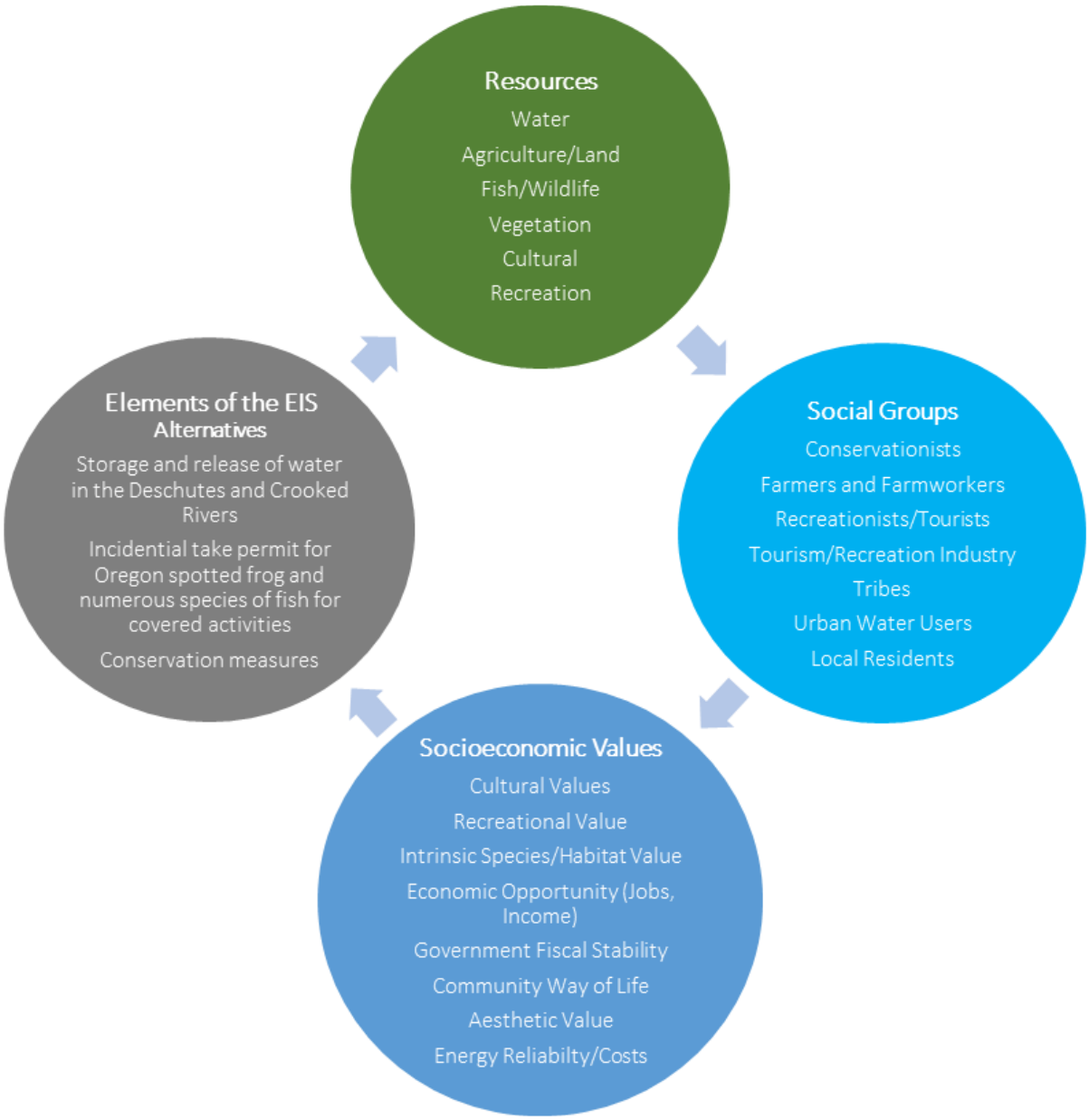
existing conditions and the EIS alternatives.[1] Ranges in effects on the agricultural economy represent the range of effects that vary based on the following factors: water year type, low and high water conservation scenarios (i.e., varying estimates of the amount of future on-farm and district water conservation), and selected years throughout the analysis period.

As shown in Figure 3.9-1, the section analyzes the following types of potentially affected socioeconomic values: economic opportunity (local jobs and income), government fiscal stability (tax revenues and expenditures), recreation value, property value, energy reliability and costs, and the social and cultural value to people of preserving species and habitat and community character. For the socioeconomic analysis, the social groups analyzed include farmers/farm workers, conservationists, recreationists/tourists, tourism/recreation industry workers, tribes, urban/suburban water users, and local residents.

As shown in Figure 3.9-1, the EIS alternatives could affect numerous resources (e.g., water, agriculture/land, fish/wildlife, aesthetics, recreation, and cultural resources). Changes in access to or changes in quality/abundance of these resources may affect the socioeconomic use and enjoyment of these resources by social groups in the study area, which, in turn, may affect diverse socioeconomic values. As identified in Figure 3.9-1 (by the arrow from Socioeconomic Values to EIS alternatives), socioeconomic values held by stakeholder groups, in turn, have influenced and shaped the EIS alternatives.

[1] 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.

**Figure 3.9.1. Socioeconomic Values and the Habitat Conservation Plan**




Effects of the proposed action and alternatives on socioeconomics would be considered adverse if implementation would result in any of the following conditions.

- A substantial reduction in economic opportunity, as measured by a 1% or more change in total employment or labor income at the county level.
- A substantial reduction in recreation value.
- A substantial reduction in property value.
- A substantial reduction in municipal water supply availability or increase in cost.
- A substantial reduction in hydropower production and increase in energy costs.

- A substantial reduction in local government revenue, as measured by a 1% or more change in tax receipts at the county level.
- A substantial reduction in social or cultural values related to community character or way of life.
- A substantial reduction in social or cultural values related to habitat and species preservation.

CEQ guidance identifies three factors to be considered to the extent practicable when determining whether a project would have disproportionately high and adverse effects on environmental justice populations (Council on Environmental Quality 1997:26–27).

- Whether there is or would be an effect on the natural or physical environment that adversely affects a minority population, or low-income population. Such effects may include ecological, cultural, human health, economic, or social effects on minority communities, low-income communities, or Indian tribes when those effects are interrelated to effects on the natural or physical environment.
- Whether the environmental effects may have an adverse effect on minority populations, or low-income populations, which appreciably exceeds or is likely to appreciably exceed those on the general population or other appropriate comparison group.
- Whether the environmental effects occur or would occur in a minority population or low-income population affected by cumulative or multiple adverse exposures from environmental hazards that appreciably exceed the cumulative or adverse exposure of the population at large.

## 3.9.2 Affected Environment

This section summarizes the affected population, social groups, and socioeconomic uses of resources that may be affected by the EIS alternatives.

### 3.9.2.1 Population and Affected Social Groups

Table 3.9-1 summarizes the 2018 population in the study area, as well as growth since 2010 and projected growth by 2050. As of July 1, 2018, the total study area population is estimated at 235,520 people, of which 80% live in Deschutes County. Nearly 60% of study area residents live in the cities of Bend, Redmond, Prineville, Madras, and Sisters (the largest urban center in the study is Bend, with 38% of the study area population). The remaining 40% of study area residents live in towns with fewer than 2,000 residents and in unincorporated areas. Since 2000, the populations of Crook and Jefferson Counties have grown by approximately 8%, just under the state average of 10%. However, Deschutes County's population has grown by 20% since 2000. Future growth is primarily projected for urban areas in the region, with the study area population as a whole projected to grow by 68% by 2050.

**Table 3.9-1. Study Area Population**

| Area | 2010 Population | 2018 Population | Projected 2050 Population | % Growth (2010-2018) | % Projected Growth (2018-2050) |
|---|---|---|---|---|---|
| Oregon | 3,831,074 | 4,195,300 | 5,588,500 | 10% | 33% |
| **Study Area** | | | | | |
| Crook | 20,978 | 22,710 | 32,277 | 8% | 42% |
| *Prineville* | *9,253* | *10,010* | *18,377* | *8%* | *84%* |
| Deschutes | 157,733 | 188,980 | 334,042 | 20% | 77% |
| *Bend* | *76,639* | *89,505* | *184,754* | *17%* | *106%* |
| *Redmond* | *26,215* | *29,190* | *59,179* | *11%* | *103%* |
| *Sisters* | *2,038* | *2,725* | *5,954* | *34%* | *118%* |
| Jefferson | 21,720 | 23,560 | 29,528 | 8% | 25% |
| *Madras* | *6,046* | *6,345* | *9,777* | *5%* | *54%* |
| **Total Study Area** | **200,431** | **235,250** | **395,847** | **117%** | **68%** |

Sources: Portland State University Population Research Center 2019a, 2019b; Oregon Office of Economic Analysis 2013 (for Oregon State 2050 population forecast). The 2010 and 2018 data are as of July 1.

The relationship between potentially affected resources, social groups, and socioeconomic values (as identified in Figure 3.9-1) is summarized in Table 3.9-2.

**Table 3.9-2. Relationship between Resources and Socioeconomic Values and Social Groups**

| Socioeconomic Value (Social Groups) | Key Resources | Description |
|---|---|---|
| **Tribal Cultural and Subsistence Values** (Tribes) | Cultural Resources, Fish/Wildlife, Vegetation, Water Quality | The Warm Springs Reservation is located in the study area, and also overlaps several adjacent counties. Cultural resources, fish and wildlife resources, and natural landscapes are closely associated with many different cultural and spiritual traditions as well as with community identity. The tribe has fishery and wildlife programs that aim to protect and improve fish and wildlife populations and habitat to sustain cultural, subsistence, and recreational values of tribal members. |
| **Economic Opportunity** (Farmers/ Farmworkers, Tourism Workers/ Proprietors, Local Residents) | Agriculture/Land Use, Recreation, Aesthetics, Fish/Wildlife | The study area has a dry climate, and the availability of water for out-of-stream consumptive uses such as agriculture and residential and municipal uses, as well as for instream recreation/aesthetic conditions that affect the tourism industry, are a key determinant of the economic opportunities in the area in terms of employment and income generation potential. |
| **Recreation Value** (Recreationists, Local Residents) | Recreation, Vegetation, Aesthetics, Fish/Wildlife | Study area residents and tourists derive value from diverse recreation activities on covered lands and waters; the socioeconomic value of this recreation depends on such factors as the abundance and diversity of recreation opportunities, aesthetics, and fish and wildlife populations. In a 2009 survey of Deschutes County voters, the most commonly cited contributors to a high quality of life were regarding the natural environment, including |

| Socioeconomic Value (Social Groups) | Key Resources | Description |
|---|---|---|
| | | outdoor recreation, open space, and natural areas (The Trust for Public Land 2010). |
| **Energy Costs and Reliability** (Local Residents) | Water | There are several hydroelectric facilities on the Deschutes and Crooked Rivers, including those in the Pelton–Round Butte Project and the Opal Springs Dam. The Pelton–Round Butte Project consists of three developments on the Deschutes, Crooked, and Metolius Rivers, with a combined capacity of 367 megawatts (MW). The Opal Springs Dam lies on the Crooked River and has a 4.3-MW capacity. Water management in the Deschutes and Crooked Rivers has the potential to affect hydropower production and/or value at these facilities. |
| **Local Government Fiscal Stability** (Local Residents) | Aesthetics, Agriculture/Land Use | Local governments provide numerous public services for local residents, many of which are funded through property taxes. Management of water in the region has the potential to affect property taxes if the assessed value of private lands changes due to changes in the availability of water or the aesthetics of the landscape. |
| **Species/Habitat Intrinsic Value** (Conservationists) | Fish/Wildlife, Vegetation, Water Quality | Restoration of habitat for fish and wildlife species and improvement in water quality in the study area has been a focus of local organizations such as the Deschutes River Conservancy and the Crooked River Native Fish Society (representing study area residents and other Oregonians). Also, conservationists in the study area (and other areas of Oregon) indicated the importance of Oregon Spotted Frog conservation and instream flow restoration through a lawsuit over water management in the Deschutes Basin. |
| **Urban/Suburban Water Uses** (Local Residents) | Water | Irrigation water is used by suburban and urban users to irrigate residential lawns, golf courses, parks, and other areas. Urban/suburban uses are highest in Swalley, Arnold, Central Oregon, and Ochoco Irrigation Districts. |
| **Community Way of Life** (Local Residents) | Agriculture/Land Use, Recreation, Aesthetics, Fish/Wildlife, Water, Cultural Resources | In addition to being members of other social groups, local residents may be affected by changes in dynamics between social groups due to the EIS alternatives, and changes in community way of life related to natural resource amenities, economic opportunity, and government fiscal stability. Community way of life is likely particularly vulnerable to any changes in recreation, and any changes in the ability to maintain commercial farms and lifestyle or "hobby" ranch operations resulting from the EIS alternatives. Outdoor recreation and ranching/farming are key aspects of community identity, culture, and way of life (Deschutes County 2010; Crook County 2003; Jefferson County 2006). |

Note: An individual may be a member of multiple social groups, such that a tribal member may also be a recreationist or a farmer.

### 3.9.2.2 Environmental Justice Populations

Table 3.9-3 summarizes the population in the study area, indicating the proportion of individuals in poverty and in each minority group. Poverty status in 2018, as defined by the U.S. Census Bureau (2019), depends on the size of the family and the number of children in the household. For example, for a two-adult (under age 65), two-child family, the poverty threshold in 2018 was $25,465. For a single-adult (under age 65) household, the poverty threshold was $13,064. Race and ethnicity in the census data are based on how respondents self-identify as of one race (e.g., white alone or black or African American alone) or as members of several races.

As highlighted in bold in the table, a higher proportion of several minority groups and low-income populations reside in Jefferson County relative to the proportion in the study area, state, and country. The Reservation of the Confederated Tribes of the Warm Springs overlaps with Jefferson County, leading to the relatively high proportion of American Indian and Alaska Native (AIAN) in the county. As noted above, the tribes are a key potentially affected social group and hold cultural, subsistence, and recreational values associated with the cultural resources, fish and wildlife resources (including covered species), and natural landscapes in the study area.

**Table 3.9-3. Population by Race, Ethnicity and Poverty (2013–2017)**

| Population | Crook County | Deschutes County | Jefferson County | Study Area | Oregon | United States |
|---|---|---|---|---|---|---|
| **Race** | | | | | | |
| White alone | 93% | 94% | 70% | 91% | 85% | 73% |
| Black or African American alone | 0% | 1% | 1% | 1% | 2% | 13% |
| American Indian and Alaska Native alone | 1% | 0% | **18%** | 2% | 1% | 1% |
| Asian alone | 0% | 1% | 1% | 1% | 4% | 5% |
| Native Hawaiian and Other Pacific Islander alone | 0% | 0% | 0% | 0% | 0% | 0% |
| Some other race alone | 2% | 1% | **8%** | 2% | 3% | 5% |
| Two or more races | 3% | 3% | 3% | 3% | 5% | 3% |
| Hispanic or Latino ethnicity | | | | | | |
| Hispanic or Latino (any race) | 8% | 8% | **20%** | 9% | 13% | 18% |
| **Low income** | | | | | | |
| Individuals in poverty | 15% | 12% | **21%** | 13% | 15% | 15% |

Source: 2013–2017 American Community Survey (U.S. Census Bureau 2017).

Farm operators and farm workers are a key social group that may be affected under the EIS Alternatives. Table 3.9-4 summarizes 2017 U.S. Census of Agriculture data on the race of farm operators in the study area (National Agricultural Statistics Service 2019). Relative to the study area as a whole, farm owners are disproportionately white in the study area (94–96%). Income status of farm operators is not readily available because the Census of Agriculture reports only farm-related income and many farm operators have significant off-farm income. Farmworkers, on the other hand, are predominantly Hispanic (Tejeda pers. comm.). Some farmworkers may also fall under the federal poverty level, depending on family size and whether they have year-round work. The Bureau of Labor Statistics provides data on hourly wages for Central Oregon. On an annualized basis, average farmworker income varies from $23,820 to $37,280 depending on the type of agricultural

work. However, as shown in Table 3.9-5, data from the 2017 Census of Agriculture (National Agricultural Statistics Service 2019) indicate that approximately one-half to two-thirds of the farmworkers in the study are employed for fewer than 150 days, with total average earnings per hired farmworker at less than $14,000 per year in all study area counties. Data from the 2017 Census of Agriculture also indicate that approximately 3 to 13% of farmworkers in study area counties are migrant workers. In summary, farmworkers are both disproportionately low-income and minority.

**Table 3.9-4. Race/Ethnicity of Farm Operators in Study Area**

| Race/Ethnicity | Crook | Deschutes | Jefferson | Study Area |
|---|---|---|---|---|
| White | 94% | 96% | 94% | 95% |
| Hispanic | 3% | 2% | 3% | 2% |
| American Indian and Alaska Native | 1% | 0% | 2% | 1% |
| Asian | 0% | 1% | 0% | 0% |
| Black | 0% | 0% | 0% | 0% |
| Native Hawaiian or Other Pacific Islander | 0% | 0% | 0% | 0% |
| Multi-race | 1% | 1% | 1% | 1% |

Source: 2017 Census of Agriculture (National Agricultural Statistics Service 2019).

