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

Final
Environmental Impact Statement

FOR THE DESCHUTES BASIN HABITAT CONSERVATION PLAN
VOLUME I: CHAPTERS 1–7

October 2020

Estimated lead agency & applicant total costs associated with developing and producing this EIS
$2,402,000

COVER SHEET

Title of Proposed Action:	Final Environmental Impact Statement for the Deschutes Basin Habitat Conservation Plan
Subject:	Final 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
County/State:	Klamath, Deschutes, Jefferson, Crook, Wasco, and Sherman Counties, Oregon

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 bull trout (*Salvelinus confluentus*) from FWS and take of the Middle Columbia River steelhead trout (*Oncorhynchus mykiss*) and one nonlisted species—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.

For Information, Contact:
Bridget Moran, Field Supervisor
Bend Field Office
U.S. Fish and Wildlife Service
63095 Deschutes Market Rd
Bend, OR 97701
(541) 383-7146
bridget_moran@fws.gov

FINAL ENVIRONMENTAL IMPACT STATEMENT

FOR THE DESCHUTES BASIN HABITAT CONSERVATION PLAN

VOLUME I: CHAPTERS 1–7

OCTOBER 2020

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

Table of Contents

Executive Summary ES-1

ES.1 Introduction ES-1

ES.2 Proposed Federal Action ES-2

ES.3 Purpose and Need for Federal Action ES-2

ES.4 Public Involvement ES-4

ES.5 Alternatives ES-4

ES.5.1 Alternative 1 – No Action ES-4

ES.5.2 Alternative 2 – Proposed Action ES-5

ES.5.3 Alternative 3 – Enhanced Variable Streamflows ES-6

ES.5.4 Alternative 4 – Enhanced and Accelerated Variable Streamflows ES-7

ES.6 Environmental Consequences ES-7

ES.6.1 Scope of Analysis ES-7

ES.6.2 General Approach to Analysis ES-8

ES.6.3 Summary of Impact Analysis ES-8

Chapter 1 **Purpose and Need 1-1**

1.1 Introduction 1-1

1.2 Proposed Federal Action 1-2

1.2.1 Purpose and Need for Federal Action 1-2

1.3 National Environmental Policy Act 1-4

1.4 Scope of Analysis 1-4

1.5 Scoping and Public Engagement 1-5

1.6 NEPA Cooperating Agencies 1-5

1.7 Tribal Consultation 1-6

1.8 Draft EIS Public Comment Period 1-6

1.9 Changes to the EIS between Draft and Final 1-6

Chapter 2 **Proposed Action and Alternatives 2-1**

2.1 Alternatives Analyzed in the EIS 2-1

2.1.1 Alternative 1: No Action 2-1

2.1.2 Alternative 2: Proposed Action 2-7

2.1.3 Alternative 3: Enhanced Variable Streamflows 2-13

2.1.4 Alternative 4: Enhanced and Accelerated Variable Streamflows 2-15

2.2 Comparison of Alternatives 2-18

2.3 Alternatives Considered but Eliminated from Further Consideration 2-20

2.3.1 Alternative 1. Accelerated Increases in Upper Deschutes River Fall/Winter Minimum Flows 2-20
2.3.2 Alternative 2. Enhanced Increases in Upper Deschutes River Fall/Winter Minimum Flows and 50-Year Permit Term 2-20
2.3.3 Alternative 5. Modified Upper Deschutes River Fall/Winter Minimum Flows 2-20
2.3.4 Alternative 6. Enhanced Variable Upper Deschutes River Fall/Winter Minimum Flows 2-21
2.3.5 Alternative 7. Variable Deschutes River Fall/Winter Minimum Flows with Reduced Permit Term 2-21
2.3.6 Alternative 8. Reduced Covered Species 2-21
2.3.7 Alternative 9. Limit Covered Activities to Deschutes River 2-21
2.3.8 Alternative 10. Continuation of 2017/2018 Fall/Winter Flows on the Upper Deschutes River 2-21
2.3.9 Alternative 11. Deschutes River Flow and Restoration/Enhancement 2-21
2.3.10 Alternative 12. Flow Enhancement through Conservation, Demand Management, and On-Farm Efficiencies 2-22
2.3.11 Alternative 13. Reduced Permit Term 2-22
2.3.12 Alternative 14. Preliminary Injunction Alternative 2-22
2.3.13 Alternative 15. No Take Alternative 2-22

Chapter 3 **Affected Environment and Environmental Consequences 3.1-1**

3.1 Introduction 3.1-1
3.1.1 Alternatives Analyzed 3.1-1
3.1.2 Effect Determinations 3.1-2
3.1.3 Modeling 3.1-2
3.2 Water Resources 3.2-1
3.2.1 Methods 3.2-1
3.2.2 Affected Environment 3.2-4
3.2.3 Environmental Consequences 3.2-12
3.3 Water Quality 3.3-1
3.3.1 Methods 3.3-1
3.3.2 Affected Environment 3.3-2
3.3.3 Environmental Consequences 3.3-8
3.4 Biological Resources 3.4-1
3.4.1 Methods 3.4-1
3.4.2 Affected Environment 3.4-13
3.4.3 Environmental Consequences 3.4-21

3.5 Land Use and Agricultural Resources ... 3.5-1
3.5.1 Methods ... 3.5-1
3.5.2 Affected Environment ... 3.5-4
3.5.3 Environmental Consequences ... 3.5-9
3.6 Aesthetics and Visual Resources ... 3.6-1
3.6.1 Methods ... 3.6-1
3.6.2 Affected Environment ... 3.6-2
3.6.3 Environmental Consequences ... 3.6-4
3.7 Recreation ... 3.7-1
3.7.1 Methods ... 3.7-1
3.7.2 Affected Environment ... 3.7-1
3.7.3 Environmental Consequences ... 3.7-5
3.8 Tribal Resources ... 3.8-1
3.8.1 Methods ... 3.8-1
3.8.2 Affected Environment ... 3.8-2
3.8.4 Environmental Consequences ... 3.8-4
3.9 Socioeconomics and Environmental Justice ... 3.9-1
3.9.1 Methods ... 3.9-1
3.9.2 Affected Environment ... 3.9-3
3.9.3 Environmental Consequences ... 3.9-11
3.10 Cultural Resources ... 3.10-1
3.10.1 Methods ... 3.10-1
3.10.2 Affected Environment ... 3.10-3
3.10.3 Environmental Consequences ... 3.10-7
3.10.4 National Historic Preservation Act ... 3.10-10
Chapter 4 **Cumulative Impacts ... 4-1**
4.1 Introduction ... 4-1
4.2 Cumulative Actions ... 4-1
4.2.1 Land Development and Agricultural Uses ... 4-1
4.2.2 Water Supply Improvements ... 4-2
4.2.3 Public Land Management ... 4-3
4.2.4 Resource Protection and Enhancement Activities ... 4-3
4.3 Evaluation of Cumulative Effects ... 4-3
4.3.1 Water Resources ... 4-3
4.3.2 Water Quality ... 4-6
4.3.3 Biological Resources ... 4-8
4.3.4 Land Use and Agriculture ... 4-12

4.3.5 Aesthetics and Visual Resources 4-12
4.3.6 Recreation 4-13
4.3.7 Tribal Resources 4-13
4.3.8 Socioeconomics and Environmental Justice 4-14
4.3.9 Cultural Resources 4-15

Chapter 5 **Additional Topics Required by NEPA 5-1**
5.1 Unavoidable Adverse Effects 5-1
5.2 Relationship between Short-Term Uses of the Environment and the Maintenance and Enhancement of Long-Term Productivity 5-1
5.3 Irreversible or Irretrievable Commitment of Resources 5-2

Chapter 6 **List of Preparers 6-1**

Chapter 7 **Distribution List 7-1**
7.1 Federal Agencies 7-1
7.2 State Agencies 7-1
7.3 Local Agencies 7-1
7.4 Tribes 7-1
7.5 Stakeholders 7-1

Appendices

Appendix 1-A, Glossary
Appendix 1-B, References Cited
Appendix 1-C, Scoping Report
Appendix 1-D, Index
Appendix 1-E, Response to Comments
Appendix 2-A, EIS Alternatives Screening Process
Appendix 2-B, No-Action and Cumulative Scenarios
Appendix 2-C, Implementation of UD-1: Oregon Spotted Frog Conservation Fund
Appendix 3.1-A, Regulatory Environment
Appendix 3.1-B, RiverWare Model Technical Memorandum
Appendix 3.1-C, Analysis of RiverWare Model Version 18 Outputs and Implications for Final EIS
Appendix 3.2-A, Water Resources Technical Supplement
Appendix 3.4-A, Vegetation and Wildlife Technical Supplement
Appendix 3.4-B, Oregon Spotted Frog Technical Supplement
Appendix 3.4-C, Fish and Mollusks Technical Supplement
Appendix 3.5-A, Agricultural Uses and Agricultural Economics Technical Supplement
Appendix 3.10-A, Cultural Resource Technical Supplement

Tables

ES-1 Summary of Potential Impacts ES-9
1-1 Changes to EIS between Draft and Final 1-7
2-1 Water Management Operations Assumptions for No-Action Alternative 2-5
2-2 Covered Storage Reservoirs and Dams 2-8
2-3 Covered Species under the Deschutes Basin HCP 2-10
2-4 Proposed Action Conservation Measures 2-10
2-5 Alternative 3 Conservation Measures 2-14
2-6 Alternative 4 Conservation Measures 2-16
2-7 Comparison of Alternatives 2-18
3.1-1 Minimum Fall/Winter Flows (cfs) below Wickiup Dam under Proposed Action, Alternative 3, and Alternative 4 Phases 3.1-3
3.2-1 Water Year Types and Associated Hydrologic Conditions 3.2-3
3.2-2 Study Area Storage Reservoirs, Capacities, and Water Rights 3.2-5
3.3-1 Water Quality Impairments in the Study Area 3.3-4
3.3-2 Water Quality Measurements for Wickiup Reservoir, Based on Samples Collected 200 Meters South of Wickiup Dam (All samples collected in July), 2007–2016 3.3-5
3.4-1 Waterbodies Included in the Area of Potential Effects for Fish and Mollusks 3.4-11
3.4-2 Vegetation Communities in the Study Area 3.4-14
3.4-3 Wildlife Species Considered in this Analysis 3.4-15
3.4-4 Fish and Mollusks Evaluated in the EIS 3.4-18
3.4-5 Geographic Extent of Fish and Mollusks Evaluated in the EIS 3.4-20
3.4-6 Effects on Vegetation Communities by Reach under the Proposed Action Compared to the No-Action Alternative based on Modeled Changes in Seasonal Flows and Elevations 3.4-27
3.4-7 Effects on Oregon Spotted Frogs by Reach under the Proposed Action Compared to the No-Action Alternative 3.4-35
3.4-8 Effects of the Proposed Action and Alternatives 3 and 4 on Oregon Spotted Frog by Key Life History Period Compared to the No-Action Alternative 3.4-40
3.4-9 Fish and Mollusks Overall Effects Summary for Proposed Action, Alternative 3, and Alternative 4 3.4-41
3.5-1 Total Agricultural Lands in the Study Area (2017 Census Data) 3.5-5
3.5-2 Deschutes Basin Board of Control Irrigation Districts 3.5-5
3.5-3 Irrigated Agricultural Lands in the Study Area (2017 Census Data) 3.5-6
3.5-4 Proportion of Agricultural Lands Irrigated in the Study Area (2017 Census Data) 3.5-6
3.5-5 Potential Increase in Acres Equivalent Irrigated under the No-Action Alternative Compared to Existing Conditions, Dry Water Year (Acres Equivalent) 3.5-10