**Table 3.9-5. Farmworker Characteristics in the Study Area**

| Characteristic | Crook | Deschutes | Jefferson | Study Area |
|---|---|---|---|---|
| Farmworker Earnings/ Job | $11,166 | $9,845 | $13,563 | $11,729 |
| Percent Farmworkers, Hired for Less than 150 Days | 62% | 65% | 48% | 57% |
| Percent Migrant Farmworkers | 13% | 7% | 3% | 7% |

Source: 2017 Census of Agriculture (National Agricultural Statistics Service 2019).

### 3.9.2.3 Employment and Income

As described above, the EIS alternatives have the potential to affect ranching and farming as well as outdoor recreation. In addition to being important components of the community way of life and identity in the study area, farming/ranching and tourism associated with outdoor recreation are important sources of income and employment. This section summarizes published data on employment and income in the study area, with a special focus on agriculture and recreation/tourism-related sectors as these are the two sectors most likely to be affected by water and habitat management under the EIS alternatives.[2] While several economic data sources are discussed, Bureau of Economic Analysis (BEA) data provide a consistent basis for comparing sectors, as these data include income and employment data for both workers and proprietors for all economic sectors. Table 3.9-6 summarizes BEA economic data for 2017, supplemented with tourism data from a study specific to that industry (Dean Runyan Associates 2018). Figure 3.9-2 also highlights the relative contribution of the agricultural and tourism/recreation sectors in the local economy based on BEA data.

[2] As discussed in the Section 3.2, *Water Resources*, municipal water supplies are not expected to be affected.

BEA data indicate that direct farm-related employment (including farmworkers and farm proprietors, many of whom may be part-time farmers), 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. However, other data sources indicate lower levels of farm worker employment, and higher levels of net farm income to proprietors. Specifically, data from the Oregon Department of Employment indicate that between 2014 and 2018 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 in Crook County, and 660 in Jefferson County. This compares to BEA data indicating total study area farm worker employment of approximately 3,000 (with an additional approximately 2,150 proprietors, for approximately 5,150 estimated farm proprietors/workers). While the data from the BEA (2019) indicate that total farm earnings is negative across all farms in the three counties, data from the 2017 Census of Agriculture (National Agricultural Statistics Service 2019) indicate that net cash farm income (a measure of farm profit that does not include such non-cash items as depreciation) in Jefferson and Crook Counties is positive. Only in Deschutes County, which has many smaller lifestyle farms, does the 2017 Census of Agriculture show a negative net cash farm income across all farms (although some farms are 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.

It is also important to note that agricultural production supports employment not just in the agricultural sector, but also in many supporting industries that provide seed, machinery, processing, and professional services to the agricultural sector. While agriculture contributes economically in all study area counties, the importance of agriculture in supporting businesses in other sectors is particularly high in Jefferson County. In Jefferson County, 4 of the top 30 employers are agricultural supply businesses (EDCO 2016).

For recreation and tourism, economic data do not separately define a recreation and tourism sector, but there are several sectors that are highly dependent on tourism and recreation spending, including arts/recreation/entertainment sector and the accommodation and food services sector. Using BEA data for these sectors would significantly overstate the economic contribution of recreation and tourism (as much spending in these sectors is not related to recreation/tourism.)[3] As such, data for recreation and tourism presented in Table 3.9-2 draws from an Oregon study of the economic impacts of tourism (Dean Runyan Associates 2018). This study estimated that in 2017 spending by visitors to study area counties totaled $732.6 million and supported approximately 8,700 jobs and $233.7 million in income in such sectors as accommodation, food services, transportation, and retail. These data indicate that the local recreation and tourism economy may directly account for approximately 6% of employment and 3% of income in the study area.

[3] Using BEA data for employment and earnings in these two sectors results in approximately twice as many estimated tourism/recreation-related jobs and earnings in the study area compared to the estimates from the Dean Runyan Associates (2018) study.

**Table 3.9-6. Agriculture, Recreation/Tourism, and Total Economic Activity in Study Area, 2017**

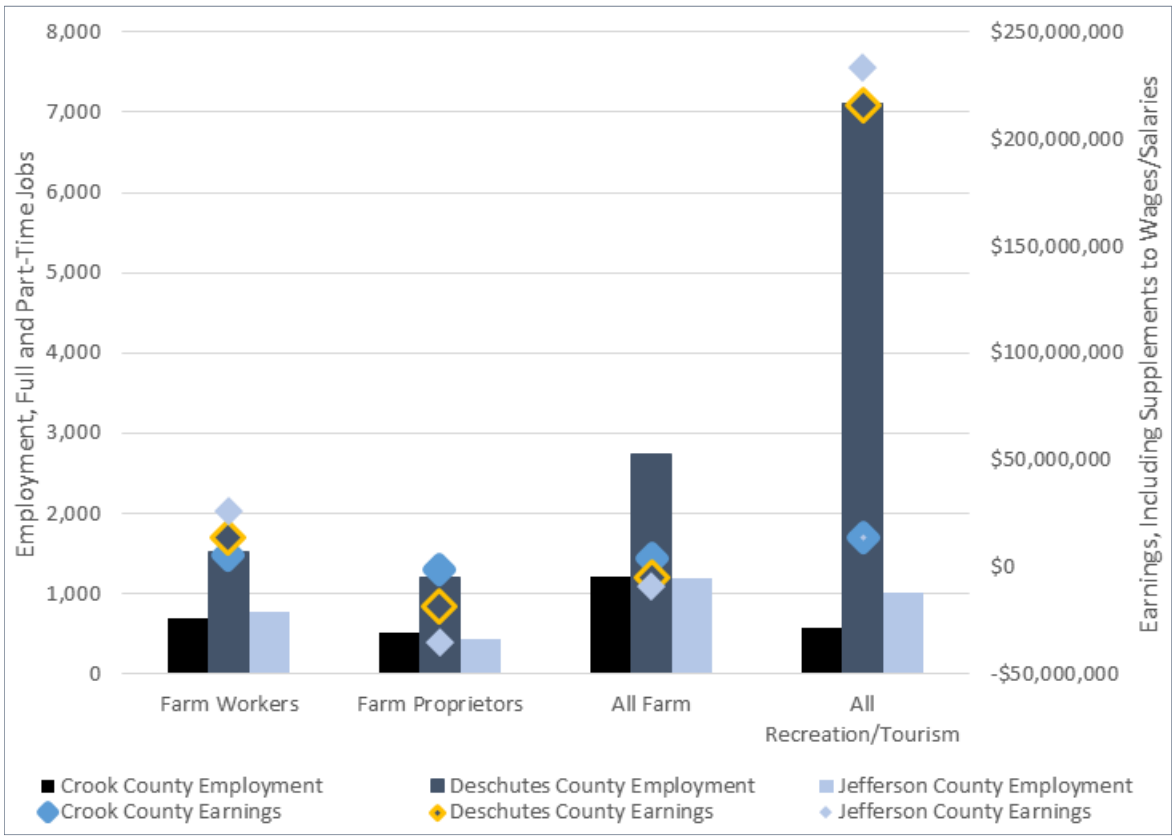
| County/Sector | Employment (full- and part-time jobs) | Earnings |
|---|---|---|
| **Crook** | | |
| Farm Workers/Proprietors[a] | 1,219 | $4,098,000 |
| Recreation/Tourism Sectors[b] | 580 | $13,800,000 |
| Other Sectors | 8,027 | $438,806,000 |
| Total | 9,826 | $456,704,000 |
| % Farm-Related[a] | 12% | 1% |
| % Recreation Tourism-Related[b] | 6% | 3% |
| **Deschutes** | | |
| Farm Workers/Proprietors[a] | 2,729 | -$9,121,000 |
| Recreation/Tourism Sectors[b] | 7,110 | $202,400,000 |
| Other | 108,320 | $5,988,892,000 |
| Total | 118,159 | $6,182,171,000 |
| % Farm-Related[a] | 2% | 0% |
| % Recreation Tourism-Related[b] | 6% | 3% |
| **Jefferson** | | |
| Farm Workers/Proprietors[a] | 1,198 | -$3,753,000 |
| Recreation/Tourism Sectors[b] | 1,010 | $17,500,000 |
| Other | 7,071 | $259,905,000 |
| Total | 9,279 | $273,652,000 |
| % Farm-Related[a] | 13% | -1% |
| % Recreation Tourism-Related[b] | 11% | 6% |
| **Study Area** | | |
| Farm Workers/Proprietors[a] | 5,146 | -$8,776,000 |
| Recreation/Tourism Sectors[b] | 8,700 | $233,700,000 |
| Other | 123,418 | $6,687,603,000 |
| Total | 137,264 | $6,912,527,000 |
| % Farm-Related[a] | 4% | 0% |
| % Recreation Tourism-Related[b] | 6% | 3% |

Sources: Highland Economics analysis of Bureau of Economic Analysis 2019; Dean Runyan Associates 2018.

[a] Based on 2017 farmworker statistics from the Oregon Employment Department (2017) and the 2017 Census of Agriculture (National Agricultural Statistics Service 2019), the farm-related employment may be overestimated, and the farm-related income may be underestimated.

[b] There is no recreation/tourism sector in BEA county-reported data. Included here are data from a Dean Runyan Associates (2018) study of the employment and earnings supported by tourism spending in the study area counties.

**Figure 3.9-2. Farm and Recreation/Tourism Employment and Earnings by County**




Sources: Highland Economics analysis of Bureau of Economic Analysis 2019; Dean Runyan Associates 2018.

Regarding farm income and employment under existing conditions, it is important to note that water supplies (and associated agricultural economic values) for existing conditions, particularly in dry water years, are lower than historical conditions. Water supplies under existing conditions are lower than historical water supplies in dry water years due to the 2016 Settlement Agreement for the Oregon spotted frog, which increased releases of storage water to enhance fall/winter flows in the Upper Deschutes River for the Oregon spotted frog. Existing conditions for Tumalo Irrigation District (ID) in particular are lower than historical conditions, but other districts with reductions in water supplies under existing conditions compared to historical conditions due to the Settlement Agreement include Central Oregon ID and North Unit ID.

Another important factor under existing conditions to note is that irrigation districts and patrons in the study area have been investing in water conservation measures to increase district conveyance efficiencies and on-farm irrigation efficiencies. These investments enable a higher proportion of water diverted to be used by crops, and thereby increase the acreage that can be irrigated with a given level of water diverted. However, these investments often come at a cost to farm operators, either through costs to pay for on-farm improvements, or through increased rates paid to the irrigation district.

### 3.9.2.4 Local Government Finance

Property taxes from farms in the study area may be affected by the EIS alternatives if the income potential from irrigated agricultural lands (usually as measured by farmland rents) changes. It is

also possible that property taxes from residential or commercial property in the study area may change if property values change due to changes in nearby amenities (such as aesthetics/recreation opportunities) due to the EIS alternatives.

Property taxes in Oregon are a function of two factors: tax rates and assessed value (Oregon Department of Revenue 2014a). County government in conjunction with local governments set the property tax rates, which can vary significantly by location and time due to local levies and bonds. In Oregon, the taxable value of land that qualified for farm-use tax assessment is the lesser of the specially assessed value (SAV) and the maximum specially assessed value (MSAV) (Solice pers. comm.). The SAV of qualified farmland is based on net income per acre of agriculture (Oregon Department of Revenue 2014b). Assessors conduct annual farm income studies specific to land class (based on soil productivity and irrigated versus dry land) and area (Oregon Department of Revenue 2014b). The MSAV is the greater of the prior year's MSAV or a 3% increase over the prior year's SAV (Oregon Department of Revenue 2014b). Availability of irrigation water is one factor that affects the value of farmland income and the SAV. Thus, a change in irrigation water supply would potentially affect SAV and resulting property taxes from farmland. An overview of total property taxes in the study area, and those received from qualified and farm/forest lands is presented in Table 3.9-7.

**Table 3.9-7. Property Tax Receipts in Study Area by County**

| | | Millions $ | | | |
|---|---|---|---|---|---|
| **County** | **Tax Year** | **Assessed Property Value** | **Property Tax Receipts** | **Farm and Forest Property Tax Receipts** | **Farm and Forest Property, % of Property Tax Receipts** |
| Crook | 2017/2018 | $2,057.9 | $29.3 | $3.2 | 11% |
| Deschutes | 2018/2019 | $24,635.8 | $378.8 | $8.7 | 2% |
| Jefferson | 2017/2018 | $1,691.2 | $27.5 | $2.8 | 10% |
| **Study Area** | | **$28,385.0** | **$435.6** | **$14.7** | **3%** |

Sources: Highland Economics analysis of Deschutes County 2018; Jefferson County 2018; Huber, Christofferson and Ott 2017.

## 3.9.3 Environmental Consequences

This section describes the direct and indirect effects of the EIS alternatives on socioeconomic resources and values.

### 3.9.1.1 Alternative 1: No Action

Based on analyses in other resource sections, there would be little to no effect on aesthetics (Section 3.6), recreation (Section 3.7), urban/municipal water supplies (Section 3.2), or cultural resources (Section 3.10) under the no-action alternative compared to existing conditions. Therefore, little to no effect on socioeconomic conditions and values associated with these resources are anticipated. However, due to potential changes in biological resources (Section 3.4) and agricultural resources (Section 3.5), there may be potential impacts on the following socioeconomic resources and values: economic opportunity, community way of life, fiscal government stability, tribal resource values, and intrinsic species/habitat conservation values. These are described below.

As described in Section 3.2, *Water Resources*, continuation of existing water management operations are assumed under the no-action alternative; thus water available for irrigation diversion and instream flows would be unchanged based on operations. However, as described in detail in Appendix 3.5-A, water conservation projects by the districts (including Deschutes Basin Board of Control Districts and Other Irrigated Lands[4]) and their patrons may increase the availability of water to crops through time under the no-action alternative compared to existing conditions in dry water years. The resulting increase in potential irrigated acreage and/or yields may increase agricultural employment and income in the study area, as summarized in Table 3.9-8 (and described in detail in Appendix 3.5-A). Economic contribution (including direct, indirect, and induced effects) from forage/grain production in the study area during dry water years would increase by 1 to 15% over the 30-year analysis period and across water conservation scenarios. As a proportion of total economic activity in the study area, this is an increase of less than 0.2% of study area employment or income. In Jefferson County, where potential impacts of water conservation under the no-action alternative are the greatest, the total beneficial effect on economic activity compared to existing conditions may be as high as approximately 1% of economic activity.

**Table 3.9-8. 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.
Note: Study area totals may not sum due to rounding. Total employment and income include direct, indirect, and induced effects.
* This percent change is relative to economic contribution from forage/grain production under existing conditions dry water years.

The increased dry water year employment and income estimated in Table 3.9-8 is based on the high water conservation scenario, which assumes investment in on-farm and district water conservation. 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 project 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 Central Oregon ID and approximately 9% in North Unit ID) (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

[4] Lands receiving irrigation water through the following non-DBBC diversions: Walker ID, People's Canal, Low Line Canal, Crooked River Central Canal, Rice Baldwin Canal, and the small private canal above Feed Canal.

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 would 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, there is likely little to no effect of investments in irrigation infrastructure on the total employment and income in the local study area.

Other factors that may affect economic opportunity associated with agriculture in the study area under no-action alternative include climate change, changing market conditions, and urban growth. Climate change, which may decrease snowpack and water supplies for summer irrigation, may reduce future agricultural production and the associated economic contribution of agriculture. Developments in new crop varieties and changes in market conditions may affect the crop mix in the study area and the total economic contribution of agricultural production. To the extent that more relatively high-value, low water use crops are suitable to be grown in the study area, the economic contribution of agriculture may rise in the study area. Overall effects on the agricultural economy may be beneficial or adverse. Economic opportunity in other sectors in the Bend area would depend largely on broad regional, state, and national economic conditions.

Per Section 3.7, *Recreation*, there is little to no expected effect on recreation resources, and thus a no adverse effect on recreation value.

As described in Section 3.4, *Biological Resources*, effects on plant, fish, and wildlife species (including the covered species) and their habitat in the study area would vary based on species and location, but in general are expected to be adverse due to climate change. In addition to potential subsistence and recreation-related values of fish and wildlife species (related to hunting, angling, and wildlife-viewing), people may value habitat and species conservation due to personal beliefs and moral ethics (i.e., believe protecting a species and its habitat is the right thing to do), altruism (i.e., believing a resource should be protected so that others can use it or benefit from it), and/or a desire to bequest the resource (i.e., believing a resource should be protected for future generations). The most common way to measure value to people of species conservation is through surveys in which people are asked about their willingness to pay to protect a species.

These surveys are highly challenging to develop and implement well, and results from different surveys aiming to measure similar changes in resources can be highly variable. However, values found in surveys can be quite high for species conservation, particularly for iconic species, well-known species, and species that are threatened or endangered (Loomis and White 1996; Mahoney 2009; Martin-Lopez, Montes, and Benayas 2008; Amuakwa-Mensah, Barenbold, and Riemer 2018). For example, U.S. household willingness to pay for enhancing or preserving fish species can vary from approximately $10 to $100 per household per year (Richardson and Loomis 2009; Rudd, Andres and Kilfoil 2016). There are no known surveys of value for amphibians, but several less iconic species such as the Palouse giant earth worm and the Riverside fair shrimp have been valued by U.S. households in the range of $15 to $35, or more, per household per year (Stanley 2005) (Decker and Watson 2016; Loomis and White 1996; Martin-Lopez, Montes, and Benayas 2008).

These two species may be similar to the OSF in that they are not iconic but may be symbols of preservation of a particular ecosystem.

While the literature does not include willingness-to-pay surveys specific to the Deschutes Basin, watershed and habitat protection is important to basin residents. In a 2009 survey of 400 randomly selected Deschutes County voters, 79% or more of respondents indicated an importance level of extremely important or very important for protecting wildlife habitat, protecting natural areas, and protecting natural watersheds (The Trust for Public Land 2010). Furthermore, there are many outdoor recreation tourists to the study area, and visitors tend to have relatively higher values (compared to local residents) for preservation of ecosystems and species in the areas they visit (Richardson and Loomis 2009) (Amuakwa-Mensah, Barenbold, and Riemer 2018). The Confederated Tribes of the Warm Springs Tribes also have special interest in and values for species and habitat preservation in the study area. In summary, effects on plant, fish, and wildlife species and habitat under the no-action alternative would affect socioeconomic values. As the biological effects may be adverse, the effects on socioeconomic value effects may also be adverse.

Per Section 3.6, *Aesthetics and Visual Resources*, effects on visual quality would not be adverse under the no-action alternative. As such, there are no expected adverse effects on the enjoyment and value to people of visual resources, and no associated adverse effects on property values in the vicinity.

To the extent that district water conservation measures under no-action alternative enhance water supplies to suburban/urban uses in dry water years, there would be a slightly beneficial effect on suburban/urban uses. Climate change, which may reduce irrigation water supplies over time, may partially or wholly offset these beneficial effects. As such, there may possible beneficial or adverse effects on urban/suburban irrigation water uses relative to existing conditions.

Continuation of existing water management operations would result in no change to the amount and timing of water flows through hydroelectric facilities. However, climate change over time, could change the amount and timing of water flows, with potential effect on the value of hydroelectric generation in the study area. Given the size of the wholesale energy market, potential shifts in hydropower generation in the study area is expected to have little to no effect on the price of electricity to study area residents. However, through time, changes in fuel prices and potential costs associated with carbon dioxide emissions associated with fossil-fuel powered electricity generation are projected to increase energy costs in the study area and throughout the Pacific Northwest (Northwest Power and Conservation Council 2016).

Agricultural production value in dry years may increase or decrease relative to existing conditions. This could potentially affect an agricultural property's SAV and associated property taxes. However, MSAV has historically been less than the SAV in study area counties (meaning that the assessed property value has been rising faster than the 3% maximum increase in MSAV) (Solice pers. comm.) If this continues to be the case throughout the analysis period, changes in water supplies and associated SAV would not affect property taxes (as changed in property taxes would be determined by MSAV and not SAV). Also, as noted above, property value effects, and associated property tax revenue effects, related to aesthetics are expected to be small. As such, there would likely be no substantial effect on local government fiscal conditions under no-action relative to existing conditions.

Relative to existing conditions, the no-action is expected to have little effect on socioeconomic resources with the exception of potential changes in economic opportunity related to agricultural production (due to potential effects associated with increased water conservation measures, climate

change, changes in crop mixture, and urban growth in agricultural areas as discussed in Section 3.5, *Land Use and Agricultural Resources*) and socioeconomic values associated with habitat/species conservation. These changes are expected to have no substantial effect on community way of life related to maintenance of farming/ranching, healthy ecosystems, and tribal resources.

Farm employment and income may increase or decrease, which may affect minority farm workers. Potential effects on cultural and economic values associated with species and habitat conservation, which also may be beneficial or adverse, would be experienced by the tribal members (an AIAN environmental justice population) of the Confederated Tribes of the Warm Springs (and other tribes outside the study area).

**Effect Conclusion:** Adverse effects related to increased electricity costs are expected through time under the no-action alternative. Adverse effects on fish, vegetation, and wildlife resources may result in adverse effects on socioeconomic values related to species and habitat conservation, as well as potential adverse effects on tribal environmental justice populations for whom fish and wildlife species are important resources. Possible beneficial to adverse effects are expected on social, cultural, and economic values related to economic opportunity, suburban/urban irrigation water costs, community way of life, and farmworker environmental justice populations. Effects on local government fiscal stability, aesthetic values (and associated property values), and recreation values are anticipated to be not adverse. Overall, depending on the severity of climate change impacts on fish and wildlife species and availability of water supplies, the socioeconomics effects would be adverse to not adverse.

### 3.9.3.1 Alternative 2: Proposed Action

This section describes potential effects on socioeconomic resources and values under the proposed action compared to the no-action alternative.

#### SOC-1: Affect Economic Opportunity (Employment and Income)

Changes in water storage and releases under the proposed action compared to the no-action alternative would affect instream flows for recreation and water available for irrigation diversions. If changes in recreation resources affect tourism spending in the study area or if changes in agricultural water supplies affect agricultural production in the region, economic opportunities could be affected. As described in Section 3.7, effects on recreational opportunities and use in rivers and creeks would not be adverse and could be beneficial in some locations, while recreation effects in Wickiup Reservoir could be adverse. Because the net effect on recreation would be not adverse, effects on outdoor recreation spending and the associated tourism economy are expected to be not adverse.

Estimated changes in economic opportunity generated by agriculture are summarized in Table 3.9-9. The potential change in annual jobs and income (direct, indirect, and induced) supported by forage/grain production are estimated for the same water year type, conservation scenario, and permit year. No effects are projected for wet water years.

The highest potential effects would be experienced in dry water years. In dry water years, agricultural production and associated economic contribution would decline 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, but no reduction in the high conservation scenario). Districts with reduced agricultural production value in dry water years may

include Arnold, Lone Pine, North Unit, and Tumalo (see Appendix 3.5-A for detailed results by district).[5] In a median water year under the low conservation scenario, Crook and Deschutes Counties are expected to experience minor reductions in the agricultural economy (less than 1% of the economic contribution of grain/forage production under the no-action alternative), while Jefferson County (North Unit ID) may experience a decline of up to 11% of total 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. Reductions in jobs and income are expected to peak in 2040 and then decline some by 2049. The table presents a reasonable range of potential long-term effects in the study area. Farm proprietors and farm workers producing grain/forage would be most affected by the proposed action and may experience economic hardship and economic dislocation from reduced income and employment opportunities. Farm operators often have substantial loan repayment obligations on farm equipment, land, and other capital and operating expenses that may be difficult to meet with reduced farm income, which could threaten the long-term viability of some farms. Also, as noted above, farmworkers are often low-income, and reduction in their employment and income potential in the study area would adversely affect a population that may be particularly economically vulnerable.

As effects are concentrated in the agricultural sector, on average across water year types, as a proportion of total economic activity at the county and study area levels, the effects represent less than 1% of total employment and earnings. However, in a few dry water years under the low conservation scenario (in and around 2030), reductions in Jefferson County would represent up to 1.4% of total employment and earnings. Effects in these years would be considered adverse because they are over 1%.

The analysis assumes all reductions in water supplies would affect the predominant forage/grain crops in the study area. However, in addition to grain and forage, higher value specialty crops such as peppermint, grass seed, and carrot seed are also grown in the study area, particularly in North Unit ID in Jefferson County, but also in Crook County (with very limited specialty crop acreage in Deschutes County). To the extent that high value crops are affected by changes in water supplies (i.e., 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), this analysis may underestimate impacts. As discussed in Appendix 3.5 (Table 42 and surrounding discussion), the largest potential economic impacts 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 assumption but provides an upper bound of potential total economic impacts for purposes of analysis. If farmers did not prioritize high value crops, total economic impacts on Jefferson County and Crook County gross agricultural production value and associated total jobs and income supported would be approximately double those presented in this

[5] Water supply modeling indicates that Ochoco ID would experience effects in very dry years (up to approximately 10% of years). Central Oregon ID is also projected to experience minor effects; however, the district anticipates that operational improvements would fully address these effects (Horrell pers. comm.). Also, subsequent to the impact analysis conducted for Lone Pine ID, Lone Pine increased the proportion of conserved water from a district piping project that would be retained for district use (thereby increasing water supplies to the district). As such, effects in Crook County may be slightly less than estimated.

section. However, the analysis expects economic impacts to be within the range presented in Tables 3.9-9, 3.9-10, and 3.9-11 based on effects on forage/grain crops, for the following reasons.

- Forage/grain crops account for approximately 80% of crop water usage in Jefferson and Crook County IDs (counties where nearly all specialty crops in the study area are grown, see Table 5 in Appendix 3.5-A).
- The high economic value per acre-foot (af) of water use provided by specialty crops relative to forage/grain crops gives farmers a strong economic incentive to apply all available techniques and resources to minimize effects on specialty crop acreage and yields.
- 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.
- Economic impacts are already presented as a range based on the low and high water conservation scenarios.
- 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).[6]

This analysis focuses on the change in agricultural production due to reduced water supplies, and how this change in production would affect employment and income in the study area. However, it is important to note that there would also be increased costs borne by farm producers that are not explicitly modeled in the analysis. First, no multi-year impacts are estimated. Forage crops are multi-year crops and reduced irrigation one year may affect crop yield the next year or may require additional cost if the crop needs to be re-established the subsequent year (before it would normally be re-established). Second, farmers may bear costs, such as additional weed control, associated with short-term fallowing or with fields that go dormant mid-way through the irrigation season. Such cost increases, combined with reduced income from agricultural production, could result in some farm operations becoming economically unviable and ceasing to operate. This in turn, could result in further reduced economic opportunity in the study area if sales of farms and subsequent integration of sold farms into other operations were to disrupt agricultural production in the short-term. However, as noted above, for Jefferson County where the projected economic opportunity effects are largest (based on reduced supply for North Unit ID), the dry water year supply conditions under the proposed action over the permit term are expected to be similar to the dry year impacts under existing conditions, so these types of impacts on farm viability are expected to be limited (i.e., if

[6] 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 af per year, but conserved water available to North Unit ID in Year 1 are estimated at 5,200 af 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 af per year, but conserved water available to North Unit ID in Year 6 are estimated at 18,200 af 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 af per year, but conserved water available to North Unit ID in Year 11 are estimated at 31,200 af 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 af per year, but conserved water available to North Unit ID in Year 1 is estimated at 49,000 af per year (low conservation scenario).

North Unit ID farms are viable under existing conditions, they are likely viable under proposed action conditions).

**Table 3.9-9. Range of Potential Change in Total Annual 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 (full- and part-time jobs) | 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.
Note: 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).

In interpreting impacts on economic contribution, such as those presented in Table 3.9-9, 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.

Also, similar to under the no-action alternative, depending on the funding mechanisms and level of infrastructure investments, irrigation district patron costs may rise to fund district and on-farm efficiency improvements, particularly in the high conservation scenario. These are an economic cost to the patrons. However, similar to under no-action, 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.

**Effect Conclusion:** Reductions in irrigation water availability under the proposed action compared to the no-action alternative would result in reductions in agricultural production and associated economic contribution. These reductions could represent an adverse effect on economic opportunity in Jefferson County in dry water years. Decreased employment and income opportunities in other counties would be less than 1% of total economic activity and are, therefore, considered not adverse compared to the no-action alternative.

### SOC-2: Affect Recreation Value

As described in Section 3.7, overall effects on recreational opportunities and use in rivers and creeks under the proposed action compared to the no-action alternative would be not adverse. These comprise beneficial effects in the Upper Deschutes River of more naturally appearing shoreline vegetation, more stable flows, and enhanced fish and wildlife habitat, a combination of beneficial and adverse effects on redband trout fishery, and adverse effects in Wickiup Reservoir due to projected lower reservoir levels and associated lower opportunities and use. Value to recreationists of a day spent fishing, boating, viewing wildlife, or swimming on both rivers and streams and reservoirs can be quite high. Economic studies of recreation value (i.e., value to the recreationist above any costs of the recreation trip) indicate an average of approximately $35 to $50 per day for water-based recreation to over $100 per day, depending on the type of activity and the quality of the experience (Loomis 2005).

**Effect Conclusion:** Because the net effect of the proposed action compared to the no-action alternative on recreation is anticipated to be not adverse, the overall effect on economic values of recreation is also expected to be not adverse, with possible slight increases and slight decreases in economic value for specific locations and activities.

### SOC-3: Affect Habitat and Species-Related Cultural and Economic Values

As described in Section 3.4, effects on plant and wildlife species (including the covered species) and their habitat in the study area under the proposed action compared to the no-action alternative would be mostly beneficial, but effects on fish habitat for several socioeconomically valuable species (bull trout, redband trout, spring Chinook salmon, and steelhead trout) may be adverse in some years. Adverse or beneficial effects on species and habitat would result in effects on cultural and economic values associated with species and habitat conservation. These effects would be particularly experienced by conservationists, tribal members, and local residents who value species and habitat conservation.

**Effect Conclusion:** Depending on the species and habitat type, there may be a net beneficial or net adverse effect on species and habitat; as a result, the effects on cultural and economic values associated with species and habitat conservation may be both adverse and beneficial. The overall effect (adverse, beneficial, or no adverse effect) on socioeconomic value associated with species and habitat conservation cannot be forecast reliably.

### SOC-4: Result in Aesthetic Changes Affecting Property Values

As described in Section 3.6, visual effects under the proposed action compared to the no-action alternative would be beneficial in the Deschutes River reaches and to a lesser extent at Crane Prairie Reservoir, and adverse at Wickiup Reservoir. In all other portions of the study area there would be no effect on visual resources. Visual quality affects enjoyment and value of visual resources to

people, which in turn can affect adjacent residential and retail business property values. Adverse effects on the visual quality at Wickiup Reservoir would have little to no effect on property values because of the lack of residential and retail business properties adjacent to the reservoir. Beneficial effects on visual quality in other parts of the study area could result in a slight increase in value (slight beneficial effect) for adjacent residential and retail business properties.

**Effect Conclusion:** Adverse effects on scenic resources at Wickiup Reservoir would have little to no effect on property values under the proposed action compared to the no-action alternative due to lack of adjacent private properties. Possible beneficial effects on scenic resources in other parts of the study area could result in a slight beneficial effect on adjacent private properties, as reflected in potential increases in property value. Overall, the proposed action would have slight beneficial effects on property values compared to the no-action alternative.

### SOC-5: Affect Urban/Suburban Water Supply Availability and Costs

As described in Section 3.2, the availability of water for the City of Prineville under the proposed action compared to the no-action alternative would be unchanged. However, reductions in district irrigation water diversions could reduce the availability of water for suburban and urban users that depend on district water to irrigate residential lawns, golf courses, parks, and other areas. However, as described in Appendix 3.5-A, the analysis models all reductions in water supply as solely affecting forage/grain crop production such that urban/suburban water users may be kept whole through in-district water trading or other mechanisms.

Reductions in irrigation water diversions would be most likely to affect urban/suburban uses in Arnold ID, although in very dry water years, urban/suburban users may be affected in Ochoco ID as well. Residential users may experience an increase in water supply costs if they obtain water from the City of Bend (Griffiths pers. comm.), or alternatively, they may experience a decrease in landscape aesthetics. Golf course irrigators may also face increased water costs. The Bend Country Club and The Back Nine Golf Course currently receive all irrigation water from Arnold ID. If Arnold ID water deliveries are reduced to a point where alternative supplies are necessary, the cost could be as high as five times current costs (Wyse pers. comm.) Invoking currently held groundwater permits would also come at a financial cost due to capital infrastructure requirements (Keller pers. comm.).

**Effect Conclusion:** Reduced irrigation diversions under the proposed action compared to the no-action alternative, particularly in dry water years, may have an adverse effect on availability and cost of water for urban/suburban users of district irrigation water, particularly in Arnold ID.

### SOC-6: Affect Hydropower Production and Energy Costs

Total annual flows on the Deschutes and Crooked Rivers under the proposed action compared to the no-action alternative would be unchanged; therefore, total hydropower generation at the Pelton–Round Butte Project and the Opal Springs Dam would not be affected. However, the change in timing of flows could affect the value of generation because average electricity prices differ between months. Wholesale electricity rates in the Mid-Columbia region (which includes Central Oregon) tend to be at their highest in July and August and at their lowest in March and April. Average prices during the highest month ($43 per MWh in August) are more than double the average price in the lowest month ($17 per MW in March). As such, increasing winter flows and decreasing summer flows would likely cause a net decrease in the value of hydropower generation and a net decrease in

the supply of electricity during high demand summer months. Given the size of the wholesale energy market, this shift in timing of hydropower generation is expected to have no effect on the price of electricity to study area residents.

Reductions in diversions to irrigation districts with in-line hydropower production (such as Central Oregon ID and Swalley ID) may reduce total district hydropower production, and associated revenues to districts. However, as these districts are expected to experience no to small changes in irrigation water availability, no substantial effect on district hydropower generation and associated revenues is expected.

**Effect Conclusion:** Shifts in timing of hydropower production at Pelton-Round Butte and Opal Springs Dam and small effects on district hydropower generation under the proposed action compared to the no-action alternative would have no substantial effect on energy costs or reliability in the study area. Therefore, effects are considered not adverse.

### SOC-7: Change Local Government Fiscal Conditions

Agricultural production value is expected to decrease under the proposed action relative to no-action alternative in dry years and to a lesser extent, in median years, in the study area. Decreased average annual production value would tend to decrease an agricultural property's SAV and associated property taxes. SAV would occur if a property were moved from irrigated to dryland farming (Langton pers. comm.), and SAV may also be affected to some extent due to short-term or infrequent reductions in irrigation deliveries. However, as no changes in irrigation delivery are expected in wet years, and nearly full irrigation water supply would be delivered to nearly all lands during the initial months of the irrigation season (April and May) even in dry years, no lands are expected to be permanently moved from irrigated to dryland status, limiting the effect on SAV and associated property taxes.