3.5-6 Estimated Maximum Affected Acres Equivalent Irrigated under the Proposed Action Compared to the No-Action Alternative, Median and Dry Water Years (Acres Equivalent) ... 3.5-11

3.5-7 Estimated Maximum Affected Acres Equivalent Irrigated under Alternative 3 Compared to the No-Action Alternative, Median and Dry Water Years (Acres) ... 3.5-13

3.5-8 Estimated Maximum Affected Acres Equivalent Irrigated under Alternative 4 Compared to the No-Action Alternative, Median and Dry Water Years (Acres) ... 3.5-15

3.6-1 Summary of Affected Viewer Groups and Associated Sensitivities ... 3.6-4

3.9-1 Study Area Population ... 3.9-4

3.9-2 Relationship between Resources and Socioeconomic Values and Social Groups ... 3.9-4

3.9-3 Population by Race, Ethnicity and Poverty (2013–2017) ... 3.9-6

3.9-4 Race/Ethnicity of Farm Operators by County in the Study Area ... 3.9-7

3.9-5 Selected Farmworker Socioeconomic Characteristics (Earnings, Days Hired, and Proportion Migrant) in the Study Area ... 3.9-7

3.9-6 Agriculture, Recreation/Tourism, and Total Economic Activity in Study Area, 2017 ... 3.9-8

3.9-7 Property Tax Receipts in Study Area by County ... 3.9-11

3.9-8 Annual Total Employment and Income from Forage/Grain Production under No-Action Alternative Compared to Existing Conditions, Dry Water Year ... 3.9-12

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 ... 3.9-19

3.9-10 Potential Property Value Effects by County ... 3.9-23

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 ... 3.9-26

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 ... 3.9-29

3.10-1 Monthly Water Surface Elevation (Feet) Range by Reservoir for Each Alternative ... 3.10-2

3.10-2 Archaeological Sites within 100 Meters of Waters of Wickiup Reservoir ... 3.10-6

3.10-3 Submerged and Partially Submerged Archaeological Site Information at Wickiup Reservoir ... 3.10-7

Figures

ES-1 Covered Lands and Waters and Irrigation District Service Areas 3

1-1 Covered Lands and Waters and Irrigation District Service Areas 1-3

3.2-1 Water Resources Study Area 3.2-2

3.2-2 Flood Zones and Flood Hazard Areas in the Study Area 3.2-10

3.3-1 Temperature (C), pH, and Dissolved Oxygen (mg/L) Levels in Wickiup Reservoir, based on Data Collected 200 meters South of Wickiup Dam, 2007–2016 .... 3.3-5

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 through December 3.3-12

3.3-3 Simulated Stream Discharge (Q), Water Temperature, pH, Dissolved Oxygen (DO), Nitrate/Nitrite (NO_3), and Phytoplankton (Phyto), for the Deschutes River at Benham Falls (BENO Gauge) under the Proposed Action in Years 13–30 Compared to No-Action Alternative 3.3-13

3.4-1 Biological Resources Study Area 3.4-2

3.4-2 Oregon Spotted Frog Study Area Reaches and Sites (Seasonal and Breeding) 3.4-5

3.4-3 Oregon Spotted Frog Key Life History Periods and the Flow Hydrograph for the WICO Gauge in the Upper Deschutes River 3.4-6

3.4-4 Fish and Mollusks Study Area 3.4-10

3.5-1 Agricultural Lands in the Study Area 3.5-2

3.6-1 Major Visual Resources in the Deschutes Basin 3.6-3

3.9.1 Socioeconomic Values and the Habitat Conservation Plan 3.9-2

3.9-2 Farm and Recreation/Tourism Employment and Earnings by County 3.9-9

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

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 2020)[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 one nonlisted species—sockeye salmon (*O. nerka*), which could become listed during the term of the ITPs. The Oregon spotted frog and bull trout are under FWS authority, and the two 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 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.

[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 become permittees if and when the ITPs are issued.

- 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 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). 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 and public comments received on the EIS and HCP. [4] 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 records of decision (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 frog, Middle Columbia River steelhead, and bull trout—and one nonlisted species—sockeye salmon.

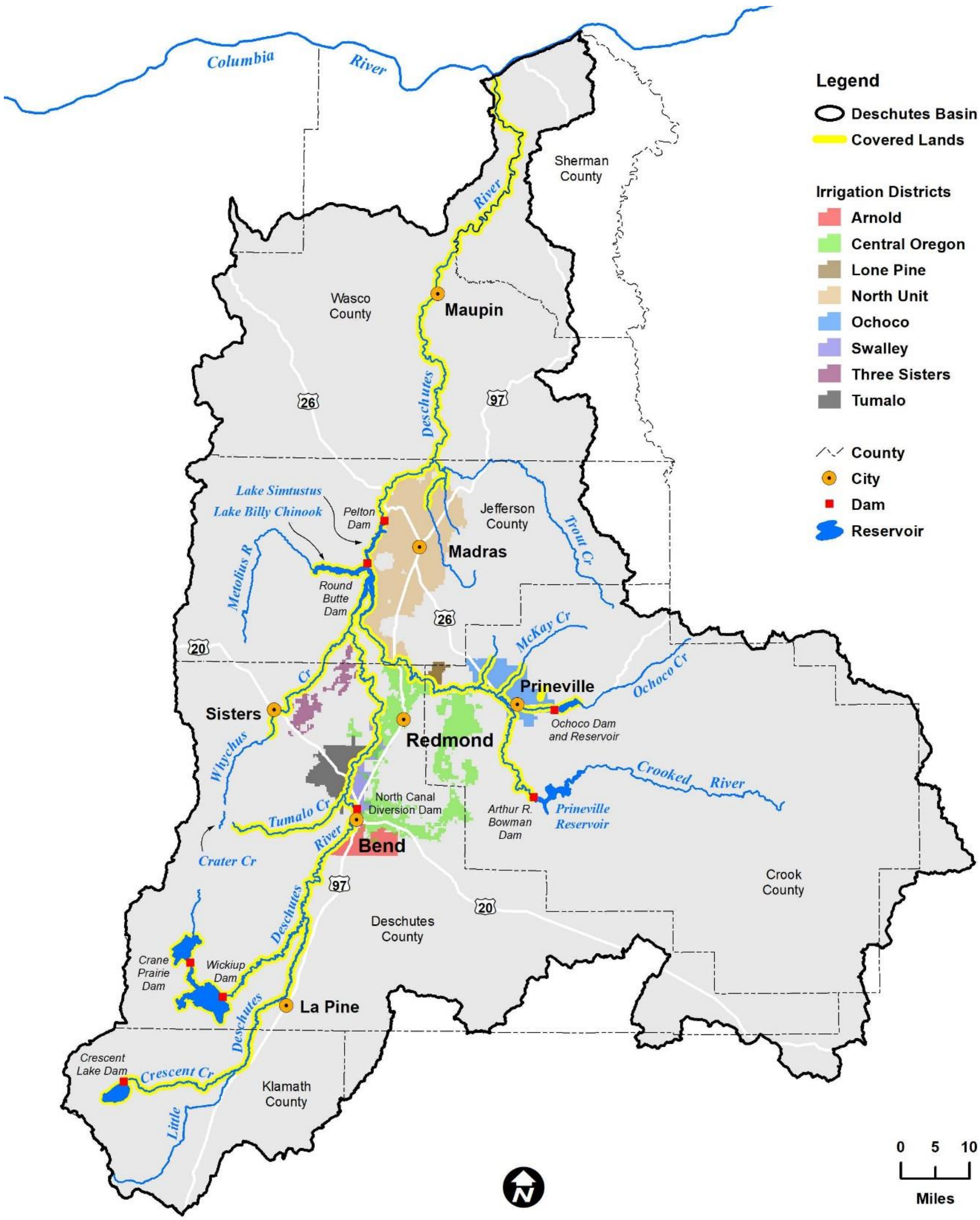
The need for the federal action is to respond to the applicants' request for ITPs for the covered species and covered activities as described in the Deschutes Basin HCP. The Services will review the ITP applications to determine if they meet permit issuance criteria. The Services will also ensure that 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. On September 21, 2020, the Services received a cover letter and revised Appendix B to the ITP applications stipulating that Chinook salmon are no longer included as a covered species.

[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.

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.

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



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 stakeholder 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.

In accordance with requirements set forth in NEPA (42 U.S.C. 4321 et seq.) and its implementing regulations (40 CFR 1500–1508) and the ESA, the Services published the Draft EIS and HCP in the *Federal Register* on October 4, 2019 (84 *Federal Register* 53164 and 53114), opening a 45-day public review and comment period. In response to public requests, the Services granted a 15-day extension to the Draft EIS and HCP public review and comment period (84 *Federal Register* 58169 and 61026), increasing the public review and comment period to 60 days up to December 3, 2019.

The Services accepted comments on the Draft EIS and HCP via online submission or hardcopy mail providing the comments were received by 11:59 p.m. Eastern Standard Time on December 3, 2019. The Services also held two open-house public meetings in Bend and Prineville, Oregon, on October 15 and 16, 2019, where computers were available to attendees to enable them to submit comments. Comments received have been considered and addressed in the Final EIS. Appendix 1-E, *Responses to Comments*, describes the public review process, identifies the number and sources of comments received, describes the approach to responding to comments, and provides responses to comments.

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 Chapter 2, *Proposed Action and Alternatives*, and Appendix 2-A, *EIS Alternatives Screening Process,* a no-take approach for the no-action alternative is not realistic, reasonable, or feasible because it would require severe restriction or substantial reduction of agricultural water supply in the basin without certainty of preventing take.

The no-action alternative considered in this EIS assumes continuation of the existing water management operations. These operations include the following: 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*;[5] 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 in Chapter 2.

[5] The current BiOp will also expire on December 31, 2020, at which time it is expected that the EIS and Deschutes Basin HCP will be completed.

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.

Based on existing knowledge, predictable future conditions under the no-action alternative analyzed in this EIS would include the Services not taking action on a permit application. 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, 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.

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 proposed action is the Services' preferred alternative.

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.[6] 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 by the City of Prineville are covered activities.

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

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—the Oregon spotted frog, Middle Columbia River steelhead trout, and bull trout—and one species that currently is not listed under the ESA—sockeye salmon. These four 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 steelhead 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 as summarized below and described in Table 2-4 of Chapter 2.

- Adjusts the range and timing of Crane Prairie Reservoir storage and drawdown rate with year-round minimum and maximum elevation levels.
- Establishes a minimum instream flow in the Deschutes River below Crane Prairie Dam.
- Increases fall and winter Deschutes River flows based on schedule of flow increases.
- Limits irrigation season flows (summer flow cap) in years 8 through 30.
- Supplements releases of uncontracted storage from Prineville Reservoir on Crooked River.
- Provides for Crooked River, Whychus Creek, and Upper Deschutes River Conservation Funds.
- 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.

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 are summarized below and described in Table 2-5 of Chapter 2.