Moreover, MSAV has historically been less than the SAV in study area counties (meaning that the assessed property value has been rising faster than the 3% maximum increase in MSAV) (Solice pers. comm.). As such, MSAV has been the basis for property taxes in the area, not SAV. If this continues to be the case throughout the permit term, then changes in water supplies and associated SAV would not affect property taxes (as increases in property taxes would be limited by the annual 3% increase in MSAV).

To project the potential change on property tax rates, this analysis assumes that SAV declines proportionately with the change in total average annual agricultural revenues, and that SAV is the basis for property tax assessment (and not MSAV). Even with these assumptions, there is very minor to no expected effect (0 to -0.1%) on total property tax receipts and overall local government fiscal stability, as shown in Table 3.9-10. Only if the change in agricultural production value were approximately 10 times greater than projected, and this change was wholly reflected in reduced property taxes, would the effect on local property tax receipts be substantial and adverse (i.e., greater than 1%). This is primarily for two reasons: (1) projected change in average annual agricultural production is small as a proportion of total county agricultural production (as estimated in the 2017 Census of Agriculture), and (2) the contribution of agricultural lands to property taxes is relatively small (11% or less) for each county in the study area. Including potential beneficial effects on property values related to visual resources, there would likely be no substantial effect on local government fiscal conditions under the proposed action compared to the no-action alternative.

**Table 3.9-10. Potential Property Value Effects by County**

| Description | Crook | Deschutes | Jefferson | Study Area |
|---|---|---|---|---|
| Average effect on total agricultural production value (Millions) | -$0.1 to -$0.2 | -$0.1 to -$0.4 | -$0 to -$4.1 | -$0.4 to -$4.6 |
| 2017 Total agricultural production value (Millions) | $44.6 | $28.8 | $67.4 | $140.8 |
| % Effect on total agricultural production value | 0 to -0.4% | -0.5 to -1.3% | 0 to -6.0% | 0 to -3.3% |
| % Property tax revenue from agricultural/ forestry lands | 11% | 2% | 10% | 3% |
| % Effect on total property tax receipts | 0% | 0 to -0.1% | 0 to -0.1% | 0 to -0.1% |

Sources: Highland Economics analysis, 2017 Census of Agriculture (National Agricultural Statistics Service 2019); Deschutes County 2018; Jefferson County 2018; Huber, Christofferson and Ott 2017.

**Effect Conclusion:** Decreased agricultural production value under the proposed action compared to the no-action alternative may decrease agricultural property value in the study area, which may decrease agricultural property taxes. However, effects on local government fiscal conditions would be not adverse because the projected change in average annual agricultural production is small as a proportion of total county agricultural production, and the contribution of agricultural lands to property taxes is also relatively small.

## SOC 8: Affect Social Values Associated with Community Character and Way of Life

As described in Table 3.9-2, the proposed action could most greatly affect community character and way of life through changes in recreation and land/use agricultural resources. Overall effects on the diversity, abundance, and quality of overall recreational opportunities and use in rivers and creeks under the proposed action compared to the no-action alternative, as described in Section 3.7, would not be adverse overall. As such, recreation-related effects on community way of life are considered not adverse.

Way of life and community character may be adversely affected if ranches and farms are no longer viable in the study area, or if farms can support fewer livestock, which could change the rural character of the area and the way of life of local ranchers and farmers. Farms are expected to be able to purchase livestock feed from other local sources to offset the reduction in on-farm forage production (as Central Oregon currently exports forage [Bohle pers. comm.], and as the proportion of total forage/grain crops produced in the study area is expected to drop by a maximum of 13% in any given year compared to the no-action alternative). However, farmers facing reduced forage/grain yields would face decreased profits, increased livestock feed costs (through purchase of hay to replace reduced forage production), and likely other costs associated with maintaining dormant hay or fallow fields (such as weed control). For farms that are operating on thin profit margins, or that are highly sensitive to feed cost increases, this may result in the proprietor having to cease farming. This, in turn, may result in changes in farm ownership, increased farm consolidation (small farms purchased by larger farms), or potential long-term fallowing of lands. Reduced agricultural production is also expected to result in reduced agricultural employment opportunities, which would adversely affect farmworkers and communities dependent on agricultural work.

**Effect Conclusion:** Because the net effect on recreation under the proposed action compared to the no-action alternative would be not adverse, effects on community way of life related to recreation are considered not adverse. However, effects on way of life of farmers and ranchers and community character under the proposed action compared to the no-action alternative could be adverse if some ranches and farms are no longer economically viable in the study area or if farms can support fewer livestock.

#### SOC 9: Affect Environmental Justice Populations

There are no expected environmental hazards that would result from the proposed action. However, the proposed action is expected to have potential ecological and economic effects compared to the no-action alternative that would be experienced by low income and/or minority populations. Effects on cultural and economic values associated with species and habitat conservation would be experienced by the tribal members (an AIAN environmental justice population) of the Confederated Tribes of the Warm Springs (and other tribes outside the study area), conservationists, and others who value species and habitat conservation. These effects are expected to be both beneficial and adverse. However, due to the importance of fishery resources to the Tribes, since effects on some fishery resources are expected to be adverse (while effects on vegetation and wildlife are expected to be beneficial), the overall species and habitat conservation effect on the Tribes could be adverse.

Potential decreases in farm employment and income opportunities would affect farm operators and farm workers. While farm operators are mostly white, farm workers are mostly minority. Effects on the farm economy would likely represent a disproportionately high and adverse effect on environmental justice populations.

**Effect Conclusion:** Due to expected adverse effects on some fishery resources (which may be partially offset by expected beneficial effects on wildlife and vegetation) under the proposed action compared to the no-action alternative, an adverse effect on cultural and economic values associated with species and habitat conservation may be experienced by the tribal members (an AIAN environmental justice population) of the Confederated Tribes of the Warm Springs (and other tribes outside the study area). Reduced agricultural income and employment opportunities would result in negative economic impacts on minority and low-income farmworkers, which could appreciably exceed those experienced by the general population. Therefore, effects on cultural and economic values associated with species and habitat conservation and the farm economy could represent disproportionately high and adverse effects on environmental justice populations.

### 3.9.3.2 Alternative 3: Enhanced Variable Streamflows

This section describes effects on socioeconomic resources and values under Alternative 3 compared to the no-action alternative. Where effects are the same or nearly the same as described for the proposed action, the description of effects under the proposed action are referenced for brevity.

#### SOC-1: Affect Economic Opportunity (Employment and Income)

Effects under Alternative 3 compared to the no-action alternative would be similar to those described for the proposed action but would differ slightly due to the acceleration of implementation (Table 3.1-1). Table 3.9-11 summarizes the estimated potential change in annual jobs and income (direct, indirect, and induced) supported by forage/grain production under Alternative 3 compared to the no-action alternative for the same water year type, conservation

scenario, and permit year. The distribution of impacts across districts, counties, water year types, permit years, and conservation scenarios are similar to the proposed action. The primary difference is slightly higher effects in Jefferson County (North Unit ID) in a dry year, but slightly lower effects in Jefferson County in a median water year.

Similar to the proposed action, on average, as a proportion of total economic activity at the county and study area levels, reduction in total employment and earnings under Alternative 3 compared to the no-action alternative would be less than 1%. However, in a few dry water years (around year 2030), employment and income would be reduced by up to 1.4% in Jefferson County under the low water conservation scenario. Effects in these years would be considered adverse because they are over 1%.

**Table 3.9-11. Potential Change in Total Annual 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 | 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.
Note: 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).

**Effect Conclusion:** Reductions in irrigation water availability under Alternative 3 compared to the no-action alternative would result in reductions in agricultural production and associated economic contribution. These reductions could represent an adverse effect on economic opportunity in Jefferson County in dry water years. Effects in other counties would be less than 1% of total economic activity and are therefore considered not adverse.

### SOC-2: Affect Recreation Value

Effects on recreation from changes in the storage and release of water under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action but would occur earlier in the permit term. Effects would be not adverse compared to the no-action alternative.

### SOC-3: Affect Habitat and Species-Related Cultural and Economic Values

Net effects on species and habitat under Alternative 3 compared to the no-action alternative would be similar to those described for the proposed action but would occur earlier in the permit term. The overall effect (adverse, beneficial, or no adverse effect) on socioeconomic value associated with species and habitat conservation cannot be forecast reliably.

### SOC-4: Result in Aesthetic Changes Affecting Property Values

Adverse effects on scenic resources at Wickiup Reservoir under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action and would have little to no effect on property values due to lack of adjacent private properties. Possible beneficial effects on scenic resources in other parts of the study area under Alternative 3 compared to the no-action alternative would also be the same as described for the proposed action with slight beneficial effects on adjacent private property value. Because improved aesthetic changes related to vegetation growth would occur earlier under Alternative 3 than the proposed action, they would have more time to mature and could have slightly more beneficial effects on property values. Overall, Alternative 3 would have a slight beneficial effect on property values compared to the no-action alternative.

### SOC-5: Affect Urban/Suburban Water Supply Availability and Costs

Reduced irrigation diversions and associated effects on availability and cost of water for urban/suburban users under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action. However, because these effects would occur earlier in the permit term than under the proposed action, they may be of greater magnitude on average due to reduced time available to implement water conservation projects. The effect would be adverse compared to the no-action alternative.

### SOC-6: Affect Hydropower Production and Energy Costs

Shifts in timing of hydropower production at Pelton-Round Butte and Opal Springs Dam and small effects on district hydropower generation under Alternative 3 compared to the no-action alternative would be nearly the same as those described for the proposed action but would occur earlier in the permit term. Effects on energy costs and reliability in the study area would be small and would, therefore, be not adverse compared to the no-action alternative.

### SOC-7: Change Local Government Fiscal Conditions

Decreased agricultural production value and potential associated decreases agricultural property value and property taxes would be similar to those described for the proposed action. However, these effects would occur earlier in the permit term and be larger on average through the permit term due to reduced time to implement conservation measures. Because the reduction in taxes

collected would be relatively small, the effect would be not adverse compared to the no-action alternative.

#### SOC 8: Affect Social Values Associated with Community Character and Way of Life

Effects on recreation resources and associated effects on community way of life under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action but would occur earlier in the permit term. Because the net effect on recreation under Alternative 3 compared to the no-action alternative would be not adverse, effects on recreation-related effects on community way of life are considered not adverse.

Effects on the way of life of farmers and ranchers and community character under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action, but the potential an adverse effect is slightly greater under this alternative due to the reduced time to implement conservation measures.

#### SOC 9: Affect Environmental Justice Populations

Potential adverse effects on cultural and economic values associated with species and habitat conservation experienced by tribal members (an AIAN environmental justice population) of the Confederated Tribes of the Warm Springs (and other tribes outside the study area) under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action but would occur earlier in the permit term.

Effects on minority and low-income farmworkers under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action but of greater magnitude due to reduced time to implement water conservation projects. Effects on cultural and economic values associated with species and habitat conservation and the farm economy could represent a disproportionately high and adverse effect on environmental justice populations.

### 3.9.3.3 Alternative 4: Enhanced and Accelerated Variable Streamflows

This section describes effects on socioeconomic resources and values under Alternative 4 compared to the no-action alternative. Where effects are the same or nearly the same as described for the proposed action, the description of effects under the proposed action are referenced for brevity.

#### SOC-1: Affect Economic Opportunity (Employment and Income)

Effects under Alternative 4 compared to the no-action alternative would be similar to those described for the proposed action, but would result in greater declines in estimated jobs and income supported by agricultural production, particularly for Jefferson County. Table 3.9-12 summarizes the estimated potential change in annual jobs and income (direct, indirect, and induced) supported by forage/grain production under Alternative 4 compared to the no-action alternative for the same water year type, conservation scenario, and permit year. The primary difference is more adverse effects in dry water years, with Jefferson County experiencing up to 50% reduction in the economic contribution of forage/grain production, Crook County experiencing up to a 3% reduction, and Deschutes County experiencing up to a 6% reduction.

Similar to the proposed action and Alternative 3, on average, as a proportion of total economic activity at the county and study area levels, reduction in total employment and earnings would be

less than 1%. However, throughout the permit period in dry water years, employment and income would be reduced by up to 2% in Jefferson County. As in Alternative 3, effects in these years would be considered adverse because they are over 1%. Adverse effects in Jefferson County would be higher under Alternative 3 than under Alternative 4.

**Table 3.9-12. Potential Change in Total Annual 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.
Note: 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).

**Effect Conclusion:** Reductions in irrigation water availability under Alternative 4 compared to the no-action alternative would result in reductions in agricultural production and associated economic contribution. In all counties, effects would be larger than under the proposed action and Alternative 3. These reductions could represent an adverse effect on economic opportunity in Jefferson County in dry water years. Effects in other counties would be less than 1% of total economic activity and are therefore considered not adverse.

### SOC-2: Affect Recreation Value

Effects on recreation from changes in the storage and release of water under Alternative 4 compared to the no-action alternative would be similar to those described for the proposed action but would

occur earlier in the permit term than under the proposed action or Alternative 3. Effects would be not adverse compared to the no-action alternative.

### SOC-3: Affect Habitat and Species-Related Cultural and Economic Values

Net effects on species and habitat under Alternative 4 compared to the no-action alternative would be similar to those described for the proposed action, though effects would occur earlier in the permit term than under the proposed action or Alternative 3, and the magnitude of both beneficial and adverse effects would be greater and would result in greater effects on cultural and economic values associated with species and habitat conservation. The overall effect (adverse, beneficial, or no adverse effect) on socioeconomic values associated with species and habitat conservation cannot be forecast reliably.

### SOC-4: Result in Aesthetic Changes Affecting Property Values

Adverse effects on scenic resources at Wickiup Reservoir under Alternative 4 compared to the no-action alternative would similar to but of slightly greater magnitude than those described for the proposed action; however, these effects would have little to no effect on property values due to lack of adjacent private properties. Possible beneficial effects on scenic resources in other parts of the study area under Alternative 4 compared to the no-action alternative also would be similar to but of slightly greater magnitude than those described for the proposed action, with slight beneficial effects on adjacent private property values. Although changes in water management associated with improved aesthetic changes related to vegetation growth would occur earlier under Alternative 4 than the proposed action or Alternative 3, they would end sooner. Overall, Alternative 4 would have a slight beneficial effect on property values compared to the no-action alternative.

### SOC-5: Affect Urban/Suburban Water Supply Availability and Costs

Reduced irrigation diversions and associated effects on availability and cost of water for urban/suburban users under Alternative 4 compared to the no-action alternative would be similar to but of greater magnitude than those described for the proposed action, in part due to reduced time to implement water conservation projects. The effect would be adverse compared to the no-action alternative.

### SOC-6: Affect Hydropower Production and Energy Costs

Shifts in timing of hydropower production at Pelton-Round Butte and Opal Springs Dam and small effects on district hydropower generation under Alternative 4 compared to the no-action alternative would be similar to but of slightly greater magnitude than described for the proposed action. These effects would occur earlier but for a shorter duration under Alternative 4 than under the proposed action or Alternative 3. Effects under Alternative 4 compared to the no-action alternative would be small and would, therefore, be not adverse.

### SOC-7: Change Local Government Fiscal Conditions

Decreased agricultural production value and potential associated decreases agricultural property value and property taxes under Alternative 4 compared to the no-action alternative would be similar to but slightly greater than described for the proposed action due to reduced time to implement water conservation projects. These effects would occur earlier in the permit term than

under the proposed action or Alternative 3. Because the reduction in taxes collected under Alternative 4 compared to the no-action alternative would be relatively small, the effect would be not adverse compared to the no-action alternative.

### SOC 8: Affect Social Values Associated with Community Character and Way of Life

Effects on recreation resources and associated effects on community way of life under Alternative 4 compared to the no-action alternative would be similar to those described for the proposed action but would occur earlier and end sooner than the proposed action and Alternative 3 and would be greater on average due to reduced time to implement water conservation projects. Because the net effect on recreation under Alternative 4 compared to the no-action alternative would be not adverse, effects on community way of life related to recreation are considered not adverse.

Effects on the way of life of farmers and ranchers and community character under Alternative 4 compared to the no-action alternative would be similar to but of slightly greater magnitude than described for the proposed action because of a greater reductions in water supply and reduced time to implement water conservation projects.

### SOC 9: Affect Environmental Justice Populations

Potential adverse effects on cultural and economic values associated with species and habitat conservation experienced by tribal members (an AIAN environmental justice population) of the Confederated Tribes of the Warm Springs (and other tribes outside the study area) under Alternative 4 compared to the no-action alternative would be similar to those described for the proposed action but would occur earlier in the permit term than under the proposed action or Alternative 3.

Effects on minority and low-income farmworkers under Alternative 4 compared to the no-action alternative would be similar to but of greater magnitude than those described for the proposed action or Alternative 3 due to reduced time to implement water conservation projects. Effects cultural and economic values associated with species and habitat conservation and on the farm economy could represent a disproportionately high and adverse effect on environmental justice populations.

# 3.10 Cultural Resources

This section describes the affected environment for cultural resources and effects on cultural resources that would result from the proposed action and alternatives. Cultural resources here specifically relate to archaeological resources as well as buildings, structures, and objects per 36 CFR 800.