- On the Upper Deschutes River:
  - Increases fall and winter flows below Wickiup Dam earlier in the permit term.
  - Reaches higher minimum flow targets during above-normal and wet years throughout the permit term.
  - Excludes summer cap.

- On the Crooked River:
  - Uncontracted fish and wildlife storage releases would be protected instream to Lake Billy Chinook (Conservation Measure CR-1).
  - On Whychus Creek, excludes Whychus Conservation Fund.

Alternative 3 would have the same adaptive management and monitoring program as 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 further modifications to the conservation strategy compared to Alternative 3.

- On the Upper Deschutes River:
  - Increases fall and winter flows below Wickiup Dam earlier in the permit term.
  - Reaches higher minimum flow targets during above-normal and wet years throughout the permit term.
  - Excludes summer cap.
- On the Crooked River:
  - Uncontracted fish and wildlife storage releases would be protected[a] instream to Lake Billy Chinook (Conservation Measure CR-1).
- On Whychus Creek, excludes Whychus Conservation Fund.

Alternative 4 would have the same adaptive management and monitoring program as 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, Alternatives 3 and 4 (action alternatives), and the no-action alternative. The no-action alternative effects are compared with existing conditions. The proposed action and Alternatives 3 and 4 effects are compared with 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, *Regulatory Environment*, provides the regulatory context for each resource.

Table ES-1. Summary of Potential Impacts[a]

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
Water Resources **WR-1: Change Reservoir Storage**			
Continuation of existing 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.	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, dry, and very dry years over the permit term in in Wickiup Reservoir; increase in Crescent Lake Reservoir; decrease in dry and very dry years in Prineville Reservoir; and decrease slightly in Ochoco Reservoir. These changes are used to inform the analysis of effects on water supply, groundwater, and reservoir recreation.	Reservoir storage under Alternative 3 would increase slightly during the storage season and decrease slightly during the irrigation season in Crane Prairie, progressively decrease in normal, dry, and very dry years over the permit term in in Wickiup Reservoir; increase slightly in Crescent Lake Reservoir; decrease in dry and very dry years in Prineville Reservoir; and decrease slightly in Ochoco Reservoir compared to the no-action alternative. 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 under recreation.	Changes in reservoir storage under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for Alternative 3 for all reservoirs except for Wickiup Reservoir. Changes in water supply storage in Wickiup, Prineville, and Crescent Lake Reservoirs would occur earlier in the permit term compared to Alternative 3 but would end sooner. 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 under recreation.
Water Resources **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 DBBC irrigation districts and other live flow diverters, mostly during dry and very dry years. North Unit, Arnold, Lone Pine, and Ochoco IDs would experience the largest water supply reductions. Central Oregon and Three Sisters IDs would experience relatively minor water supply reductions. Tumalo ID would experience an increase in water supply. Swalley ID would not be affected. Other Crooked River water users would experience reduced supply in very dry years. Other Deschutes River water users junior to North Unit ID would experience no change in water supply. The effects of these	Overall, changes in reservoir storage under Alternative 3 would result in varying degrees of water supply reductions for DBBC irrigation districts and other live flow diverters compared to the no-action alternative. Reductions in water supply would generally be greater than under the proposed action and would occur earlier in the permit term. Most of these reductions would occur during dry and very dry years. North Unit, Arnold, Lone Pine, and Ochoco IDs would experience the largest water supply reductions. Central Oregon ID and Three Sisters ID would experience relatively minor water supply reductions. Tumalo ID would experience a slight increase in water supply. Swalley ID would not be affected. The effects of these water	Changes in water supply under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for Alternative 3 for all users except North Unit ID, but changes would occur earlier in the permit term than under Alternative 3. Changes in water supply for North Unit ID would also occur earlier in the permit term, but changes at full implementation would be greater in magnitude during a dry water year than described for Alternative 3. The effects of these water supply changes are addressed under land use and agricultural resources, and socioeconomics and environmental justice.

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
	changes are addressed under land use and agricultural resources and socioeconomics and environmental justice.	supply changes are addressed under land use and agricultural resources and socioeconomics and environmental justice.	
Water Resources **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. If reservoir inflows during fall and winter storage exceed historical patterns due to climate change effects, Upper Deschutes River reservoir managers may have to manage reservoir stage more frequently.	The proposed action would result in more days of 90% reservoir capacity exceedance at Crescent Lake Reservoir, but the same or similar number of exceedance days at the other reservoirs compared to the no-action alternative. Therefore, effects on flood storage capacity would be not adverse. Effects of changes in reservoir surface water elevations on water quality, biological resources, aesthetics and visual resources, and recreation are addressed under the respective resources.	Changes in reservoir water surface elevations and flood storage capacity under Alternative 3 compared to the no-action alternative would be similar to or result in lower flood risk than the proposed action. Effects of changes in reservoir surface water elevations on water quality, biological resources, aesthetics and visual resources, and recreation are addressed under the respective resources.	Changes in reservoir water surface elevation and flood storage capacity under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for Alternative 3 for all reservoirs except for Wickiup Reservoir where surface water elevations would be further reduced. Effects on flood storage capacity under Alternative 4 would be not adverse compared to the no-action alternative. Effects of changes in reservoir surface water elevations on water quality, biological resources, aesthetics and visual resources, and recreation are addressed under the respective resources.
Water Resources **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. Planned water conservation projects assumed under the no-action alternative would result in increased instream flows in the Deschutes River below Wickiup in the storage season and in Tumalo Creek and the Deschutes Rivers below Bend during the irrigation season. 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 streamflows 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. During the irrigation season, flows between Wickiup and Bend would generally be lower. On the Crooked River, flows below Bowman Dam would become more variable, especially during dry years. Streamflow changes in the remainder of the study area would be minor, although seasonally important differences may affect water users and other resources. Effects of the changes are addressed under water quality, biological resources, aesthetics and visual resources, recreation, and tribal resources.	Changes in seasonal streamflows under Alternative 3 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. Streamflow would generally be higher during winter storage. Wickiup Reservoir may be drawn down more from July through September compared to the no-action alternative and the proposed action. On the Crooked River, flows below Bowman Dam could become more variable, especially during dry years as irrigation season flows increase. Streamflow changes in the remainder of the study area would be minor, although seasonally important differences may affect water users and	Changes in seasonal river and creek flows under Alternative 4 compared to Alternative 3 would be the same or nearly the same in all reaches except the Upper and Middle Deschutes 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 under water quality, biological resources, aesthetics and visual resources, recreation, and 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.

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
	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.	other resources. Effects of the changes in streamflow are addressed under water quality, biological resources, aesthetics and visual resources, recreation, and tribal resources. Changes in flood flows under Alternative 3 compared to the no-action alternative would be the same as described for the proposed action. Effects would be not adverse.	
Water Resources **WR-5: Affect Groundwater Recharge**			
Continuation of current water management operations would have no effect on groundwater recharge compared to existing conditions. 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 **WQ-1: Affect Water Quality in Deschutes River Subbasin**			
Continuation of existing water management operation is expected to 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 could be compensated somewhat by beneficial	The proposed action would result in adverse effects on water quality in Wickiup Reservoir, including decreased oxygen levels and increased phosphorous levels, which in turn, could increase intensity and duration of algae and cyanobacteria blooms in the reservoir during the summer and into early fall. Reduced water quality in Wickiup would also affect the Upper Deschutes River below Wickiup Dam, including increased turbidity	Effects of Alternative 3 on water quality in the Deschutes River Subbasin compared to the no-action alternative would be the same or nearly the same as described for the proposed action for Crane Prairie and Crescent Lake Reservoir, the Middle and Lower Deschutes, Whychus and Tumalo Creeks, and Crescent Creek. Effects on water quality under Alternative 3 compared to the no-action alternative would be	Effects of Alternative 4 on water quality in the Deschutes River Subbasin compared to the no-action alternative would be the same or nearly the same as described for the proposed action in Crane Prairie and Crescent Lake Reservoirs, the Middle and Lower Deschutes River, and Whychus and Tumalo Creeks. Winter flows in the Crescent Creek–Little Deschutes River system would not decline as much as under

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
effects associated with water conservation and restoration projects assumed under the no-action alternative over the analysis period. Overall, the effect on water quality could be adverse compared to existing conditions.	from organic matter and increased levels of cyanobacteria. However, the degree of this effect would be somewhat offset by a higher percentage of flow from springs and groundwater input. In addition, a reduction in peak flows and overall more stable river levels would be expected to reduce streambank erosion along the Upper Deschutes River and associated turbidity. Therefore, overall effects on water quality in the Upper Deschutes River are expected to be not adverse. There would be no effect on water quality in Tumalo Creek and potential minor beneficial effects in the Little Deschutes River and Whychus Creek.[a] Effects in other reservoirs and streams in the Upper Deschutes Subbasin would be not adverse. Overall, effects on water quality in the Upper Deschutes Subbasin under the proposed action would be adverse.	similar to those described for the proposed action in Wickiup Reservoir and the Upper Deschutes River, except that adverse effects in Wickiup Reservoir would be of greater magnitude and would result in potential adverse effects downstream in the Upper Deschutes River, and beneficial effects in the Upper Deschutes River would be of lesser magnitude and would occur earlier in the permit term. Flows on the Little Deschutes River would be similar to the no-action alternative and, therefore, effects on water quality would be not adverse. Overall, effects compared to the no-action alternative would be adverse.	the proposed action, but effects would still be not adverse. Effects on Wickiup Reservoir and the Upper Deschutes River would be nearly the same as described for Alternative 3, except that effects would occur earlier in the permit term. Overall, effects compared to the no-action alternative would be adverse.
Water Quality **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. Increased water temperatures in the lower Crooked River during late summer could intermittently and temporarily degrade water quality. Overall, effects of the proposed action on water quality in the Crooked River Subbasin would be not adverse compared to the no-action alternative.	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 for the Crooked River between the North Unit ID pumps and Smith Rock State Park. The effects of Alternative 3 in this reach would be slightly improved or slightly reduced compared to the proposed action, depending on the water year type and stage in the permit term. Overall, effects of Alternative 3 on water quality in the Crooked River Subbasin compared to the no-action alternative would be not adverse.	Changes in streamflows and surface water elevations under Alternative 4, 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. Effects in this reach would be the same as described for Alternative 3, except that adverse effects for the reach between the North Unit ID pumps and Smith Rock State Park would also occur in the reaches upstream to Bowman Dam. Overall, effects of Alternative 4 on water quality in the Crooked River Subbasin compared to the no-action alternative would be not adverse.
Biological Resources **BIO-1: Change Vegetation Communities**			
Although continuation of existing water management operations under the no-	The proposed action would have no effect on riparian and wetland vegetation in Tumalo	Effects on vegetation communities under Alternative 3 would be the same as	Changes in vegetation communities under Alternative 4 compared to the no-action

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
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.	Creek, the Deschutes River between Wickiup and Crane Prairie Reservoirs (reach Des-14), the Lower Deschutes River including Lake Billy Chinook and Lake Simtustus (reaches Des-1 and Des-2), and Prineville and Ochoco Reservoirs. Effects in Crane Prairie Reservoir, Crescent Lake Reservoir, the Upper Deschutes River, Ochoco Creek, McKay Creek, Whychus Creek, and the Crescent Creek–Little Deschutes River system would be beneficial. [a] Effects the Middle Deschutes River (reaches Des-3 to Des-6) and the Crooked River would be not adverse. Effects in Wickiup Reservoir would be adverse. Overall, the effect of the proposed action would be beneficial compared to the no-action alternative.	described for the proposed action. 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.	alternative would be the same or nearly the same as described for Alternative 3, except that effects would occur several years earlier but accrue over a shorter permit term. Overall, effects compared to the no-action alternative would be beneficial.
Biological Resources **BIO-2: Change Habitat for Wildlife Species**			
Although the continuation of existing 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 on wildlife habitat in the study area would be adverse compared to existing conditions.	The proposed action would have no effect on wildlife in Tumalo Creek, the Deschutes River between Wickiup and Crane Prairie Reservoirs (reach Des-14), the Lower Deschutes River including Lake Billy Chinook and Lake Simtustus, and Prineville and Ochoco Reservoirs. Effects in Crane Prairie and Crescent Lake Reservoirs; the Upper Deschutes River; Ochoco, McKay, and Whychus Creeks; and the Crescent Creek–Little Deschutes River system would be beneficial. [a] Effects in the Deschutes River between Wickiup and Crane Prairie Reservoirs (reach Des-14),the Middle Deschutes River (reaches Des-3 to Des-6) and the Crooked River would be not adverse. Effects in Wickiup Reservoir would be adverse. Overall, the effects of the proposed action would be beneficial compared to the no-action alternative.	Changes to habitat for wildlife species under Alternative 3 would be of the same magnitude as described for the proposed action, but would differ in timing. 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 compared to the no-action alternative would be beneficial.	Changes to habitat for wildlife species under Alternative 4 compared to the no-action alternative would be the same as described for Alternative 3, but would begin to accrue several years earlier and would occur over a shorter permit term. Overall, the effect compared to the no-action alternative would be beneficial.

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
Biological Resources **BIO-3: Affect Oregon Spotted Frog Habitat**			
Although the continuation of existing 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 all reaches except Wickiup Reservoir (Des-13 and Upper Deschutes River between Crane Prairie and Wickiup Reservoirs (Des-14) considered in this analysis, the proposed action at full implementation (years 13–30) would have a beneficial effect on the Oregon spotted frog and its habitat compared to the no-action alternative. During the first phase of implementation (years 1–7), and to a lesser extent during phase 2 (years 8–12), the proposed action would perpetuate degraded habitat conditions for Oregon spotted frog in the basin, although Conservation Measures CP-1, WR-1, CC-1, and UD-1 could be deployed to actively improve degraded conditions and offset some of those effects. Starting in phase 2 (year 8), the proposed action would have an adverse effect in Wickiup Reservoir during all life history periods of the Oregon spotted frog and in other reaches during rearing. Overall, compared to the no-action alternative, effects would be beneficial.	Beneficial and adverse effects under Alternative 3 compared to the no-action alternative would be similar to those described for the proposed action, except that both the beneficial effects in the Upper Deschutes River reaches below Wickiup Reservoir and adverse effects in Wickiup Reservoir and the reach above it would be amplified and would occur earlier in the permit term (starting in year 1 and reaching full implementation starting in year 13) and would, therefore, have a longer duration. Also, effects in Crescent Creek would be mixed: beneficial during breeding and rearing to slightly adverse during other life history periods. Effects in Crane Prairie (Des-15) would be the same as described for the proposed action. Overall, effects on Oregon spotted frog and its habitat under Alternative 3 would be beneficial compared to the no-action alternative.	Beneficial and adverse effects under Alternative 4 compared to the no-action alternative would be similar to those described for the proposed action and Alternative 3. The exceptions would be that both beneficial effects in the Upper Deschutes River reaches below Wickiup Reservoir and the adverse effects in Wickiup Reservoir and the reach above it would be amplified and would occur earlier in the permit term than under the proposed action or Alternative 3, but full implementation would occur for a shorter duration. Beneficial effects in Crane Prairie (Des-15) would be the same as described for the proposed action. Mixed effects in Crescent Creek would be similar to Alternative 3. Overall, effects on Oregon spotted frog and its habitat under Alternative 4 would be beneficial compared to the no-action alternative.
Biological Resources **BIO-4: Affect Bull Trout Habitat**			
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 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 fish species. However, the	In the Crooked River, Conservation Measures CR-4, CR-5, and CR-6 would result in partial beneficial effects on bull trout habitat. Conservation Measure WR-1 would have no effect on bull trout habitat conditions in wet water years compared to the no-action alternative, but habitat quantity and quality during bull trout critical life stages could decline in dry and normal water years at full implementation, depending on annual water management practices. This effect on bull trout habitat in the Crooked River would be adverse, but would be limited to summer months in dry and normal water years in	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. 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. Overall, effects	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. Adverse irrigation season effects in reaches of the Crooked River would also occur and

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
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 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.	years 13 through 30 of the permit term in the approximately 63 miles between Bowman Dam and Osborne Canyon. Habitat conditions would improve on the Middle Deschutes River and Whychus, Ochoco, and McKay Creeks, and would be unchanged in other areas occupied by bull trout. Overall, compared to the no-action alternative, effects would be not adverse.	compared to the no-action alternative would be not adverse.	be of slightly greater magnitude. These effects would increase, though only slightly, in the reach between the North Unit ID pumps and Osborne Canyon. 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 would be of shorter overall duration than under the proposed action or Alternative 3. Overall, effects compared to the no-action alternative would be not adverse.
Biological Resources **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 and Whychus Creek 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 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 beneficial effects would be of greater magnitude at full implementation. These beneficial effects would occur earlier in the permit term but would be of shorter overall duration than under the proposed action or Alternative 3. Overall, effects compared to the no-action alternative would be beneficial.
Biological Resources **BIO-6: Affect Steelhead Trout Habitat**			
See BIO-4.	In the Crooked River, Conservation Measures CR-1, CR-4, and CR-6 would result in beneficial effects on steelhead habitat under the proposed action compared to the no-action alternative. However, Conservation Measure WR-1 would have an adverse effect on water temperatures and juvenile habitat in all water year types in years 13–30 of the permit term, depending on annual water management practices. Adverse effects on the Crooked River would be limited to summer months in reaches where existing	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 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 Crooked River would occur slightly earlier in the permit term and, therefore, be of longer duration.	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 would be of greater magnitude than described for the proposed action. These beneficial and adverse effects would occur

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
	conditions are less favorable to steelhead trout. Conditions would improve in Whychus Creek, the Middle Deschutes River, and Ochoco and McKay Creeks, and would be unchanged in other areas occupied by steelhead trout. Across the entire study area, overall effects of the proposed action on steelhead trout habitat compared to the no-action alternative would be not adverse.	Overall, compared to the no-action alternative, effects would be not adverse.	earlier in the permit term but would be of shorter overall duration than under the proposed action and Alternative 3. Overall, compared to the no-action alternative, effects would be not adverse.
Biological Resources BIO-7: Affect Steelhead Trout Migratory Life Stages			
See BIO-4.	In all river reaches, there would be a beneficial effect or 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 a small beneficial effect on steelhead migration. In Whychus Creek, access to additional habitat would provide beneficial effects. In the Crooked River, water temperature changes would have no effect or possibly small beneficial effects with more preferred days during steelhead trout migration. Protection of pulse streamflows on the Crooked River would have a beneficial effect on steelhead migration. In Ochoco and McKay Creeks, increased streamflows would have small beneficial effects. Overall, 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 BIO-8: Affect Spring Chinook Salmon Habitat			
See BIO-4.	In the Crooked River, Conservation Measures CR-1, CR-4, 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	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, except for in the Crooked River reach between the North Unit ID pumps and Osborne Canyon where adverse effects would be of slightly	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

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
	quality during juvenile Chinook salmon summer rearing and adult holding in some reaches in dry and normal water years toward the end of the permit term, depending on annual water management practices. Furthermore, increased North Unit ID reliance on the Crooked River under Conservation Measure WR-1 would decrease streamflows and adversely affect spring Chinook salmon habitat on the Crooked River downstream of the North Unit ID pumps. Effects would be not adverse in the remainder of the Crooked River, beneficial in Whychus Creek and Ochoco Creek, and unchanged in other portions of the study area occupied by spring Chinook salmon. Across the entire study area, effects would be not adverse compared to the no-action alternative.	lesser magnitude than described for the proposed action. 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.	magnitude than described for the proposed action. These beneficial and adverse effects would occur earlier in the permit term but would be of shorter overall duration than under the proposed action or Alternative 3. Overall, compared to the no-action alternative, effects would be not adverse.
Biological Resources BIO-9: Affect Spring Chinook Salmon Migratory Life Stages			
See BIO-4.	In the Crooked River, water management operations under the proposed action compared to the no-action alternative would have no effect on migrating adult spring Chinook salmon and migrating spring Chinook salmon smolts from March to April, but may result in an adverse effect on habitat for adult spring Chinook salmon migrating in May, June, July, and August. There would be no effects in other areas occupied by migrating spring Chinook salmon. Increases in streamflows in other portions of the study area would not change enough to suggest an overall effect during spring Chinook salmon migration life stages. 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 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. Overall, compared to the no-action alternative, effects would be not adverse.