## 3.10.1 Methods

For the purposes of this NEPA analysis, the study area for cultural resources is defined as the areas where changes in storage and release of water under the proposed action and alternatives could affect cultural resources as a result of erosion and water level fluctuation. Although erosion and water level fluctuation occur under existing conditions throughout the covered waters and would continue to occur under the no-action alternative, Wickiup Reservoir is the only location where operations are known to affect cultural resources under existing conditions. Moreover, based on review of the RiverWare model results (Section 3.2, *Water Resources*), Wickiup Reservoir also is the location where changes in water levels under the proposed action and Alternatives 3 and 4 would be greatest compared to the no-action alternative. Water level fluctuation in the other reservoirs would be comparatively small.[1] As such, the study area for cultural resources was limited to Wickiup Reservoir.

Table 3.10-1 shows the amount of fluctuation in reservoir water levels (difference between minimum and maximum) for the modeled wet, normal, and dry year total volumes for Wickiup Reservoir. To assess the level of possible fluctuation, historical total annual volume data was ranked (acre-feet) and then the years corresponding to the wet, normal, and dry water year types in terms of total volumes were selected. The daily volume data for each of those years was then plotted for the proposed action and alternatives. The proposed action and Alternatives 3 and 4 were assessed at full implementation of fall/winter flows downstream of Wickiup Reservoir (Table 3.1-1). These differences are used here as a proxy for assessing the amount of potential disturbance and the amount of land exposed in each volume scenario and each alternative.

**Table 3.10-1. Changes in Water Surface Elevation (feet) in the Wet, Normal, and Dry Water Year at Wickiup Reservoir under the Proposed Action and Alternatives**

| Scenario | No-Action Alternative | Proposed Action (Years 21–30) | Alternative 3 (Years 11–30) | Alternative 4 (Years 6–20) |
|---|---|---|---|---|
| Wet Year | 2.82 | 1.30 | 1.30 | 4.63 |
| Normal Year | 43.95 | 20.21 | 20.21 | 19.70 |
| Dry Year | 45.34 | 22.85 | 22.85 | 21.60 |

[1] Changes in average median water surface elevations under the proposed action and Alternatives 3 and 4 compared to the no-action alternative would be less than 1 foot in Crane Prairie, Crescent Lake, Prineville, and Ochoco Reservoirs (Appendix 3.2-A, *Water Resources Technical Supplement*).

The description of the existing conditions for cultural resources in the study area was based on an initial archaeologist review of the Archaeological Inventory Database managed by the Oregon State Historic Preservation Office (SHPO) to identify previously documented archaeological, ethnographic, and historic-period resources within the study area and a 0.25-mile radius around it. The database contains 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. Results of this record search are included in Appendix 3.10-A, *Literature Review*. 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 the alternatives impact analysis. Additionally, some archaeological sites with poorly defined boundaries may extend into the area that would typically be submerged.

The Confederated Tribes of Warm Springs Tribal Historic Preservation Officer was contacted at the direction of FWS regarding tribal knowledge of archaeological resources in the vicinity of the study area. Tribal archaeologist Christian Nauer noted that he had no specific information on archaeological sites in the vicinity of Wickiup Reservoir but that there were many sites in the vicinity of the reservoir and that the areas surrounding the reservoir are important gathering and fishing locations (Nauer pers. comm.).

The greatest impacts on archaeological sites comes from movement of water and its effects on artifact distribution through transport of artifacts and erosion (i.e., natural site disturbance) and exposure of sites for human access (i.e., human site disturbance), which can lead to either looting or displacement of artifacts. Therefore, the analysis of potential impacts of the EIS alternatives focus on fluctuation of water level and amount of land exposed during low water periods. Impacts would occur on sites that are already inundated or partially inundated as well as sites that may be newly inundated by increased water surface elevations. Impacts were considered to have potential to occur within approximately 100 meters of average water surface elevations.

Analysis of reservoir storage capacity under the proposed action and alternatives, described in Section 3.2, was used as a proxy for understanding the amount of land exposed over the analysis period (e.g., if storage is decreased, more previously submerged land is exposed).

The dam at Wickiup Reservoir, as well as the associated infrastructure, constitute cultural resources that meet the minimum age criteria for consideration under federal regulations. However, no impacts on these resources are anticipated; thus, they are not considered further in the analysis. Similarly, other historic-era irrigation, transportation, or other cultural features not located within approximately 100 meters of average water surface elevation at Wickiup Reservoir are not considered in the analysis. Cultural resource isolates[2] identified in the study area are generally not considered in the analysis. Some of these isolates may be archaeological sites but have not been further assessed.

[2] An Isolated Find in Oregon is defined as one (1) to nine (9) artifacts discovered in a location that appears to reflect a single event, loci, or activity (Oregon SHPO n.d.).

For the purposes of this NEPA analysis, effects of the proposed action and alternatives on cultural resources would be considered adverse if implementation would result in any of the following conditions.

- Affects an archaeological resource that includes human remains.
- Affects an archaeological resource that has been determined to be eligible for listing in the NRHP.
- Affects an archaeological resource that is potentially eligible for the listing in the NRHP.

## 3.10.2 Affected Environment

This section describes the environment for cultural resources in the study area that could be affected under the proposed action or alternatives.

### 3.10.2.1 Natural Setting

The study area vicinity includes portions of three regional geologic provinces, including the Western Cascades, High Lava Plains, and the Blue Mountains (Franklin and Dyrness 1988). Common geologic landform types for the Western Cascades include volcanic peaks, glacially carved valleys, and lava flows. Many of these landforms formed between the Pliocene epoch (5.3 million to 2.6 million years before present) and the present (Franklin and Dyrness 1988; O'Connor et al. 2003). Common geologic landform types of the High Lava Plains include lava flows, cinder cones, and the playa lakebeds; formed during the same approximate period as the common landform types located in the Western Cascades (Franklin and Dyrness 1988; O'Connor et al. 2003). Common geologic landform types for the Blue Mountains include uplifted bedrock hills and glacially carved valleys. Uplift in the region appears to have started after the Miocene epoch (23 million to 5.3 million years before present [BP]), while the glacially carved valleys formed during the Pliocene and Pleistocene epochs (Walker 1990). For all three geologic provinces, sediments have been deposited along stream banks, lake shorelines, and as dunes during the Holocene epoch (Madin 2009). These Holocene aged deposits, particularly alluvium have the potential to contain or overlie deeply buried archaeological deposits. Combined, these geologic attributes provided widely distributed and a broad range of raw materials for the production of stone tools, caves and rock shelters for habitation, and introduced the potential for buried archaeological sites in areas where Holocene-aged sediments are present.

The study area contains a diverse array of plant and animal resources across a range of environments that would have been used during the precontact era. The three geologic provinces in the vicinity of the study area contain a complex mix of vegetation zones, including the forested *Pinus ponderosa* (Ponderosa pine), the Shrub-Steppe (with *Artemisia tridentate* [big sagebrush]) zone, and the *Juniperus occidentalis* (western juniper) variant of the Shrub-Steppe zones. The portion of the Ponderosa pine zone located in the study area is located along the eastern flanks of the Cascades (Franklin and Dyrness 1988). In addition to containing Ponderosa pine, overstory plants commonly associated with this zone include western juniper, *Populus tremuloides* (quaking aspen), *Pinus contorta* (lodgepole pine), and *Quercus garryana* (Gary oak). Understory shrubs of potential food value include *Prunus virginiana* (chokecherry), *Rosa* sp. (wild rose), *Berberis repens* (creeping Oregon grape), and various grasses and forbs (Franklin and Dyrness 1988; Coupe et al. 1999). Shrub Steppe (with Artemisia tridentate) vegetation zones commonly contain abundant big sagebrush, as well as *Agropyron spicatum* (bluebunch wheatgrass) and *Poa sandbergii* (Sandberg bluegrass). The western juniper variant of the Shrub-Steppe zone is similar to the Shrub Steppe (with Artemisia

tridentate), but also includes western juniper as a major plant constituent (Franklin and Dyrness 1988). These vegetation zones provide habitat for a range of terrestrial fauna. Notable terrestrial fauna of potential food value include *Ovis Canadensis* (bighorn sheep), *Odocoileus hemionus* (mule deer), *Marmota flaviventris* (yellow-bellied marmot), *Spermophilus* sp. (ground squirrels), *Sylvilagus nuttallii* (mountain cottontail), and *Lepus* sp. (jackrabbits) (Eder 2002).

### 3.10.2.2 Cultural Setting

Wickiup Reservoir is located on the edge of two distinct cultural areas, the Columbia Plateau and the Great Basin (Aikens et al. 2011; Steward 1938). The Great Basin is home to some of the oldest and most well studied archaeological sites in Oregon, indicating that the area has been in use by humans for at least the last 14,000 years (Jenkins et al. 2012).

Academic study of archaeological sites from both the Columbia Plateau and Great Basin have resulted in the development of several cultural chronologies that illustrate how precontact patterns of land use change over time. These cultural chronologies are academic constructs and do not reflect Native American views. No detailed cultural chronology has been developed specifically for the study area. Following are brief summaries of two commonly-used cultural chronologies for the Columbia Plateau (Ames et al. 1998) and the Great Basin (Bedwell and Cressman 1971).

Cultural developments on the Columbia Plateau are commonly divided into three periods, including Period I (11,500 to 7000 years BP), Period II (7,000 to 4,000 years BP), and Period III (4000 to around 250 years BP). The transition between these periods are characterized by successive decreases in the mobility of the region's inhabitance and a concomitant increased reliance on aquatic resources and stored food, semi-permanent housing, as well as the appearance of trade goods during Period III (Ames et al. 1998). Toward the end of Period III, horses were introduced into the region. This drastically changed the mobility and subsistence patterns of the region's precontact inhabitants, who became more seasonally mobile, covered a larger area during periods of mobility, and focused on collecting a smaller range of resource types (Walker 1998).

The development of cultural chronologies in the northern Great Basin has been limited, with one of the most commonly used chronologies developed by Bedwell and Cressman (1971). This chronology divides the cultural developments in the northern Great Basin into four units, including Period 4 (14,000 to 11,000 years BP), Period 3 (11,000 to 8,000 years BP), Period 2 (8000 to 7000 years BP), and Period 1 (5000 to around 250 years BP). There is a 2,000 year hiatus in this period between 7000 and 5000 years BP, which correlates to a period during which there is limited archaeological evidence of human use of the region. This hiatus occurs around the time of the eruption of Mount Mazama and the desiccation of several lakes in the region. The transition between these periods is largely based on changes in ***lithic*** (stone tool) technology observed in the archaeological record over time. In general, projectile points appears to have decreased in size over time, and generally transitioned from large fluted projectile points to smaller points (Bedwell and Cressman 1971). Notably, the Great Basin is home to some of the oldest and most well studied archaeological sites in Oregon, indicating the that area has been in use by humans for at least the last 14,000 years (Jenkins et al. 2012).

Early archaeological work in the study area, as in much of Oregon, was conducted by Luther Cressman. Two notable sites, the Wickiup Dam Site No. 1 and the Odell Lake Site (Cressman 1937, 1948), identified cultural deposits underlying 7000-year-old tephra attributed to the eruption of Mount Mazama. Subsequent investigations of the region have identified numerous archaeological

sites dating to the Middle and Late Holocene epoch—primarily lithic scatters in reservoir settings (Oetting 2012)—where ground surface visibility is excellent. The context in which most of the archaeological sites in the region have been discovered, in reservoirs, indicates that archaeological sampling methods and logistical factors associated with ground surface visibility may be influencing the known distribution of archaeological sites in the region.

Several groups, including the Tenino, the Northern Paiute, and the Molala used this study area prior to Euro-American contact, and traditionally, tribes like the Klamath also have connections to the region (Walker and Lipscomb 1989). Each of the groups who inhabited the area practiced substantially different lifeways (Steward 1938). River and marsh systems, like those that would have been located in the study area, were important sources of food resources and raw materials and would have been the focus of seasonal resource harvests.

The first Euro-Americans to enter the territory were fur traders and trappers in the early 1800s. The Hudson's Bay Company began explorations into Central Oregon in 1825, and soon after, developers and settlers began to show growing interest in the area (Mulligan 1991). Through a series of treaties, tribes were 'cleared' off the land by the Superintendent of Oregon Joel Palmer. In the 1855 Treaty with Tribes of Middle Oregon (12 Stat. 963, 1859), the Warm Springs Tribes ceded title in millions of acres of land, reserved the approximately 640,000-acre Warm Springs Reservation, reserved the exclusive right of taking fish at all other usual and accustomed stations, and reserved rights to hunting, gathering, and pasturing on unclaimed land (Ruby and Brown 1986). By the time Oregon became a state in 1859, several large land grants were distributed to developers to begin settling the area and accessing the natural resources, primarily logging and fur trapping. The Oregon Central Military Wagon Road was commissioned in 1863 to allow goods to be more conveniently transported across the Cascades from Central and Southeastern Oregon (Merriam 1959). This increased transportation made agricultural use and natural resource extraction in Central Oregon.

By the early 1900s, the increase in population and the need for agricultural irrigation put significant strain on the Upper Deschutes Basin. In 1938, the construction of the Wickiup Reservoir and Dam began on the Deschutes River, an effort spearheaded by the Civilian Conservation Corps (Doncaster and Horting-Jones 2013). By the time it was completed in 1946, the reservoir was and remains the second largest in the state of Oregon. The dam and its reservoir were and remain critical for continued, large scale irrigation throughout the Deschutes Basin.

### 3.10.2.3 Previous Cultural Resource Investigations

A total of 30 cultural resource studies have been conducted within 0.25 mile of Wickiup Reservoir (Appendix 3.10-A). 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. There has been no systematic survey between high and low water surface elevations across the entire reservoir.

### 3.10.2.4 Previously Recorded Archaeological Resources

Some sites discussed in this section were recorded as submerged or partially submerged. The current state (exposed, partially submerged, submerged) of these sites is not known; for purposes of this analysis, the originally recorded state is used.

There have been 21 sites and 9 isolates identified within 0.25 mile of Wickiup Reservoir (Appendix 3.10-A). 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 2004a) and one multicomponent isolate (80-BRD-89). 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.

Two archaeological sites are completely submerged at Wickiup Reservoir (Table 3.10-2). Four previously recorded archaeological sites are partially submerged and 10 are located within 100 meters of the mapped pool level available on Oregon's SHPO database.

**Table 3.10-2. Archaeological Sites within 100 Meters of Waters of Wickiup Reservoir**

| Reservoir | Submerged | Partially Submerged | Within 100 Meters of Mapped Waterline |
|---|---|---|---|
| Wickiup | 35DS296, 35DS990<br>CCC Camp Wickiup | 35DS295, 35DS299, 35DS619, 35DS1640 | 35DS227, 35DS228, 35DS288, 35DS291, 35DS292, 35DS293, 35DS294, 35DS297, 35DS389, 35DS421 |

Two of the seven archaeological sites that are submerged or partially submerged by the waters in Wickiup Reservoir have been determined eligible for listing in the NRHP, the remaining five have not been evaluated for NRHP eligibility (Table 3.10-3). Both of the NRHP-eligible sites are associated with Native American land use in the region and consist of lithics, specifically ***debitage*** and formed tools. Of the remaining sites, three are exclusively Native American associated sites and one includes debitage, as well as items and features generally associated with Euro-American land use.

**Table 3.10-3. Submerged and Partially Submerged Archaeological Site Information at Wickiup Reservoir**

| Citation | Trinomial/ Forest Service Site Number | Site Type | Description | NRHP/WHR Eligibility Status |
|---|---|---|---|---|
| **Submerged Sites** | | | | |
| Appleby 1984b | 35DS296 | Precontact lithic material | Debitage | Determined eligible (Lipscomb 1996) |
| Lipscomb 1992 | 35DS990 | Precontact lithic material | Debitage | Unevaluated |
| Doncaster and Horting-Jones 2013 | None | Historic-era camp: CCC Camp | Historic-era debris | Unevaluated |
| **Partially Submerged Sites** | | | | |
| Appleby 1984c | 35DS295 | Precontact lithic material | Projectile point and debitage | Determined eligible (Mulligan 1991) |
| Appleby 1984d | 35DS299 | Precontact lithic material | Debitage | Unevaluated |
| Hatfield 1988 | 35DS619 | Precontact lithic material | Debitage | Unevaluated |
| Hickerson 2004b | 35DS1640 | Precontact lithic material and historic-period structure | Debitage, log cabin wall remnants, tin can | Unevaluated |

## 3.10.3 Environmental Consequences

The geographic setting of archaeological sites is an important piece of their value, as is the spatial relationship between artifacts within sites (Schiffer 1987). These two pieces of data (i.e., context) would be disturbed through natural processes that are ongoing in the reservoir. The flow of water and fluctuation of water levels has been demonstrated to move artifacts and archaeological deposits through direct transport and deflation of surfaces (i.e., erosion of soils).

### 3.10.3.1 Alternative 1: No Action

The effects of the no-action alternative are described in comparison to existing conditions.

Continuation of existing operations under the no-action alternative is anticipated to result in continuation of relatively low variability in Wickiup Reservoir elevations in wet years and high variability in drier years (Table 3.10-1).