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
Biological Resources BIO-10: Affect Sockeye Salmon Habitat			
See BIO-4.	In the Middle Deschutes River, increased winter streamflows would be relatively small in locations used by sockeye salmon 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 small. 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 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.	Same as proposed action.	Same as proposed action.
Biological Resources BIO-12: Affect Redband Trout Habitat			
See BIO-4.	There would be no effect on redband trout habitat in Tumalo Creek, the Lower Deschutes River, Lake Billy Chinook, Lake Simtustus, and Prineville Reservoir under the proposed action compared to the no-action alternative. Overall, there would no effect on redband trout in Crane Prairie Reservoir and the Upper Deschutes River between Crane Prairie Reservoir and Wickiup Reservoir, and a not adverse effect in Crescent Creek. There would be a beneficial effect in the Upper and Middle Deschutes River, Little Deschutes River,[a] Crescent Lake Reservoir, and Whychus, Ochoco, and McKay Creeks. There would be adverse effects on redband trout habitat in Wickiup Reservoir and the Crooked River. Adverse effects in the Crooked River would be limited to summer months. Overall, across the entire study area the proposed action would have a beneficial effect on redband trout habitat compared to the no-action alternative.	Effects on redband trout 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 Upper Deschutes River, Wickiup Reservoir, Crescent Lake Reservoir, Crescent Creek, Little Deschutes River, and the Crooked River between North Unit ID pumps and Osborne Canyon. Effects on redband trout on the Upper Deschutes River would be beneficial compared to the no-action alternative for the reasons described for the proposed action. Channel complexity for juvenile redband trout could be reduced, compared to the proposed action, without the summer flow cap. Conditions in Wickiup Reservoir would be more adverse under Alternative 3 compared to the proposed action. In Crescent Lake Reservoir, there would likely be no discernable effect on redband trout connectivity to tributary spawning habitat compared to the no-action alternative. In	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, except for Crescent Lake Reservoir, Crescent Creek, the Little Deschutes River, Wickiup Reservoir, the Upper and Middle Deschutes River, and the Crooked River. Under Alternative 4, effects on redband trout habitat in Crescent Creek, the Little Deschutes River, and Crescent Lake Reservoir would be the same or nearly the same as described for Alternative 3. Beneficial effects on redband trout habitat in the Middle Deschutes River and Crooked River would be of greater magnitude than described for the proposed action. In the Upper Deschutes River, beneficial impacts for redband trout 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
		Crescent Creek there would likely be no discernable effect on redband trout habitat compared to the no-action alternative. In the Little Deschutes River higher summer streamflows described for the proposed action would not occur and there would be no discernible effect on redband trout habitat compared to the no-action alternative. In the Crooked River between North Unit ID pumps and Osborne Canyon, effects would be adverse but of slightly lesser magnitude compared to the no-action alternative. 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. The combination of effects on Wickiup Reservoir and the Upper Deschutes River below Wickiup Reservoir would occur earlier in the permit term and could lead to adverse water quality effects of higher magnitude than the proposed action. Overall, the effects on redband trout habitat under Alternative 3 would be not adverse compared to the no-action alternative.	Adverse effects in Wickiup Reservoir and the Crooked River would also be the same as described for the proposed action but of greater magnitude. In the Crooked River, adverse effects in summer would also be of greater magnitude than described for the proposed action. Beneficial and adverse effects in the Crooked River would occur earlier in the permit term but would be of shorter overall duration than under the proposed action or Alternative 3. Overall, effects on redband trout habitat under Alternative 4 would be not adverse compared to the no-action alternative for the reasons described for the proposed action and Alternative 3.
Biological Resources **BIO-13: Affect Nonnative Resident Trout Habitat**			
See BIO-4.	The proposed action would have no effect in several reaches and beneficial effects in the Upper Deschutes River, Middle Deschutes River, Little Deschutes River[a], and Whychus, Ochoco, and McKay Creeks. There would be an adverse effect in Wickiup Reservoir. Overall, the effect of the proposed action would be not adverse on nonnative trout habitat compared to the no-action alternative.	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, except in the Upper Deschutes River, Crescent Lake Reservoir, Crescent Creek, Little Deschutes River, and the Crooked River between North Unit ID pumps and Osborne Canyon, as described for redband trout (Impact BIO-12). Effects in Wickiup Reservoir, the Upper and Middle Deschutes River, and Crooked River would be of longer duration. Overall, compared to	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, except Crescent Lake Reservoir, Crescent Creek, the Little Deschutes River, and Wickiup Reservoir, where effects would be the same as described for Alternative 3. Effects in Wickiup Reservoir, the Upper and Middle Deschutes River, and the Crooked River would occur earlier in the permit term but would be of shorter overall duration than under the proposed action or Alternative 3.

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
		the no-action alternative, effects would be not adverse.	Overall, effects under Alternative 4 would be not adverse compared to the no-action alternative.
Biological Resources 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 BIO-15: Affect Kokanee Salmon Habitat			
See BIO-4.	There would be no effect on kokanee salmon habitat in Lake Billy Chinook, Lake Simtustus, or Whychus Creek. Effects would be adverse in Wickiup Reservoir compared to the no-action alternative. Beneficial effects would occur in Crescent Lake and Crane Prairie Reservoirs. There would be no effect in the remaining reaches occupied by the species. Overall, compared to the no-action alternative, effects would be not adverse.	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, except for Crescent Lake Reservoir, as described for redband trout (Impact BIO-12). 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 not 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 Crescent Lake Reservoir, where effects would be the same as described for Alternative 3, and Wickiup Reservoir, where adverse effects would be the same as described for the proposed action but of greater magnitude. These effects would occur earlier in the permit term but would be of shorter overall duration than under the proposed action or Alternative 3. Overall, compared to the no-action alternative, effects would be adverse.
Biological Resources 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 (as described for redband trout in Impact BIO-12) and the Crooked River, not adverse in the Upper Deschutes River, beneficial in the Middle Deschutes River, Little Deschutes River,[a] 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 for Crescent Lake Reservoir, Crescent Creek, and the Little Deschutes River, as described for redband trout (Impact BIO-12). 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	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 Crescent Lake Reservoir, Crescent Creek, and the Little Deschutes River, where effects would be the same as described for Alternative 3 and the Upper Deschutes River, Wickiup Reservoir and the Crooked River. Adverse effects in Wickiup Reservoir and in the Crooked River would be the same as described for the proposed action but of slightly greater magnitude. These

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
		action. Overall, compared to the no-action alternative, effects would be not adverse.	effects would occur earlier in the permit term but would be of shorter overall duration than under the proposed action or Alternative 3. Overall, compared to the no-action alternative, effects would be not adverse.
Biological Resources **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. Effects would be adverse in the Crooked River. Overall, compared to the no-action alternative, effects would be a mixture of beneficial, not adverse and adverse depending on the species.	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 adverse effects in the Crooked River would only include floater species mussels and western pearlshell mussels. There would be no effect on freshwater mollusk habitat in the Little Deschutes River. 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 Alternative 3. Effects in Wickiup Reservoir, the Upper and Middle Deschutes River, and the Crooked River would occur earlier in the permit term but would be of shorter overall duration than under the proposed action or Alternative 3. Overall, compared to the no-action alternative, effects would be not adverse.
Land Use and Agricultural Resources **LUAG-1: Change Irrigated Agricultural Acreage**			
Under the no-action alternative, the water available to crops in dry water years is anticipated to decrease over time due to climate change, but increase over time compared to existing conditions because of on-farm and district water conservation through the piping of canals and increased irrigation efficiency. The aggregate effect of conservation and climate change may result in possible beneficial or adverse effects on total irrigated acreage, depending on the overall effect on the total amount of water available for irrigation compared to existing conditions. Population growth in the region may have an adverse effect on	Reduced water supply under the proposed action would result in increased fallowing or deficit irrigation of irrigated lands in dry years in Lone Pine ID and North Unit ID. These changes in the acreage of land irrigated 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 fallowing or deficit irrigation of irrigated lands could affect the local economy.	Reduced water supply under Alternative 3 compared to the no-action alternative would result in increased fallowing or deficit irrigation of irrigated lands in North Unit ID, Arnold ID, and Lone Pine ID. Increased fallowing or deficit irrigation would be similar to but greater than that described for the proposed action. These changes in the acreage of land irrigated 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. The effects of increased fallowing or deficit irrigation of irrigated lands on local the	Reduced water supply under Alternative 4 compared to the no-action alternative would result in increased fallowing or deficit irrigation of irrigated lands in North Unit ID, Arnold ID, and Lone Pine ID. Increased fallowing or deficit irrigation would be similar to but greater than that described under the proposed action and Alternative 3. These changes in acreage of land irrigated 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. The effects of increased fallowing or deficit irrigation of irrigated lands on

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
agricultural lands through increased urbanization and associated conversion of agricultural land to urban uses within established urban growth boundaries. Additionally, population growth in the region may result in increased fragmentation of agricultural land into smaller lifestyle or hobby farms. Therefore, effects on agricultural land use under the no-action alternative in terms of total irrigated lands and total land in agricultural use may be beneficial or adverse, depending primarily on future water availability and population growth patterns.		economy are discussed in socioeconomics and environmental justice.	local the economy are discussed in socioeconomics and environmental justice.
Aesthetics and Visual Resources **AES-1: Change Visual Character and Quality of Lands and Waters in the Direct Effects Study Area**			
Although the continuation of existing 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. 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, Crescent Lake Reservoir, and the lower three reaches of the Crescent Creek–Little Deschutes River system 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. Changes in flows would reduce the number of days that many popular whitewater runs in the Upper Deschutes could be used, but would have little effect on popular lower reaches of the Deschutes River or other areas of the Deschutes used for water recreation. 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 both beneficial and adverse effects related to changes in hydrology under Alternative 3 would occur earlier in the permit term than under the proposed action, so they would be of greater duration. 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 similar to those described for Alternative 3, but the changes would occur several years earlier but over a shorter permit term. Overall, compared to the no-action alternative, effects would be not adverse.

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
Aesthetics and Visual Resources **AES-2: Change Visual Character and Quality of Irrigated Lands**			
See AES-1.	Changes in visual character and quality of irrigated croplands under the proposed action compared to the no-action alternative would only occur in dry years and would not be notable, and other water users, including residential developments and golf courses, would not be affected. Therefore, compared to the no-action alternative, effects would be not adverse.	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. Reduced irrigation of agricultural lands would affect a greater acreage under Alternative 3 than the proposed action. There would also be a small increase in affected acreage in North Unit ID in normal water years near the middle of the permit term and would have an overall longer duration under Alternative 3 than the proposed action. In addition, these changes would occur earlier in the permit term and would have a longer duration under Alternative 3 than the proposed action. Compared to the no-action alternative, effects would be not adverse.	Changes in irrigation water application and associated effects on the visual character and quality of irrigated lands under Alternative 4 compared to the no-action alternative would be similar to those described for the proposed action and Alternative 3. Reduced irrigation of agricultural lands would affect slightly greater acreage under Alternative 4 than the proposed action or Alternative 3 in Lone Pine ID and North Unit ID in dry years. Affected acreage in North Unit ID in normal water years identified for Alternative 3 would also increase under Alternative 4. In addition, these changes would occur earlier but over a shorter permit term than the proposed action or Alternative 3. As described for the proposed action, the reduced irrigation would not result in notable changes in visual character and the quality of irrigated lands and would, therefore, be not adverse compared to the no-action alternative.
Recreation **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.	The proposed action would result in adverse effects on whitewater sports in the Upper Deschutes. The proposed action would also result in more natural and consistent flows and improved shoreline vegetation, fish and wildlife habitat, and aesthetics. In the Upper Deschutes River Basin, recreational opportunities and experiences other than whitewater rafting 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	Changes in recreational opportunities or quality of experiences in and along rivers, creeks, and reservoirs under Alternative 3 compared to the no-action alternative would be similar to those described for the proposed action, with reduced summer flows, more natural and stable overall flow levels and associated improvement in shoreline vegetation, fish and wildlife habitat, and aesthetics. Eliminating the flow cap would also reduce beneficial effects on shoreline vegetation, although improvements would still occur due to overall less extreme flow levels. In addition, under Alternative 3, the duration of both	Effects on recreational opportunities and experiences related to reservoir levels and streamflows under Alternative 4 compared to the no-action alternative would be the same as described for Alternative 3, except that beneficial and adverse effects would start earlier and would have an overall shorter duration. Overall, effects on recreation under Alternative 4 compared to the no-action alternative would be not adverse for the reasons 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
	opportunities and experiences. Wickiup Reservoir is the one exception, where low water events may occur more frequently or with more severity; this would result in adverse effects related to access and aesthetic values and recreational opportunities and experiences. Some adverse effects would occur on the recreationally popular redband trout in Wickiup Reservoir and portions of the Crooked River. Overall, compared to the no-action alternative, effects would be not adverse.	beneficial and adverse effects related to reduced flows would be greater than under the proposed action because they would begin earlier in the permit term. Alternative 3 would reduce opportunities for whitewater recreation in the Upper Deschutes, although to a lower extent than under the proposed action. Overall, effects on recreation under Alternative 3 compared to the no-action alternative would be not adverse for the same reasons identified for the proposed action.	
Recreation **REC-2: Conflict with Existing and Future Wild and Scenic River Designations**			
See REC-1.	While the proposed action would reduce whitewater opportunities, it would improve vegetation, shorelines, and other recreational opportunities. Therefore, the overall effect of the proposed action on designated Wild and Scenic River and State Scenic Waterways reaches would be not adverse compared to the no-action alternative.	Effects on existing and future Wild and Scenic River designations under Alternative 3 compared to the no-action alternative would be similar to those described for the proposed action, with the exception that adverse effects on whitewater rafting in the Upper Deschutes would be lower without the cap on irrigation season flows. As with the proposed action, Alternative 3 would result in more natural and consistent flows and enhanced ecological function on the Upper Deschutes River. Both beneficial and adverse effects would involve a longer duration. Overall, compared to the no-action alternative, effects would be not adverse for the reasons described for the proposed action.	Effects on the values and uses of Wild and Scenic Rivers associated with changes to streamflows under Alternative 4 compared to the no-action alternative would be the same as described for Alternative 3, except that beneficial and adverse effects would start earlier and have an overall shorter duration. Overall, effects on designated Wild and Scenic River reaches under Alternative 3 would be not adverse compared to the no-action alternative for the reasons described for the proposed action.
Tribal Resources **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-	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 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 in the Upper and	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