Low water levels expose sediments at the bottom of the reservoir that are likely to contain archaeological sites. As noted, sites have been documented below historically documented minimum surface water elevations. This exposure provides increased access to archaeological sites and can lead to looting and disturbance by humans. Additionally, water level fluctuation leads to deflated soils and movement of artifacts. Although it is not possible to comment on the specific intensity of

these impacts because they act differently on different types of sites and artifacts, they would continue under the no-action alternative over the analysis period.

Climate change will affect environmental conditions at Wickiup Reservoir over the analysis period. It is anticipated that climate change will contribute to higher peak winter/spring flows and lower low summer flows compared to existing conditions (Halofsky et al. 2018). The timing of changes is not known, but by 2040, summer flows are anticipated to decrease by between 40 and 60%. Lower summer flows and higher winter/spring flows would lead to increased fluctuation in water flowing through the reservoir. This increased fluctuation would cause more natural disturbance but not necessarily lead to increased human access and associated disturbance of archaeological sites. Disturbance is likely to be incremental year on year but over the analysis period may result in dramatic changes to the sites.

**Effect Conclusion:** Continuation of existing operations of the reservoir under the no-action alternative is likely to result in continued exposure of and increased access to archaeological sites during low water that could lead to looting and disturbance and movement of artifacts from water level fluctuations over the analysis period. These effects could be adverse. Climate change could intensify the impacts related to water fluctuations.

### 3.10.3.2 Alternative 2: Proposed Action

The effects of the proposed action are compared to the no-action alternative.

**CUL-1: Naturally Transport and Disturb Archaeological Materials**

Wickiup Reservoir operations under the proposed action could disturb and expose sensitive archaeological resources that are known to occur in Wickiup Reservoir. Two of the archaeological resources (35DS295 and 35DS296) that are either submerged or partially submerged in the reservoir have been determined eligible for listing in the NRHP. Archaeological resource locations cannot be specifically disclosed, but Table 3.10-3 includes information on sites within Wickiup Reservoir. Disturbance of these sites related to reservoir fluctuations and drawdown rates may cause an irretrievable loss of integrity of these sites. Other archaeological sites that are completely or partially submerged may also lose integrity as a result of operations under the proposed action.

Analysis of reservoir variability indicates that proposed action reservoir operations would result in average median annual water surface elevations that would be approximately 8.5 feet lower than under the no-action alternative over the permit term and would range up to nearly 21 feet lower during the irrigation season in years 21 through 30. Reservoir water surface elevations would be substantially less variable at this lower surface water elevation throughout the year when compared to the no-action alternative (Table 3.10 -1) because of the changes in fall and winter releases to the Upper Deschutes River. In general, more water would be transported through the reservoir and less would be held behind the dam during the storage season compared to the no-action alternative. Variations in water elevations and lower water levels would be greatest in years 21 through 30. These reservoir operations changes have the potential to expose sensitive archaeological resources more often and increase the transportation and disturbance of archaeological materials in reservoir areas where resources are known to occur.

**Effect Conclusion:** The proposed action could have an adverse effect on previously recorded archaeological resources, including NRHP-eligible sites, because it is likely to expose resources in

Wickiup Reservoir more frequently, result in increased artifact transport and potentially increased site size as a result of artifact movement in the reservoir.

**CUL-2: Disturb Archaeological Materials through Human Access**

The collection and disturbance of artifacts would irretrievably affect the integrity of archaeological sites, but these impacts would likely be incremental, except during periods when modeling shows seasonal low water surface elevations (reservoir levels) and in years 21 through 30 of the permit term. Wickiup Reservoir is commonly used for recreation, and with human access comes increased likelihood of artifact collection and inadvertent disturbance. The amount of artifact collection cannot be quantified but could continue throughout the permit term with higher intensities at sites with more artifacts.

As described in CUL-1, water levels would generally be lower and less variable under the proposed action compared to the no-action alternative. With reduced fluctuation in water level, archaeological sites, which have predictable locations, if repeatedly exposed, could be more consistently exposed for human access, especially in years 21 through 30 when water levels are expected to be substantially lower than historically known conditions.

Looting and other human disturbance constitute adverse impacts specifically because there are NRHP-eligible archaeological sites that may be exposed.

**Effect Conclusion:** The proposed action may have an adverse effect on previously recorded archaeological resources, including NRHP-eligible sites, because decreased water levels could provide greater access to previously submerged archaeological sites, which may lead to increased looting and human disturbance compared to the no-action alternative.

### 3.10.3.3 Alternative 3: Enhanced Variable Streamflows

**CUL-1: Naturally Transport and Disturb Archaeological Materials**

Modeled changes in water surface elevation and variability in Wickiup Reservoir under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action but would be implemented earlier in the permit term (Table 3.1-1). However, it is anticipated that the difference in level of effect on archaeological site disturbance through natural forces would be negligible. Therefore, effects on archaeological resources that are submerged or partially submerged would be the same as described for the proposed action.

**Effect Conclusion:** As under the proposed action, Alternative 3 may have an adverse effect on previously recorded archaeological resources, including NRHP-eligible sites because it could result in increased artifact transport and potentially increased site size as a result of increased water flowing through the system when compared to the no-action alternative.

**CUL-2: Disturb Archaeological Materials through Human Access**

Similar to Impact CUL-1, accelerated implementation of increased releases from Wickiup Reservoir would result in a negligible difference in the level of effect on archaeological site exposure and related disturbance compared to the proposed action. Therefore, effects on archaeological resources that are submerged or partially submerged under Alternative 3 compared to the no-action alternative would the same as described for the proposed action.

**Effect Conclusion:** As under the proposed action, Alternative 3 may be adverse on previously recorded archaeological resources, including NRHP-eligible sites because decreased water levels could provide greater access to previously submerged archaeological sites, which may lead to increased looting and human disturbance compared to the no-action alternative.

### 3.10.3.4 Alternative 4: Enhanced and Accelerated Variable Streamflows

**CUL-1: Naturally Transport and Disturb Archaeological Materials**

Wickiup Reservoir elevation variability under Alternative 4 compared to the no-action alternative would be similar to that described for the proposed action, but water levels would be overall lower than under the proposed action throughout the year (Table 3.10-1). Therefore, effects under Alternative 4 compared to the no-action alternative would be the same as described for the proposed action but of greater magnitude (i.e., increased releases could hypothetically contribute to increased soil deflation and artifact disturbance). These impacts would be localized but could adversely affect archaeological resources through degradation of integrity. In addition, modeled changes in water elevation and variability from increased fall/winter releases from Wickiup Reservoir flow would occur earlier in the permit term under Alternative 4 than under the proposed action or Alternative 3.

**Effect Conclusion:** As under the proposed action and Alternative 3, Alternative 4 may have an adverse effect on previously recorded archaeological resources, including NRHP-eligible sites, because it may result in increased artifact transport and potentially increased site size as a result of increased water flowing through the system when compared to the no-action alternative. Any adverse effects may be of greater intensity under Alternative 4 than under the proposed action or Alternative 3.

**CUL-2: Disturb Archaeological Materials through Human Access**

Lower elevations in Wickiup Reservoir under Alternative 4 compared to the no-action alternative would be similar to described for the proposed action, but water levels would be overall lower than under the proposed action throughout the year (Table 3.10-1). Therefore, effects on archeological materials under Alternative 4 compared to the no-action alternative would likely be the same as described for the proposed action but of slightly greater intensity because lower water levels throughout the year could allow increased human access to areas that were previously submerged and where archaeological sites may be located. In addition, lower water elevations from increased fall/winter releases from Wickiup Reservoir would occur earlier in the permit term under Alternative 4 than under the proposed action or Alternative 3.

**Effect Conclusion:** As under the proposed action and Alternative 3, Alternative 4 may have an adverse effect on previously recorded archaeological resources, including NRHP-eligible sites because decreased water levels could provide greater access to previously submerged archaeological sites, which may lead to increased looting and human disturbance compared to the no-action alternative. Any adverse effects would likely be of slightly greater intensity under Alternative 4 than under the proposed action or Alternative 3 because reservoir levels would be lower and could lead to more potential human disturbance and looting than the no-action alternative, the proposed action, or Alternative 3.

## 3.10.4 National Historic Preservation Act

In addition to the Services obligations under NEPA to assess impacts to cultural resources, the the Services must also comply with the National Historic Preservation Act (NHPA). The issuance of an incidental take permit (ITP) (and its associated conservation measures in the applicants' HCP) to the applicants is defined as a federal undertaking and, therefore, requires compliance with Section 106 of the NHPA. As the federal agencies responsible for the undertaking, the Services will work together to determine if the undertaking has the potential to affect "historic properties."[3]

As part of the Services' NHPA compliance process, the Services identify the geographic area of potential effects (APE),[4] where such properties may be affected, and consult with interested parties. This includes the SHPO, the confederated Tribes of the Warm Springs Indian Reservation, the Klamath Tribes, the applicants, the U.S. Forest Service, the Bureau of Reclamation, and other interested parties. The purpose of the consultation is to gather information on the potential historic properties, including properties of religious and cultural significance to Indian Tribes in the APE. The Services scale the historic property identification effort to the nature of the undertaking activities, past land use, the degree of federal control, and the potential for undertaking activities to cause effects on historic properties. The results of the identification effort are used to further assess and refine the effects of the undertaking on historic properties. The Services will conduct this assessment in consultation with the consulting parties. Prior to implementing undertaking activities that have potential to affect historic properties, the agencies and interested and consulting parties consult to resolve adverse effects.

[3] ***Historic property*** means 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).

[4] Note that the APE as defined by the Services under the NHPA may not directly correspond to the study area defined for the purposes of NEPA.

Chapter 4
# Cumulative Impacts

## 4.1 Introduction

This chapter presents the analysis of potential cumulative impacts of the proposed action and action alternatives (Alternatives 3 and 4), on the human environment. The Council on Environmental Quality (CEQ) NEPA Regulations define a cumulative impact as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions" (40 Code of Federal Regulations [CFR] § 1508.7). Cumulative impacts can result from individually minor but collectively substantial actions taking place over a period of time.

## 4.2 Cumulative Actions

***Cumulative actions*** are 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. The study area considered in this analysis is the same for each resources as defined in Chapter 3.

The types of cumulative actions relevant to this analysis include land/agricultural development, water supply infrastructure improvements, public lands management, and resource protection and enhancement activities in the study area.

Appendix 2-B, *No-Action and Cumulative Scenarios*, presents additional information on specific projects considered in the cumulative analysis.

### 4.2.1 Land Development and Agricultural Uses

Past and present urban development in the Deschutes Basin is primarily concentrated in the cities of Bend, La Pine, Sunriver, Sisters, Redmond, Culver, Prineville, and Madras and comprises residential, commercial, industrial, and recreational uses. The estimated combined population of Deschutes, Jefferson, and Crook Counties increased from approximately 200,431 in 2010 to 235,250 in 2018 and is expected to reach 395,847 by 2050 (Portland State University Population Research Center 2019).

Past agricultural development in the basin began in the late nineteenth century and expanded with development of irrigation systems on the Deschutes River, Crooked River, and local creeks. Agricultural acreage in the three-county area is approximately 1,769,096 acres. Current agricultural crop production and grazing is concentrated in the eight Deschutes Basin Board of Control irrigation district boundaries: the Central Oregon Irrigation District (ID), North Unit ID, Swalley ID, Tumalo ID, Arnold ID, Lone Pine ID, Ochoco ID, and the Three Sisters ID (Figure 1-1). Agricultural and grazing activities are dependent on annual water supply availability. Total agricultural acreage in the basin

is not expected to grow in future years (U.S. Department of Agriculture–Natural Resources Conservation Service 2018).

The State of Oregon has maintained a strong policy to protect agricultural land across the state (Oregon Revised Statutes [ORS] 215.243). Oregon's Statewide Planning Program has carried out this policy over the years and has effectively slowed the loss of farmland in Oregon, especially those lands formally designated as exclusive farm use (EFU).[1] It is anticipated that the State of Oregon would continue to carry out this policy; however, the conversion of rural land (i.e., land not designated EFU) to other land uses could continue to occur in the future. For example, local jurisdictions in Central Oregon could expand urban growth boundaries to include rural land for future urbanization.

### 4.2.2 Water Supply Improvements

Past and present water supply improvements have changed the hydrology of the Deschutes Basin. Water supply infrastructure in the basin includes storage reservoirs, irrigation diversions and canals, and a distribution system serving basin water supply patrons. Covered facilities are summarized in Chapter 2, *Proposed Action and Alternatives*, and described in detail in Chapter 3, *Scope of the HCP*, of the Draft Deschutes Basin HCP. Operation of covered storage reservoirs—Crane Prairie, Wickiup, and Crescent Lake—and other basin impoundments including Prineville Reservoir have generally reduced fall and winter streamflow during the storage season and increased spring and summer streamflow during the irrigation season. Water supply diversions on basin rivers and creeks have caused a reduction in streamflows downstream of diversion locations on the Deschutes and Crooked Rivers and Whychus and Tumalo Creeks. Basin water supply canals have also created new surface waterbodies where they did not previously exist prior to basin water supply development. All of the water supply facilities require annual maintenance activities on rivers and creeks and at reservoirs.

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 water conservation projects (often referred to as irrigation modernization projects or canal lining and piping projects) that eliminate seepage from district canals in the stretches that are lined or piped as well as 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 acre-feet per year (af/year) 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/year was permanently conserved instream through district piping projects in the Central Oregon, North Unit, Swalley, Three Sisters, and Tumalo IDs (Newton and Perle 2006). Appendix 2-B provides descriptions of water conservation projects that have been completed. District piping is 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 (Appendix 2-B). For the past several years, in an ongoing district modernization effort, the Deschutes Basin irrigation districts have been developing System Improvement Plans 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. The total

[1] The purpose of the exclusive farm use (EFU) zone is to provide areas for continued practice of commercial agriculture. It is intended to be applied in those areas composed of tracts that are predominantly high-value farm soils and generally well-suited for large-scale farming.

potential water conservation in the basin related to district water conservation projects is estimated at approximately 200,000 af/year (Bureau of Reclamation and Oregon Water Resources Department 2018).

Future water supply improvements consist of operation and maintenance actions for current and new water supply facilities, including storage reservoirs, diversion facilities and canals, and the irrigation distribution system. On-farm irrigation efficiencies, including converting to more efficient sprinkler and drip irrigation technologies, would reduce irrigation water demand.

### 4.2.3 Public Land Management

Public lands managed by the federal government represent approximately 80% of total land in the Deschutes Basin. The Bureau of Land Management (BLM) and U.S. Forest Service (USFS) are the primary federal land managers. Because of the extent of these public lands, the influence of BLM and USFS management in the basin and the intersection of specific projects near the covered lands and waters as well as Prineville Reservoir is considerable. Multiple types of projects are implemented each year in these areas , including those for facility and recreation management; forest products, fuels, grazing, and vegetation management; and heritage resource and other land management projects and activities. These projects are generally intended to improve and carefully manage the forest and grazing lands in the basin and occasionally could have short-term physical effects that could contribute to adverse cumulative effects.

### 4.2.4 Resource Protection and Enhancement Activities

Considerable past and present resource protection actions, including streamflow augmentation and physical habitat enhancement and restoration, have taken place in the vicinity of covered lands and waters in the past, and many projects are currently proposed on rivers and creeks in the basin (Appendix 2-B). The range of projects include flow enhancement and water leasing actions to improve streamflow in portions of rivers and creeks, physical enhancement and restoration of river and creek habitat, marsh restoration, erosion control and trail improvement, public access improvement, watershed protection and enhancement actions, fish passage improvements, and wastewater wetland development projects. These actions are conducted by federal and state agencies, watershed councils, the Deschutes River Conservancy, municipalities, and other stakeholders.

## 4.3 Evaluation of Cumulative Effects

For each resource, this section describes anticipated effects of the cumulative actions in the study area. It then evaluates the potential for the proposed action and action alternatives to result in cumulative effects when considered in the context of effects of the cumulative actions.

### 4.3.1 Water Resources

Past development of the existing water supply system in the Upper Deschutes Basin has fundamentally changed the hydrology and hydraulics of surface water and groundwater systems in the study area. Dependence on both natural flow and stored water for irrigation supply have resulted in low winter flows, when water is being stored, high summer flows above irrigation

diversions as water is released from storage, and low summer flows below irrigation diversions. District water conservation projects over the past 20 years have begun to reverse this trend, smoothing the annual hydrograph by increasing low winter flows below reservoirs and summer flows below irrigation diversions (Farmers Conservation Alliance 2018). In addition, implementation of water operation requirements of the Deschutes Project Biological Opinion have resulted in increased winter flows below Wickiup and Crescent Lake Reservoirs.

Reasonably foreseeable district water conservation projects are expected to continue this trend. If water conservation projects planned by Central Oregon, Lone Pine, and Arnold IDs over the analysis period provide water that is protected instream from their respective points of diversion to Lake Billy Chinook during summer, flows from Wickiup Dam to Bend would be unchanged and flows below each point of diversion would be higher, but there would be no effect on water supply. [2] If water saved through conservation in Central Oregon, Lone Pine, or Arnold ID were available to North Unit ID, it would reduce North Unit ID's demand for stored water from Wickiup Reservoir, which would be anticipated to reduce late summer flows in the Upper Deschutes River below Wickiup Reservoir and increase flows below Wickiup Reservoir during winter. The most pronounced effect of district water conservation projects would be the reduction of North Unit ID's water supply shortages, especially during dry years. This would have the associated impact of increasing irrigation season surface water flow from Wickiup Reservoir to Bend, and from the North Unit ID pumps on the Crooked River to Lake Billy Chinook. Water conservation projects planned by Tumalo and Swalley IDs, and assumed under the no-action alternative (Section 3.2, *Water Resources*) would increase instream flows below irrigation diversions in the Deschutes River and Tumalo Creek.