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
action alternative would be adverse compared to existing conditions. Although the continuation of existing 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 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.	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 salmon. Changes in Wickiup Reservoir elevation, volume, and water quality 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.	Middle Deschutes River, Wickiup Reservoir, and Crooked River. Streamflows during the irrigation season in the Crooked River would be higher than described for the proposed action during release of uncontracted fish and wildlife storage from Prineville Reservoir. Beneficial effects in the Upper Deschutes River would be not as great without the summer cap on streamflow included in Conservation Measure WR-1 under the proposed action in years 13 through 30. Adverse effects in Wickiup Reservoir would be more severe under Alternative 3 than described for the proposed action because reservoir elevation and volume would be lower and would vary more under Alternative 3. 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.	Wickiup Reservoir, in the Upper and Middle Deschutes River, and the Crooked River where both beneficial and adverse effects would be of greater magnitude. These effects would occur earlier in the permit term than under the proposed action or Alternative 3, but effects of full implementation would be of a shorter duration. Overall, compared to the no-action alternative, effects would be not adverse.
Tribal Resources **TR-2: Affect Reintroduction of Salmon and Steelhead into Habitats Upstream of the Pelton-Round Butte Complex**			
See TR-1.	Under the proposed action, the effects of reintroducing salmon and steelhead into habitats upstream of the Pelton-Round Butte Complex 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 on the Crooked River that could delay or prevent reintroduction success and potentially result in reintroduction failure. Overall, compared to the no-action alternative, effects would be adverse, despite small beneficial effects in the Middle Deschutes River, Whychus Creek, Ochoco Creek, and McKay Creek.	Under Alternative 3, the effects on reintroducing salmon and steelhead into habitats upstream of the Pelton-Round Butte Complex compared to the no-action alternative would be the same as described for the proposed action, except that adverse effects in the Crooked River described for the proposed action would be of slightly lesser magnitude due to instream protection of uncontracted fish and wildlife releases under Alternative 3. 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,	Under Alternative 4, the effects on reintroducing salmon and steelhead into habitats upstream of the Pelton-Round Butte Complex 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, but effects of full implementation would be of a shorter duration. Overall, compared to the no-action alternative, effects would be adverse.

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
	As described in more detail in Section 3.8, *Tribal Resources*, the effect conclusion for Impact TR-2 should not be directly compared to the effect conclusions for Impacts BIO-6 through BIO-9. Impact TR-2 is specific to effects on reintroduction; whereas Impacts BIO-6 through BIO-9 evaluate effects on steelhead and spring Chinook salmon habitat and migratory life stages across the entire study area.	compared to the no-action alternative, effects would be adverse.	
Tribal Resources **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 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. Overall, compared to the no-action alternative, effects would be not adverse.	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 or nearly the same as described for the proposed action. Adverse effects in Wickiup Reservoir would be more severe under Alternative 3 than described for the proposed action because reservoir elevation, and volume would be lower and would vary more than it would under Alternative 3. 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.	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 and would occur earlier in the permit term, but would be of a shorter duration at full implementation. Overall, compared to the no-action alternative, effects would be not adverse.
Tribal Resources **TR-4: Affect Warm Springs Tribes' Reservation Reserved Water Right**			
See TR-1.	There would be no effect on the Warm Springs Tribes' ability to exercise their reserved 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 **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	Reductions in irrigation water availability under the proposed action compared to the no-action alternative would result in reductions in agricultural production and	Effects on economic opportunity (employment and income) under Alternative 3 compared to the no-action alternative would consist of reductions in	Effects on economic opportunity (employment and income) under Alternative 4 compared to the no-action alternative would consist of reductions in

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
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 related to these resources would be adverse to not adverse compared to existing conditions.	associated economic contribution. These reductions are concentrated in North Unit ID and Jefferson County. Decreased employment and income opportunities in other counties would be less than 1% of total economic activity. Compared to the no-action alternative, effects would be not adverse.	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 (under the low conservation scenario). Effects in other counties would be 0% of total economic activity and are therefore considered not adverse compared to the no-action alternative.	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 activity and are therefore considered not adverse.
Socioeconomics and Environmental Justice **SOC-2: Affect Recreation Value**			
See SOC-1.	The proposed action would decrease economic value for whitewater sports in Upper Deschutes River reaches downstream of Wickiup and all recreational uses at Wickiup Reservoir, and increase recreational value for aesthetics, bank stability and vegetation, fish and wildlife habitat, and associate recreational values in the Upper Deschutes. The overall effect on economic values of recreation 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 similar to those described for the proposed action but would occur earlier in the permit term. In addition, flow caps would not be place on the Upper Deschutes River, so extreme flow events are expected to continue to provide some opportunities for whitewater rafting at popular reaches. However, the absence of a cap would diminish but not eliminate the benefits of improved bank stability, shoreline vegetation, and fish and wildlife habitat that would occur under the proposed action. Across the study area, effects on socioeconomic value related to recreation would be not adverse compared to the no-action alternative.	Effects on recreation value 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. Overall, effects on socioeconomic value related to recreation would be not adverse compared to the no-action alternative.

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
Socioeconomics and Environmental Justice SOC-3: Affect Habitat and Species-Related Cultural and Economic Values			
See SOC-1.	Depending on the species, location, and habitat type, there may be beneficial or adverse effects on habitat and species and associated socioeconomic values. Overall, as species and habitats are anticipated to experience not adverse to beneficial effects, there would be no effect to beneficial effects expected on cultural and economic values associated with species and habitat conservation.	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 and, therefore, be of longer duration under Alternative 3 than under the proposed action.	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 would be of shorter overall duration than under the proposed action or Alternative 3. Further, for some species, 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.
Socioeconomics and Environmental Justice 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. 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.	Effects would be the same as the proposed action, but effects would occur slightly earlier in the permit term.	Effects would be the same or nearly the same as the proposed action, but effects would occur earlier in the permit term.
Socioeconomics and Environmental Justice SOC-5: Affect Urban/Suburban Water Supply Availability and Costs			
See SOC-1.	Reduced irrigation water diversions under the proposed action are expected to have a not adverse effect on the availability and cost of water for urban or suburban users of district irrigation water compared to the no-action alternative, except in very dry years.	Reduced irrigation diversions under Alternative 3 compared to the no-action alternative, particularly in dry water years, could have an adverse effect on availability and cost of water for urban/suburban users of district irrigation water, particularly in Arnold ID.	Reduced irrigation diversions under Alternative 4 compared to the no-action alternative, particularly in dry water years, could have an adverse effect on availability and cost of water for urban/suburban users of district irrigation water, particularly in Arnold ID, similar to Alternative 3 but of slightly greater magnitude.

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
Socioeconomics and Environmental Justice 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 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 would be the same or nearly the same as the proposed action but would occur slightly earlier in the permit term.	Effects would be the same or nearly the same as the proposed action but would occur earlier in the permit term.
Socioeconomics and Environmental Justice 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. Similarly, the effect of changes in employment and income on local government spending is expected to be not adverse.	Effects would be the same or nearly the same as the proposed action but would occur slightly earlier in the permit term and would be of slightly greater magnitude.	Effects would be the same or nearly the same as the proposed action but would occur earlier in the permit term and would be of slightly greater magnitude.
Socioeconomics and Environmental Justice SOC-8: Affect Social Values Associated with Community Character and Way of Life			
See SOC-1.	Recreation-related effects on social values associated with community character and way of life under the proposed action compared to the no-action alternative would be not adverse. If some ranches and farms are no longer economically viable in the study area (most likely to occur in North Unit ID in Jefferson County) 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.	Effects would be the same or nearly the same as the proposed action but would occur slightly earlier in the permit term and could be of slightly greater magnitude.	Effects would be the same or nearly the same as the proposed action but would occur earlier in the permit term and could be of slightly greater magnitude.

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
Socioeconomics and Environmental Justice **SOC-9: Affect Environmental Justice Populations**			
See SOC-1.	Effects on tribal cultural and economic values associated with species and habitat conservation may be beneficial, not adverse, or adverse due to the variety of effects on different species and locations. Any 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. Any increased environmental compliance costs associated with the Pelton Round-Butte Project, which is co-owned by the Confederated Tribes of Warm Springs, would be partially borne by the tribe under the proposed action compared to the no-action alternative. These adverse effects on tribal cultural and economic values may constitute a disproportionately high and adverse effect on the tribal environmental justice population. Reduced agricultural income and employment opportunities would result in negative economic impacts on minority and low-income farmworkers (an environmental justice population of concern), which could appreciably exceed those experienced by the general population. Therefore, effects on environmental justice populations could be disproportionally high and adverse.	Effects would be the same or nearly the same as the proposed action but would occur slightly earlier in the permit term and could be of slightly greater magnitude.	Effects would be the same or nearly the same as the proposed action but would occur earlier in the permit term and could be of slightly greater magnitude.

Alternative 1 – No Action	Alternative 2 – Proposed Action	Alternative 3 – Enhanced Variable Streamflows	Alternative 4 – Enhanced and Accelerated Variable Streamflows
Cultural Resources **CUL-1: Disturb Cultural Resources**			
Continuation of existing water management operations of Wickiup Reservoir under the no-action alternative is likely to result in continued erosion, exposure, and burial of cultural resources in the study area reservoirs at a rate that is consistent with existing conditions. Long-term climate change could incrementally intensify impacts related to looting. The no-action alternative would have an adverse effect on cultural resources.	While water surface elevation range under the proposed action would remain comparable to the no-action alternative across the study area reservoirs, the duration of ground surface exposure across various elevations would substantively differ from the no-action alternative at the Wickiup Reservoir, Crescent Lake, and Crane Prairie. In Crescent Lake and Crane Prairie Reservoirs, the proposed action would result in an overall reduction in ground surface exposure, which would reduce the amount of time cultural resources would be subject to looting and erosion as reservoir levels oscillate relative to the no-action alternative—a beneficial effect on cultural resources. In Wickiup Reservoir, duration of ground surface exposure at the upper elevations of the reservoir would increase relative to the no-action alternative, increasing the potential for cultural resources to be subject to looting and erosion. Overall, effects on cultural resources under the proposed action would be adverse relative to the no-action alternative, despite beneficial effects in Crane Prairie and Crescent Lake Reservoirs.	Alternative 3 would have no effect on cultural resources related to range of water surface elevation in Crane Prairie, Wickiup, Crescent Lake, and Ochoco Reservoirs compared to the no-action alternative for the reasons described for the proposed action. Alternative 3 would have an adverse effect related to range of water surface elevation at Prineville Reservoir. Effects on cultural resources under Alternative 3 associated with duration of ground surface exposure at the upper elevations compared to the no-action alternative would be the same as described for the proposed action in Crane Prairie, Wickiup, Crescent Lake, and Ochoco Reservoirs, except that adverse effects in Wickiup Reservoir would be greater than under the proposed action and beneficial effects at Crescent Lake would be greater than under the proposed action. At Prineville Reservoir, lower water surface elevation under Alternative 3 would result in an adverse effect. Effects on cultural resources under Alternative 3 would be adverse relative to the no-action alternative.	Effects on cultural resources relative to the no-action alternative would be the same as outlined for Alternative 3.

[a] See Appendix 3.1-C, *Analysis of RiverWare Model Version 18 Outputs and Implications for Final EIS*, for correction due to modeling update.

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 Final Deschutes Basin Habitat Conservation Plan (Deschutes Basin HCP) (Deschutes Basin Board of Control and City of Prineville 2020)[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 (IDs)—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 IDs 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 the Services.
- 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 one nonlisted species—sockeye salmon (*O. nerka*), which could become listed during the term of the ITPs. The Oregon spotted frog and bull trout are under FWS authority, and the two 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 Deschutes Basin HCP include storage, release, diversion, and return of irrigation water by the

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

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

[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 if and when the ITPs are issued.

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 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) and U.S. Department of the Interior's NEPA regulations (43 CFR 46), and the Services' *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' decisions will also be informed by the information, analyses, and findings in this EIS, and public comments received on the EIS and HCP.[4] 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 ***records of decision (RODs)***.

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.

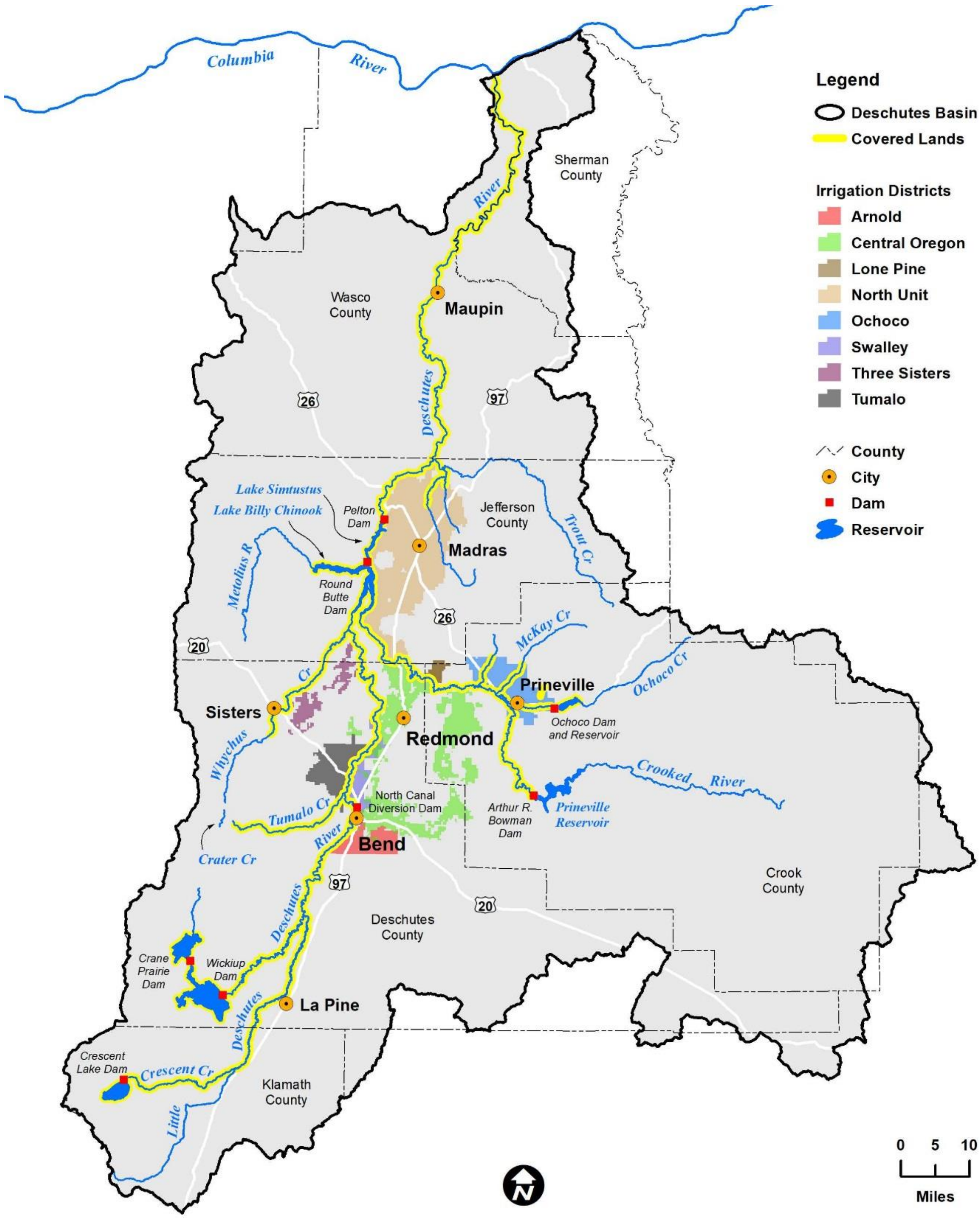
1.2.1 Purpose and Need for Federal Action

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 one nonlisted species—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.

[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



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. On September 21, 2020, the Services received a cover letter and revised Appendix B to the ITP applications stipulating that Chinook salmon are no longer included as a covered species. 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.[5] 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 action 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 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,

---

[5] On July 16, 2020, CEQ published its final rule (85 *Federal Register* 43304) modifying the regulations implementing NEPA. This final rule, which went into effect on September 14, 2020, applies only to NEPA processes begun after September 14, 2020 (40 CFR 1506.13). The Deschutes Basin HCP EIS began with the publication of an NOI in the *Federal Register* on July 21, 2017, and has, therefore, been completed under the previous CEQ regulations.

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 stakeholder 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 (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

FWS conducted cooperating agencies meetings on November 1, 2018, and September 11, 2019, to facilitate input for and understanding of the EIS contents. Cooperating agencies provided expert advice and review of administrative drafts of the EIS.

FWS included the Confederated Tribes of Warm Springs (CTWS) in the communication and document review provided to the cooperating agencies.

1.7 Tribal Consultation

Through monthly informal government-to-government meetings FWS requested tribal involvement, information, and review of materials. Prior to the NEPA scoping process, in September 2016 FWS initiated two-hour staff-level informal government-to-government consultation with CTWS and requested tribal involvement, information, and review of materials relating to the HCP. Since that initial meeting, FWS and representatives of CTWS have held approximately 27 HCP-specific consultation sessions. In addition, CTWS staff have also participated in an at least 12 water modeling-specific technical team meetings, six state, federal, and tribal HCP coordination sessions, and three NEPA cooperators' meetings. Since publication of the Draft HCP and Draft EIS, the Services and Reclamation requested formal government-to-government consultation with the CTWS Tribal Council. Representatives from the Services and Reclamation met with the CTWS Tribal Council on February 24, 2020. The Services respect, have implemented, and will continue to implement the necessary consultation processes with CTWS.

1.8 Draft EIS Public Comment Period

In accordance with requirements set forth in NEPA (42 U.S.C. 4321 et seq.) and its implementing regulations (40 CFR 1500–1508) and the ESA, the Services published the Draft EIS and Draft HCP in the *Federal Register* on October 4, 2019 (84 *Federal Register* 53164 and 53114), opening a 45-day public review and comment period. In response to public requests, the Services granted a 15-day extension to the Draft EIS and Draft HCP public review and comment period (84 *Federal Register* 58169 and 61026), increasing the public review and comment period to 60 days up to December 3, 2019.

The Services accepted comments on the Draft EIS and Draft HCP via online submission or hardcopy mail providing the comments were received by 11:59 p.m. Eastern Standard Time on December 3, 2019. The Services also held two open-house public meetings in Bend and Prineville, Oregon, on October 15 and 16, 2019, where computers were available to attendees to enable them to submit comments. Comments received have been considered and addressed in the Final EIS. Appendix 1-E, *Responses to Comments*, describes the public review process in more detail; comments received on both the Draft HCP and Draft EIS; the general approach to responding to comments; the format, content, and organization of the appendix; and the terminology used. It also provides responses to the comments received, additional information on modifications to the proposed action and action alternatives (as described in the Final HCP and the Final EIS Chapter 2, *Proposed Action and Alternatives*) and any revisions that have been made between the Draft EIS and Final EIS and Draft HCP and Final HCP (as summarized in the Final EIS Section 1.9, *Changes to the EIS between Draft and Final*).

1.9 Changes to the EIS between Draft and Final

The Final EIS reflects the following changes to the Draft EIS. In general, revisions have been made to clarify details of the proposed action, correct inadvertent errors, and provide additional information related to the analysis of impacts. No new or more significant impacts were identified as a result of these updates. Substantive revisions are identified in Table 1-1.

Table 1-1. Changes to EIS between Draft and Final

Chapter, Section, Appendix	Change
Chapter 1, Purpose and Need	• Added a description of the public comment period to Section 1.8. • Added a description of changes to the EIS between draft and final as Section 1.9.
Chapter 2, Proposed Action and Alternatives	• Updated the description of the proposed action to reflect the removal of spring Chinook as a covered species and changes to the following conservation measures to improve species conservation: ○ Conservation Measure CP-1: Modified to include added use of Crane Prairie storage in certain years for Oregon spotted frog conservation. ○ Conservation Measure WR-1: Modified timing and volume of fall/winter releases from Wickiup Reservoir and added an irrigation season flow cap. ○ Conservation Measure UD-1: Added the Upper Deschutes Basin Conservation Fund, which was only included under Alternatives 3 and 4 (as Conservation Measure DR-2) in the Draft EIS. ○ Conservation Measure CC-1: Modified winter minimum flow in Crescent Creek and added specified volume of water to be shaped for Oregon spotted frog conservation. ○ Conservation Measure WC-1: Clarified minimum flow requirement with respect to water the district has converted and may convert in the future to permanent instream water rights, as well as water the district is required to pass under Oregon water law to senior downstream water right holders. ○ Conservation Measure WC-6: Added measure for $10,000 annual conservation fund for Whychus Creek. ○ Conservation Measure WC-7: Added measure to provide in-kind services for specific restoration efforts on Whychus Creek. ○ Conservation Measure CR-6: Modified to clarify bypass requirement exclusions. ○ Conservation Measure CR-7: Added measure restricting diversion of water released on the Crooked River for a downstream fish migration pulse flow. • Updated the description of the specific no-action alternative assumptions to reflect new information and provide clarity.
Chapter 3, Affected Environment and Environmental Consequences	• All Chapter 3 resource sections and associated technical appendices reflect updated analyses in response to the changes to the proposed action described above and updated RiverWare model outputs. Model assumptions for the RiverWare model were refined between the Draft EIS and Final EIS, based on public comments. Appendix 3.1-B, *RiverWare Model Technical Memorandum* (*Preface*), lists these refinements and identifies where they are described in the memorandum. In addition, the following updates were made to Chapter 3 sections: ○ Section 3.1, *Introduction*: – Acknowledged effects of water facility maintenance activities. – Updated Table 3.1-1 comparison of fall/winter releases from Wickiup Reservoir. – Updated description of how water conservation projects were incorporated into the RiverWare model.