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 cubic feet per second (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 (Gannet et al. 2001:52; Gannet et al. 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. Canal piping and lining projects have localized effects on groundwater; meaning that near the affected canals, seepage would be reduced, which would in turn reduce nearby groundwater levels. If all water conservation projects described in Appendix 2-B are implemented, groundwater levels in the middle portion of the basin would be affected. The artificially elevated spring discharges in this portion of the basin would be reduced as river flows return to more natural discharge rates. Because the proposed action and action alternatives would

[2] After determining the quantity of conserved water, if any, required to mitigate the effects on other water rights, the Water Resources Commission shall allocate 25% of the remaining conserved water to the state and 75% to the applicant, unless the applicant proposes a higher allocation to the state or more than 25% of the funds used to finance the project comes from federal or state public sources. If more than 25% of the funds comes from federal or state public sources and is not subject to repayment, the commission shall allocate to the state a percentage equal to the percentage of public funds used to finance the conservation measures and allocate to the applicant a percentage equal to the percentage of other funds used to finance the conservation measures (ORS.537.470). This statute does not preclude irrigation districts and conservation funders from agreeing to other arrangements regarding conservation funding and the obligations of the entity receiving funds.

have only minor effects on the regional groundwater system, they would not have potential to contribute to cumulative impacts.

With regard to population growth and land development, 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. Consequently, future population growth and land development are not expected to have only a small effect on water supply, surface water, or groundwater.

Future climate change is expected to change the way the water supply system is operated and managed. Extreme climate events, such as drought, and ecological disturbances, such as flooding and wildfire, are forecasted to increase with climate change. These events could alter streamflow throughout the study area (Halofsky et al. 2018). Upper Deschutes River tributaries are likely to experience more rain and less snowfall with a warming climate. Tributaries, especially those that are more influenced by surface water runoff and less so by groundwater hydrology, are likely to become flashier, with earlier annual runoff and lower summer flows.

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 supply later in the season. However, the groundwater system and the study area reservoirs' storage capacities would moderate the effects of decreased snowfall and runoff timing. Under such a scenario, study area reservoirs are expected to be equally likely to fill to capacity (Halofsky et al. 2018). However, higher evapotranspiration rates that are anticipated under climate change, would reduce available stored water by an unknown amount.

Under a climate change scenario that includes significant variation in annual precipitation, there may be more years in which reservoirs do not fill and water users experience supply shortages. Conversely, groundwater-influenced systems may be less affected because of the longer residence time of water passing through subsurface geology. Precipitation and snowmelt infiltration and groundwater discharge to surface water occurs over a longer period of time and groundwater-dominated systems, compared to surface-dominated systems, are less influenced by annual precipitation. However, climate changes that include significant lengthening of the current climate cycles being experienced in the basin (i.e., extended droughts or wet period) could be reflected in the groundwater system over time.

Based on the historical record, basin-scale groundwater levels will continue to fluctuate in response to climate cycles that affect the overall recharge to the system. 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 and would likely not significantly impact the overall recharge to the groundwater system (Halofsky et al. 2018). In addition, the magnitude of water level changes will generally dampen moving eastward across the basin away from the basin's primary recharge source (the Cascade Range). The exception is groundwater levels in wells immediately adjacent to canals with planned piping projects, where declines in water levels may exceed the climate cycle driven fluctuations.

Overall, decreased reservoir water supply storage and increased water supply shortages that occur under the proposed action and action alternatives are expected to be exacerbated by climate change

effects but offset somewhat by future district water conservation projects depending on the amount of water conserved for instream uses. In particular, reductions in water supply for North Unit ID under the proposed action and action alternatives may be partially offset by future piping actions.

## 4.3.2 Water Quality

Past and present actions have resulted in adverse effects on water quality in the study area. Water resources have been greatly modified in the Deschutes Basin over the last 150 years by construction of numerous reservoirs and the creation of a complex irrigation system to support a large agricultural economy. The most important water quality change has been an increase in river temperatures caused by releasing impounded waters that have been warmed by solar radiation, a decrease in summer streamflows in some river reaches resulting in longer travel times and greater solar warming, and discharge of warm irrigation return flows back to the rivers. The increase in river temperatures combined with the discharge of more nutrients to the rivers have likely increased algal growth in the rivers (Allan 1995; Dodds 2006; Dodds & Smith 2016; Goldman & Carpenter 1974; McDowell et al. 2009; Paerl & Paul 2012; Raven & Geider 1988; Singh & Singh 2015). The algal productivity in the rivers has also increased from release of reservoir waters, especially those systems with outlets near the water surface level (Eilers and Vache 2019; Marcus 1980; Duffard et al. 1987). Climate change is also adding to the thermal load in the lakes and rivers, and this trend is expected to increase (Isaak 2017 et al.; Sahoo & Schadlow 2008; Schindler et al. 1996).

Future changes in climate are expected to increase mean annual temperature and decrease annual precipitation, as described in Section 4.3.1, *Water Resources*. This would likely increase cyanobacteria blooms in the study area reservoirs because of the positive association between water temperature and favorable cyanobacteria habitat (Paerl and Huisman 2008). Water temperatures in the rivers and creeks also are expected to increase as a result of warming in the reservoirs and greater heat transfer from atmospheric warming during river flow. Increased water temperature would also increase the likelihood of increased periphyton (attached algae) growth. All of these gradual changes would likely increase pH and daytime concentrations of dissolved oxygen and nighttime reductions in dissolved oxygen, possibly resulting in exceedances of water quality standards. These changes are expected to be proportional to the increases in air temperature and decreases in precipitation. Effects may be greater in the Crooked River Subbasin because the subbasin has lower permeability and fewer springs[3] and less recharge. Also, because the subbasin has less precipitation, relatively small increases in annual air temperature (and associated increases in evaporation) and decreases in summer precipitation, greater effects on water temperature and streamflow could occur.

Continued population growth and development in the basin over the analysis period could increase the disturbance of land cover and increase the delivery of nutrients and thereby increase algal growth in study area waters. Increased development often results in increased demand for water. Long-term demands are likely to be met through additional groundwater pumping, which would decrease groundwater discharges to the Deschutes River. However, as described above under Section 4.3.1, with mitigation required under the Deschutes Groundwater Mitigation Program,

[3] An exception is Opal Springs, which discharges about 1,100 cfs; however, this spring is located near the confluence of the Crooked River and Lake Billy Chinook, so only supports the lowest reach of the river.

future groundwater pumping is not expected to affect streamflows and, therefore, is not expected to affect water quality.

Conversely, streamflow augmentation, water right leasing, and water conservation projects would likely improve flows and thereby water quality in rivers and creeks in the study area.

Restoration projects in the study area are expected to improve water quality over the analysis period. Projects developed for the City of Prineville wastewater treatment wetlands would improve water quality in the Crooked River by reducing the discharge of nitrogen, phosphorus, suspended solids (contributing to turbidity), and biochemical oxygen demand. Reduction in discharge of nutrients reduces growth of algae in the river bottom, thereby reducing the daily fluctuations in pH and dissolved oxygen. Reduction in suspended solids increases water transparency and improves the aesthetic property of water. Reduction of biochemical oxygen demand reduces the amount of oxygen that is consumed by bacteria in water; bacteria consume oxygen in water during the process of decomposing organic wastes. The river restoration projects in the Deschutes River Subbasin assumed under the no-action alternative would improve water quality by stabilizing stream banks and, thus, increasing water transparency. Suspended solids also contain phosphorus, which can become available to aquatic plants when transported in water.

Potential adverse effects under the proposed action and action alternatives on water quality in Crane Prairie Reservoir (increases in daytime temperature, dissolved oxygen, pH, chlorophyll, turbidity, and nuisance algae as a result of changes in reservoir volume and surface water elevation), and Wickiup Reservoir (daytime increases in pH, dissolved oxygen, chlorophyll, turbidity, and nuisance algae; decreases in dissolved oxygen and pH in the bottom waters; and increased cyanobacteria blooms) could be exacerbated by lower water elevations under climate change.

Minor changes in temperature, pH, dissolved oxygen, nitrate or phytoplankton (from Wickiup Reservoir) and the potential for downstream transport of algal blooms in the Upper Deschutes River under the proposed action and action alternatives could be exacerbated by similar effects of climate change and offset by planned restoration projects (Appendix 2-B).

Decreased irrigation season flows under the proposed action and action alternatives in certain reaches of the Crooked River that could result in adverse effects on water quality (increased daytime temperature, pH, and dissolved oxygen) could be exacerbated by lower summer flows with climate change over the permit term, but could be offset if water conservation projects were to result in reduced North Unit ID reliance on Crooked River water supply, as described in Section 4.3.1.

## 4.3.3 Biological Resources

### 4.3.3.1 Vegetation and Wildlife

Past and present actions have resulted in changes to vegetation types in the study area. Development has encroached upon riparian and wetland vegetation communities and has converted native vegetation to agricultural, suburban, and urban land uses. The construction of numerous impoundments and diversions and management of most streams for water supply has substantially altered the natural hydrograph in the study area, resulting in greatly increased summer flows and greatly decreased winter flows. As a result, native vegetation communities have been altered through removal and conversion. Most of these changes have been historical; riparian and wetland areas are now recognized as special-status plant communities and have some level of regulatory

protection throughout the study area. Past and present activities have also cumulatively resulted in the introduction and spread of invasive plants.

As described above, reasonably foreseeable future changes in and near the study area include continuing land development, primarily for residential and industrial uses; continuing water supply changes, especially in the form of water conservation projects; continuing resource protection, especially in the form of river restoration; and climate change effects. Projects listed in Appendix 2-B constitute examples of such projects but do not constitute a complete list of changes that would occur during the analysis period. Pressure for land development in basin communities could result in the localized removal and conversion of native riparian and wetland vegetation, thereby reducing available habitat for wildlife. Although mitigation would likely be required for such actions, such land development would contribute to the continuing fragmentation of habitats and could impede migration and dispersal movements by plants and animals. Water conservation projects planned to improve agricultural water supply efficiency could result in increased river and streamflows and could reduce the seasonal and annual variability in basin reservoirs. The positive river and reservoir changes could contribute to improved conditions for riparian and wetland habitats. Similarly, future resource protection actions, such as habitat restoration and river flow augmentation projects, are expected to improve riparian and wetland habitats with the potential to benefit fish and wildlife species.

Climate change effects forecast for the region include higher peak flows and lower summer low flows. Extreme climate events, such as drought, and ecological disturbances such as flooding, wildfire, and insect outbreaks, are expected to increase in the future. The timing of these changes is uncertain, but summer low flow reductions of 40 to 60% are forecast by 2040, approximately 20 years into the analysis period (Halofsky et al. 2018). The forecast elevated risk of extreme climate events and ecological disturbances has a high potential to substantially alter riparian and wetland vegetation; most of the forecasted types of disturbance would cause elevated mortality within plant communities, shifting ecological states to less complex plant communities in an earlier successional state. Such plant communities also experience heightened vulnerability to invasion by nonnative plant species. These adverse changes in plant communities would have adverse consequences for wildlife species dependent upon mature or late-successional riparian forest habitats. Increased frequency and severity of drought and flood, and substantial reductions in summer streamflow in streams (such as Whychus Creek, Tumalo Creek and the Little Deschutes River) lacking headwater reservoirs would likely have adverse consequences for wildlife using riparian and wetland habitats along those streams.

Beneficial effects of the proposed action and action alternatives, related to improvements in vegetation communities, especially riparian and wetland habitats in the Upper Deschutes River, could be further improved by in-stream flows made available by water conservation projects but may be offset by future climate change effects.

Adverse effects of the proposed action and action alternatives on habitat quality for riparian vegetation and use by both aquatic and riparian species in Wickiup Reservoir could potentially be reduced in some years by conservation projects if they result in stabilizing reservoir water fluctuations. However, these adverse habitat effects could also be exacerbated by climate change effects.

#### 4.3.3.2 Oregon Spotted Frog

Unnaturally high summer flows and low winter flows resulting from regulation of streamflows and impoundment have adversely affected the quantity, quality, and distribution of vegetated wetlands and riparian areas that provide essential habitat for the Oregon spotted frog. These disturbances have also facilitated the introduction and spread of invasive species, such as reed canarygrass and the bullfrog.

Future effects of climate change, continued management of water resources, and continued human development within the basin are likely to adversely affect aquatic environments, including Oregon spotted frog habitat. Changes in precipitation patterns and precipitation type (e.g., a shift from snowpack to rain) due to climate change could affect the quantity, quality, and distribution of wetland vegetation communities that are essential for the conservation of the spotted frog. Water resource management to support continued development in the basin could also adversely affect wetland habitats supporting the Oregon spotted frog by changing inundation patterns.

Conversely, current and reasonably foreseeable water conservation and riparian and wetland habitat restoration projects in the Upper Deschutes Basin, such as those listed in Appendix 2-B, would improve habitat conditions for the Oregon spotted frog by contributing more water to the system and restoring wetland vegetation communities that have been degraded by nonnative species such as reed canarygrass or invaded by nonnative predatory species such as the bullfrog, three-spined stickleback, and the brown bull-head.

The proposed action and action alternatives would generally contribute to improvements in the quantity, quality, and distribution of Oregon spotted frog habitat by maintaining or improving wetland vegetation habitat conditions at some breeding and rearing locations and providing improved winter flow conditions that protect overwintering frogs. These beneficial effects could be offset by lower summer streamflows anticipated with climate change over the analysis period. However, planned restoration actions (Appendix 2-B) could enhance beneficial effects by improving riparian and wetland habitats.

Oregon spotted frogs occupying Wickiup Reservoir would continue to experience degraded habitat conditions year-round due to changes in wetland vegetation inundation patterns. These effects could be exacerbated by longer and more frequent drawdowns of the reservoir as a result of climate change effects over the analysis period.

Adverse effects on the frog that stem from threats other than flow (e.g., invasive and predatory species) would continue under the proposed action and under cumulative conditions, but could be reduced through Conservation Measure DR-2 under Alternatives 3 and 4 and other cumulative restoration projects.

#### 4.3.3.3 Fish and Mollusks

Past and present actions have resulted in adverse changes to fish and mollusk populations in the study area. Reservoir construction and operations for water storage and irrigation supply have flooded stream channels and created migration barriers for resident and migratory species in just about every portion of the study area (the only exceptions are Whychus and Tumalo Creeks, and these streams have migration barriers at diversion dams). At the same time, the reservoirs are providing additional habitat for some native and introduced species, which are flourishing in the reservoirs.

The Pelton-Round Butte Complex is the most significant passage barrier in the basin for anadromous salmon and trout and the Pacific lamprey (Nehlsen 1995). The Pelton-Round Butte Complex was constructed in the 1950s and early 1960s, and efforts were made to provide fish passage and sustain the upper basin's salmon and summer steelhead runs, but those efforts failed and were abandoned in 1969. Migration barriers in the Crooked River have also greatly affected fish species access and movement in this watershed at Opal Spring Dam in the Lower Crooked River, Bowman Dam in the Crooked River, and Ochoco Dam on Ochoco Creek. These are just a few of the barriers in the basin affecting migration of fish species. Efforts are underway to provide fish passage at many of the barriers on smaller tributaries in the study area (GeoEngineers, Inc. 2014). Reintroduction of salmon and steelhead above the Pelton-Round Butte Complex was initiated in 2008 (Oregon Department of Fish and Wildlife and Confederated Tribes of the Warm Springs Reservation 2008). Final construction of fish passage at Opal Springs Dam is planned to be operational by fall or early winter 2019; operation of the fish passage facility will remove a barrier to resident and anadromous fish species to the Crooked River that has been in place since 1982. Bull trout are currently encountered at Opal Springs Dam (Lickwar pers. comm.), and foraging subadult bull trout are expected to migrate upstream of Opal Springs Dam with construction of fish passage facilities. Naturally produced summer steelhead and spring Chinook from reintroduction efforts and returning adults from releases in the Crooked River are also expected to migrate upstream of Opal Springs Dam.

Water management activities in the study area have substantially altered the natural hydrograph in most streams with greatly increased summer and greatly decreased winter streamflows. The natural function of aquatic habitats has been impaired and fish and mollusk species have declined as a result of impaired habitat conditions and the direct effects of water management activities (e.g., Porter and Hodgson 2016). These adverse effects are continuing to occur across the study area, with some improvements in the Upper Deschutes River downstream of Wickiup Reservoir that provide higher winter streamflows for the Oregon spotted frog.

Reasonably foreseeable future actions relevant to fish and mollusks include urban development, water conservation projects, river restoration, and climate change effects. Pressure for urban development within the basin could result in the localized removal and conversion of native riparian and wetland vegetation, thereby further impairing aquatic habitats for fish and mollusks. Water supply conservation projects planned to improve agricultural water supply efficiency could result in increased river and streamflows, especially during drought years, and could reduce the seasonal and annual variability in basin reservoirs. Such positive river and reservoir changes could contribute to improved habitat conditions for fish and mollusks. Similarly, future habitat restoration and river flow augmentation projects are expected to improve riparian habitats with potential benefits to fish species and the Oregon spotted frog.

Reasonably foreseeable climate changes could result in adverse effects on the quality, quantity, and distribution of riparian and aquatic habitats in the study area. Halofsky et al. (2018) forecast that peak winter/spring streamflows will be higher and summer low streamflows lower compared to existing conditions as a result of climate change. 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 low streamflow reductions of 40 to 60% are forecast by 2040, approximately 20 years into the analysis period (Halofsky et al. 2018). Changes in precipitation patterns and precipitation type (e.g., a shift from snowpack to rain) due to climate change could adversely affect fish habitats, causing reduced abundance, productivity, and distribution of fish and mollusk species.

When combined with other past, present, and reasonably foreseeable future actions, the implementation of the proposed action and action alternatives could result in cumulative effects on several fish and mollusks species in the study area. Beneficial effects on the Upper Deschutes River for winter fish habitat and recovery of emergent riparian vegetation with lower summer streamflows could be further enhanced with water conservation projects and restoration actions (Appendix 2-B), but could be offset by climate change effects. Adverse effects during spring and summer with more years experiencing irrigation storage shortages and more variable streamflows during the irrigation season could be offset somewhat by water conservation projects, but also exacerbated by climate change effects. Specifically, if water conservation projects result in the ability of water managers to avoid the more frequent and earlier use of storage water in Prineville Reservoir reflected in modeling for the proposed action and action alternatives, adverse effects on the Crooked River for bull trout, steelhead, spring Chinook salmon, and redband trout could be avoided and beneficial effects of higher winter streamflows could result in an overall beneficial effect in the Crooked River reaches.

## 4.3.4 Land Use and Agriculture

Past and present water resources and urban development in the Deschutes River Basin have resulted in current land uses, including extensive agricultural land uses, in the study area.

Water supply for irrigation has been effected by recent cumulative actions. The 2016 Settlement Agreement resulted in increased releases of storage water to enhance fall and winter flows for the Oregon spotted frog below Wickiup Dam, which has reduced water supply in dry water years; however, past water conservation projects have offset the effect of these reductions by reducing the amount of water needed for irrigation.

Because the proposed action and action alternatives would not modify land uses in the study area, they would not contribute to cumulative effects on land use.

The proposed action and action alternatives would result in reduced irrigation water supply that could result in increased fallowing or deficit irrigation on irrigated lands in the study area. These effects could be exacerbated with climate change. Future water conservation projects are expected to increase agricultural water use efficiencies, both through piping/lining of leaky canals and on-farm irrigation efficiencies, as reflected in the analysis in Section 3.5, *Land Use and Agriculture*. Although the precise outcome is currently uncertain, the goal of water conservation projects and other on-farm water use efficiency programs is to reduce the potential cumulative effects of changes in water supply availability on agricultural land production.

Urban and suburban growth could result in the conversion of rural land within urban growth boundaries. Some study area counties are considering rezoning farm and forest lands for rural residential uses, especially on non-working forestlands and lands zoned EFU that could be defined by the state as "non-resource lands." However, as described in Section 4.2.1, *Land Development and Agricultural Uses*, lands zoned EFU are protected in the state. Because reduced irrigation water supply under the proposed action and action alternatives is not expected to result in conversion of agricultural land uses to other land uses, they would not contribute to cumulative effects related to land conversion. In addition, the transition to lower water use but higher value crops would reduce the effect of reduced water supply by reducing agricultural crop water demand per acre.

## 4.3.5 Aesthetics and Visual Resources

Past actions affecting aesthetics and visual resources include agricultural and urban development, agricultural practices, water supply infrastructure improvements, public lands management, and restoration projects. Future actions include continued urban growth, changes in agricultural practices, and restoration projects. Beneficial effects of the proposed action and action alternatives of improved visual quality related to improved wetland and riparian habitat along the Upper Deschutes River would be further enhanced by planned restoration actions in the area and water conservation projects that conserve water instream but could be offset by climate change effects described in Section 4.3.3.1, *Vegetation and Wildlife*. Adverse effects on visual quality in Wickiup Reservoir could result in a cumulative impact if climate changes effects result in longer and more frequent drawdowns of the reservoir.

## 4.3.6 Recreation

Over the past 100 years, recreational opportunities and experiences in the Deschutes Basin have been altered by timber harvest, livestock grazing, fire suppression, wildfires, recreational uses, water storage impoundments, stream diversion, road closures, trail and road construction, and agricultural and residential and commercial development. In addition, local and regional population growth has greatly increased demand for and use of recreational areas, and this trend is expected to continue.

Water management in the Deschutes Basin has particularly altered recreational opportunities and experiences. Reservoirs have created opportunities, but these opportunities are reduced as reservoir levels are lowered over the summer due to irrigation use. In addition, regulated streamflows have greatly increased summer flows and greatly decreased winter flows. Increased summer flows may benefit some recreational uses, such as rafting, but these flows may also make recreational water access difficult or dangerous and have also altered the natural appearance of rivers, including altered streambanks and vegetation.

Present and reasonably foreseeable future impacts on recreation include the continuation of altered flows as well as expected increased recreational use and associated use-related impacts, such as crowding, littering, and vegetation and soil damage. Recreational facilities (e.g., parks, trails, boat ramps) may be improved and increased over time to accommodate increased demand and use.

Climate change is expected to result in more dry years, which would have associated effects of lower summer flows and lower reservoir levels.

Beneficial effects of the proposed action and action alternatives on recreational opportunities and experiences that could be offset by climate change effects include those effects related to more stable flows and river levels, increased native shoreline vegetation, and potential benefits to recreationally important fish populations due to more consistent flows in the Upper Deschutes River.

Adverse effects in Wickiup Reservoir, including reduced access to boat ramps and shoreline campgrounds, aesthetic values, and fishing opportunities and experiences (including redband trout), and adverse effects on the redband trout fishing in areas of the Upper Deschutes and Crooked Rivers could be exacerbated by climate change effects.

Similarly, reduced summer reservoir levels at Prineville and Ochoco Reservoirs, while minor under the proposed action and action alternatives, could contribute to ongoing cumulative effects on recreation from low reservoir levels due to drought, and such effects are expected to increase over time because of climate change.

## 4.3.7 Tribal Resources

Past and present actions have resulted in significant changes to the distribution and abundance of tribal resources on ceded lands of the Confederated Tribes of the Warm Spring Reservation (Warm Springs Tribes) and the Klamath Tribes. The Pelton-Round Butte Complex eliminated native salmon and steelhead populations in the upper basin. Treaty-reserved harvest of native salmon and steelhead from the upper basin was replaced by hatchery fish released below the complex. Migration barriers in the Upper Deschutes River and Crooked River affected resident fish. Development has encroached on riparian and wetland vegetation communities and has converted native vegetation to agricultural, suburban, and urban land uses. This conversion has reduced or eliminated native plant and animal tribal resources.

The proposed action and action alternatives would have a combination of beneficial and adverse effects on fish populations harvested by tribes depending on the species and location. Effects of climate change could offset beneficial effects and exacerbate adverse effects. Water conservation projects, especially if they were allow water managers to avoid the more frequent and earlier use of storage water in Prineville Reservoir reflected in modeling for the proposed action and action alternatives, could eliminate adverse effects on the Crooked River for bull trout, steelhead, spring Chinook salmon, and redband trout. The same applies to adverse effects of the proposed action and action alternatives on reintroduction of steelhead trout and spring Chinook salmon on the Crooked River.

Beneficial effects on wildlife and plant species potentially harvested by tribal members expected in Crane Prairie Reservoir and the Upper Deschutes River under the proposed action and action alternatives would be further improved by water conservation projects and restoration projects (Appendix 2-B). Adverse effects in Wickiup Reservoir would have a cumulative effects given that wildlife and plant species are impaired under current water management operations and by further challenged with climate change.

## 4.3.8 Socioeconomics and Environmental Justice

Cumulative impacts on biological, aesthetic, recreation and tribal resources would affect the socioeconomic values associated with these resources. This section focuses on the cumulative impacts associated with the agricultural economy and agricultural way of life in the study area. In addition to the effects of the proposed action and action alternatives, two primary factors would affect the agricultural economy in the Deschutes Basin: climate change and market conditions.

Climate change, which could decrease water supplies for irrigation, could exacerbate water supply shortages and associated economic impacts under the proposed action and action alternatives. Once a shortage is experienced, additional reductions in water tend to be more costly to farmers. Market conditions and the potential availability of new crops, including relatively high-value, low water use crops suitable to be grown in the study area, could offset socioeconomic effects of the proposed action and action alternatives on the agricultural economy.

Water conservation projects and on-farm water use efficiency projects, accounted for in the analysis in Section 3.9, *Socioeconomics and Environmental Justice*, could reduce socioeconomic effects on agriculture by reducing irrigation canal water losses and preserving agricultural water supplies. On the other hand, urban growth in central Oregon cities such as Bend and Prineville may result in the conversion of some farmland and reduce the size of the local agricultural economy. This may lead to an even greater change in community character and way of life than anticipated under the proposed action and action alternatives.

Similar to the agricultural economy, climate change would also have the potential to amplify adverse effects on reservoir recreation and economic activity associated with reservoir recreation under the proposed action and action alternatives, as well as adverse effects on habitat-related socioeconomic values and tribal environmental justice population related to adverse effects on biological and tribal resources.

## 4.3.9 Cultural Resources

Past and present actions have had and continue to have adverse effects on cultural resources in Wickiup Reservoir. Construction of Wickiup Dam disturbed artifacts thought to be over 7,000 years old (Cressman 1937). Operation of the reservoir for irrigation water supply has resulted in fluctuating water levels within the reservoir, which deflates soils and can disturb artifacts. Movement of water through the system can also disturb and damage cultural resources. During minimum surface water elevations, access to archaeological sites is increased and can lead to looting and disturbance by humans. At times in the past, damage has likely been of variable intensity but has altered the archaeological deposits. Archaeological survey, NRHP evaluation, and additional cultural resources work during low water periods has demonstrated the presence of significant archaeological sites in areas that have been and continue to be influenced by operation of the dam and reservoir.

The proposed action and action alternatives would have adverse effects on cultural resources related to exposure of cultural resources in Wickiup Reservoir more frequently and for longer periods. These effects could be exacerbated by similar effects of climate change, which are anticipated to result in more drought years and lower reservoir elevations. District water conservation projects would have an uncertain effect on reservoir fluctuations but could potentially affect annual reservoir water elevations in Wickiup Reservoir that could improve adverse cumulative effects on reservoir archaeological resources.

# Chapter 5
# Additional Topics Required by NEPA

As required under the National Environmental Policy Act (NEPA) (42 United States Code 4321 et seq.) and Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 Code of Federal Regulations [CFR] Parts 1500–1508), in addition to discussing the potential direct, indirect, and cumulative impacts, this EIS must discuss "*any adverse environmental effects which cannot be avoided should the proposal be implemented, the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and any irreversible or irretrievable commitments of resources which would be involved in the proposal should it be implemented*" (40 CFR §1502.16).

## 5.1 Unavoidable Adverse Effects

As described in Chapter 3, *Affected Environment and Environmental Consequences*, the proposed action and Alternatives 3 and 4 would have adverse effects on water quality in Wickiup Reservoir (Section 3.3), non-covered game fish species (Section 3.4), tribal resources related to salmon and steelhead reintroduction (Section 3.8), socioeconomics (Section 3.9), and cultural resources in Wickiup Reservoir (Section 3.10) when compared to the no-action alternative. No mitigation measures have been identified to reduce these adverse effects.

## 5.2 Relationship between Short-term Uses of the Environment and the Maintenance and Enhancement of Long-Term Productivity

The proposed action and alternatives would not result in short-term construction impacts that would affect the natural and human environment in the study area because they do not involve construction of facilities or other physical modifications of the terrestrial environment. Maintenance of covered facilities at their current locations would occur under all of the alternatives and would have minimal short-term effects on the environment.

Chapter 3, *Affected Environment and Environmental Consequences*, discloses the potential effects of the proposed action and alternatives. These analyses indicate that the proposed action and alternatives would have beneficial and adverse effects on resources during the analysis period. Overall, effects of modification of water management operations under the proposed action and Alternatives 3 and 4 would generally improve conditions for terrestrial and aquatic species including the Oregon spotted frog because of the increase in fall and winter streamflows and reduction in seasonal streamflow fluctuations. Some habitat quality effects related to localized river temperature changes during drought years would occur during summer months that could affect aquatic species, including bull trout, steelhead, and spring Chinook salmon, particularly on the Crooked River. Changes in Wickiup Reservoir drawdown during the irrigation season would likely be the biggest long-term effect of implementing the proposed action or Alternatives 3 or 4, with Alternative 4 effects being the most severe. Effects on Wickiup Reservoir including potential

seasonal effects on reservoir water quality and recreation would be offset by the potential benefits to fish and wildlife from improved Deschutes River flow conditions.

One of the longer-term implications of proposed water supply operations modification is the potential to reduce irrigation water supplies to basin farmers. Reduction of winter storage in Wickiup Reservoir would reduce irrigation supplies in some years, particularly for North Unit ID, which relies on storage in the reservoir for patron irrigation deliveries. In years when irrigation supply shortages occur, the agricultural and associated socioeconomic effects could be partially reduced by ongoing and future district water conservation projects and continued on-farm water use efficiency projects that would be implemented independent of the proposed action, as discussed in Section 3.9, *Socioeconomics and Environmental Justice*.

## 5.3 Irreversible or Irretrievable Commitment of Resources

***Irreversible commitments*** are decisions affecting non-renewable resources such as soils, wetlands, and waterfowl habitat or commitments 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. The term *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. ***Irretrievable commitments*** are those that are lost for a period of time.

Implementation of the proposed federal action would not result in irreversible or irretrievable commitment of resources.

# Chapter 6
# List of Preparers

| Preparer Name | Entity | Role | Education | Years of Experience |
|---|---|---|---|---|
| Bridget Moran | FWS | Natural Resource/ESA Policy Management | MS Environmental Toxicology; BS Microbiology | 20 |
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| Peter Lickwar | FWS | Biological Resources (Fish and Mollusks) Reviewer | MS Ecology and Forestry; BS Biology and Zoology | 28 |
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| Steve Centerwall | ICF | Project Manager | BS Environmental Policy Analysis and Planning | 33 |
| Deborah Bartley | ICF | Deputy Project Manager | BA Political Science | 20 |
| Laura Zanetto | ICF | Project Coordinator | BLA Bachelor of Landscape Architecture | 8 |
| Stephanie Monzon | ICF | Lead Editor | MA and BA English | 20 |
| Laura Cooper | ICF | Editor | BA English | 14 |
| Saadia Byram | ICF | Editor | | 25 |
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| Brad Stein | ICF | GIS | BS International Affairs | 19 |
| Greg Blair | ICF | Aquatic Resources; Tribal Resources | MSand BS Fisheries | 28 |
| Laura McMullen, PhD | ICF | Aquatic Resources | PhD Zoology; BS Biology | 8 |
| Chris Earle, PhD | ICF | Vegetation and Terrestrial Wildlife | PhD Forest Ecology; MS Geosciences; BA Biology, Geology | 25 |
| Colleen Lingappaiah | ICF | Land Use and Agricultural Resources | BA Biology | 26 |
| Jennifer Ban | ICF | Aesthetics and Visual Resources | BLA Bachelor of Landscape Architecture | 20 |
| Steve Hall | ICF | Recreation | BS Wildlife and Wildland Recreation Management | 32 |

| Preparer Name | Entity | Role | Education | Years of Experience |
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| Chris Nelson | River Design Group | RiverWare Model Output Post-Processing | PE CFM; BS Civil Engineering (Bio-Resources) | 18 |
| Wendy Wente, PhD | Mason, Bruce, & Girard, Inc. | Oregon Spotted Frog | PhD Ecology, Evolution and Animal Behavior; BS Zoology | 27 |
| Joseph Eilers | MaxDepth Aquatics, Inc. | Water Quality | MS Water Resources; BA Biological Sciences | 42 |
| Barbara Wyse | Highland Economics | Agricultural Resources, Socioeconomics and Environmental Justice | MS Agricultural and Natural Resource Economics; BA Environmental Sciences and Policy | 15 |
| Adam Sussman | GSI Water Solutions | Groundwater Resources and Water Storage and Supply | MS Resource Geography; BS Environmental Studies and Physical Geography | 26 |
| Bruce Brody-Heine | GSI Water Solutions | Groundwater Resources | MS Contaminant Hydrogeology; BS Geology | 30 |
| Owen McMurtrey | GSI Water Solutions | Water Storage and Supply | MS Water Resource Policy and Management; BA Environmental Studies | 5 |

# Chapter 7
# Distribution List

The following is a list of agencies, organizations, and persons to whom copies of the EIS will be sent.

## 7.1 Federal Agencies

- Bureau of Land Management
- Bureau of Reclamation
- National Marine Fisheries Service
- U.S. Environmental Protection Agency
- U.S. Forest Service

## 7.2 State Agencies

- Oregon Department of Agriculture
- Oregon Department of Environmental Quality
- Oregon Department of Fish and Wildlife
- Oregon Water Resources Department

## 7.3 Local Agencies

- Crook County
- Deschutes County
- Jefferson County

## 7.4 Tribes

- Confederated Tribes of Warm Springs

## 7.5 Stakeholders

- Deschutes Basin HCP Stakeholder Group (list available upon request)