Chapter, Section, Appendix	Change
	○ Section 3.2, Water Resources: – Provided additional detail and recent citations to the description of climate change effects. – Provided additional information for flood control and flood flow management. – Added discussion of effects of the Central Oregon Irrigation District (Smith Rock-King Way project on water supply, flows, and groundwater; clarified effects of Tumalo ID and Swalley ID projects. ○ Section 3.3, *Water Quality*: – Added description of effects in Lake Billy Chinook and Lower Deschutes River. – Added additional information to the description of the affected environment per public comments. – Clarified connection between affected environment and environmental consequences. – Clarified discussion of effects to better tie to existing impairments and effect thresholds in responses to comments. – Added discussion of effects of return flows. – Revised and shortened text to improve readability. ○ Section 3.4, Biological Resources: – Vegetation and Wildlife ▪ Added assessment of effects of conservation measures not represented in the RiverWare output. – Oregon Spotted Frog ▪ Removed the site-specific analysis and focused on the reach-level assessment. ▪ Adjusted the life history period dates for breeding, rearing, and overwintering, and separated out a new period for pre-breeding (March 1–March 31). ▪ Added new thresholds for pre-breeding and for reaches associated with the BENO gauge. ▪ Updated analysis of Crescent Creek flows and added a tool to visualize hypothetical scenarios of how storage could be allocated to benefit Oregon spotted frogs under the proposed action. ▪ Added analysis of early phases of the proposed action and action alternatives. – Fish ▪ Revised to include Mud Springs Creek and Trout Creek in the study area and address return flow effects. ▪ Added summary table of effect conclusions by species or species group under each alternative. ○ Section 3.5, Land Use and Agricultural Resources: – Added information on trends in harvested cropland acreage, number of farms, proportion of farmland in smaller farms, data on study area population growth, and relationship between population growth on land use and agricultural land conversion.

<table>
<tr><th>Chapter, Section, Appendix</th><th>Change</th></tr>
<tr><td></td><td>
○ Section 3.7, Recreation:
– Added analysis of effects on whitewater recreational opportunities in the Upper Deschutes River reaches.
– Added effects on designated State Scenic Waterways as part of Wild and Scenic River evaluation.
○ Section 3.8, Tribal Resources:
– Expanded discussion of potential effects on tribal water rights on the Lower Deschutes River.
○ Section 3.9, Socioeconomics and Environmental Justice:
– Added to affected environment information on the overall economic contribution of the agricultural sector, general economic benefits of natural resource protection, and clarification of potentially affected environmental justice populations in the study area.
– In Impact Soc-1, added discussion of importance of carrot seed industry to the Jefferson County farm economy, possible effects on agricultural land values, potential for economic effects to be more permanent if affected workers relocate, and potential for a water market to shift the distribution of effects on economic opportunity within the study area.
– In Impact Soc-7, added discussion on potential effects on local governments of increased demand for social services.
– Impact Soc-8, identified that Jefferson County farms would be most affected.
– In Impact Soc-7, added description of potential effect of increased environmental compliance costs for Pelton-Round Butte Hydroelectric Project owners associated with fish reintroduction.
– In Impact Soc-9, clarified the three factors to evaluate effects on environmental justice populations and added environmental justice effect for the CTWS related to environmental compliance costs as a co-owner of the Pelton-Round Butte Hydroelectric Project.
○ Section 3.10, Cultural Resources:
– Updated the introduction to define cultural resources more broadly.
– Revised the methods section to more broadly focus on cultural resources rather than archaeological resources in particular.
– Updated the study area definition to include all five of the reservoirs, to explicitly rule out consideration of the areas downstream of the reservoirs, and to more precisely characterize the two main factors that have the potential to impact cultural resources.
– Updated the affected environment section to cover all five reservoirs.
– Updated the effects section based on the revised methodology and to include consideration of all five reservoirs.
</td></tr>
<tr><td>Chapter 4, Cumulative Impacts</td><td>• Revised to reflect updated effects of the proposed action and action alternatives and to address additional cumulative actions as appropriate.</td></tr>
<tr><td>Chapter 5, Additional Topics Required by NEPA</td><td>• Updated to reflect updates to Chapter 3 analyses.</td></tr>
</table>

Chapter, Section, Appendix	Change
Appendix 2-B, No-Action and Cumulative Scenarios	• Updated list of projects to reflect change in status of actions since the Draft EIS and information provided in public comments.
Appendix 2-C, Implementation of UD-1: Oregon Spotted Frog Conservation Fund	• Added detail on phases of project implementation to align with phases of the Final HCP.
Appendix 3.1-A, Regulatory Environment	• Updated to reflect additional regulations considered.
Appendix 3.1-B, RiverWare Model Technical Memorandum	• Updated to reflect the updates made to the RiverWare model used for the Final EIS.
Appendix 3.2-A, Water Resources Technical Supplement	• Added a detailed table of Crooked River water right holders.
Appendix 3.4-A, Vegetation and Wildlife Technical Supplement	• Added tables of RiverWare model outputs by reach used in the vegetation and wildlife analysis.

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 in the basin, stores and releases water at Bowman Dam on the Crooked River, and implements other related actions. On the non-federal side, the eight applicant irrigation districts (IDs) 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 purpose of this no-action alternative is to serve as a point of comparison for determining the impacts of the proposed federal action (46 FR 18026 [March 23, 1981]) throughout the term of the ITP. The purpose of the no-action alternative is not to guide the decisions of applicants in the event that an ITP is not issued.

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, or a scenario in which there is "no change" from a current management direction or level of management intensity (43 CFR 46.30). Consistent with this, the no-action alternative considered in this EIS assumes continuation of the existing water management operations. These operations include the following: the actions covered in the current ESA Section 7 Biological Opinion for the Upper Deschutes River (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.

Based on existing knowledge, predictable future conditions under the no-action alternative analyzed in this EIS would include the Services not taking action on a permit application. No ITPs for the Deschutes Basin HCP would be issued, and the applicants would remain subject to the take prohibition for listed species under 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.

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. Although this no-take approach can be feasible for projects involving terrestrial species that occur in specific or localized habitats, it is less than practical for ongoing water management operations. In the Deschutes Basin, historical operations have resulted in such significant modification to the physical structure of the river and the current location of listed species that it is unclear what flow regime, if any, could be implemented that would result in no take. No take of covered species in the context of ongoing water facility operations also does not appear to be physically possible given the broad geography affected by the current water management regime and the inability to simultaneously inundate Oregon spotted frog sites (to create suitable habitat) in the many wetland, oxbow, and riverine habitats that the Oregon spotted frog occupies. The historical impacts on the diversity of sites across this broad geography make it challenging, and likely not possible, to design a water management approach that could be implemented to prevent all take of Oregon spotted frog and other covered species. Further, a no-take scenario would likely involve severe restrictions to water supply operations that may preclude the applicants from effectively delivering irrigation water and would likely conflict with existing state and federal law, including basin water rights. Therefore, a no-take scenario was considered to be not realistic, reasonable, or feasible because it would not resolve covered species conflicts with water supply delivery and would require severe restriction or substantial reduction of agricultural water supply in the basin without certainty of preventing take.

It should be noted that defining a no-action alternative for ongoing actions can be very difficult. As discussed above, the applicants' current water management operations do not represent no take and crafting a no-take alternative for water management in the ***Upper Deschutes Basin*** as the no-action alternative is not feasible. Without further action, 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 the current actions to continue for the 30-year period of analysis that this EIS covers, FWS considers it reasonable to assume continuation of the existing water management operations, as described 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.[1] 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 right now.
- 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 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.
- Concerns regarding the selected no-action alternative—that the current operations are not intended or expected to continue for 30 years—are offset by the other factors listed above: (1) the no-action alternative reflects what is actually and currently occurring on the landscape, (2) crafting a "no take" alternative is not possible based on the physical and geographical realities in the basin, and (3) "no take" is not an appropriate choice for a no-action alternative in this situation, because of the nature and limitations of ongoing water supply facilities and operations.

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.[2]

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.

[1] The current BiOp will also expire on December 31, 2020, at which time it is expected that the EIS and Deschutes Basin HCP will be completed.

[2] 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.

  - 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 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 IDs 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.[3]
- 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).[4]
- 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.

[3] Middle Columbia River steelhead trout distinct population segment (DPS) is currently listed as threatened only downstream of the Pelton–Round Butte Project; upstream of the project the DPS has a nonessential experimental population status. In January 2025, the nonessential experimental population status will expire and the entire range of the DPS will be listed as threatened. Continuation of the reasonable and prudent measures and terms and conditions of the 2005 NMFS BiOp was assumed for the EIS analysis, because it represents the best available information at this time.

[4] Concurrent with the HCP, Reclamation is consulting with the Services under Section 7 of the ESA. Reclamation is currently preparing a biological assessment that may result in Prineville Reservoir operational changes during the permit term.

- 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).[5]
    - Tumalo ID Irrigation Modernization Project
    - Swalley ID Irrigation Modernization Project
    - Central Oregon ID Smith Rock-King Way Infrastructure Modernization Project
- Resource protection and enhancement projects including fish passage facilities at Opal Springs Dam on the Crooked River and other 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.

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). • 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. • Store up to 50,000 af except for short durations to address flood events. • 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. • Operate reservoir to minimize fluctuations in water depth between May 15 and July 15 with no stored water released before July 15. • 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. • 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.

[5] This assumption applies to all resources except agricultural resources and economic effects as described in Chapter 3, Section 3.1, *Introduction*.

Reservoir or Stream	Operations Assumptions for No-Action Alternative
Wickiup Reservoir and Deschutes River downstream of Wickiup Dam	• Operate reservoir to provide minimum instream flows of 600 cfs (WICO gauge) from April 1 through September 15 and 100 cfs from September 16 through March 31. • Operate reservoir to provide maximum instream flow (WICO gauge) of 800 cfs until April 15; from April 1 through April 30 flow can increase but not decrease. • 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. • 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). • Ramp down releases no earlier than September 1 and no later than October 31.
Crooked River Act Actions Carried out by Reclamation	

Crooked River	Release of contracted storage, 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.
	• Releases uncontracted, stored water to benefit downstream fish and wildlife. All such releases pursuant to an annual release schedule to be developed by Reclamation in coordination with the Services.
	• All stored accounts are 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:
	  ○ 68,273 af of water to fulfill 16 existing Reclamation water supply contracts;
	  ○ 2,740 af of water to supply certain McKay Creek lands;
	  ○ 10,000 af of water made available to North Unit ID (or certain other Reclamation contractors) under temporary water service contracts; and
	  ○ 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,[6] summarized in this section. The proposed action is the Services' preferred alternative.

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 Deschutes Basin HCP, Chapter 3, *Scope of the HCP,* for details on the covered lands and waters.

2.1.2.2 Covered Activities

The covered activities, summarized in this section and described in detail in the Deschutes Basin HCP, Chapter 3, *Scope of the 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.[7] 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.[8] 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.

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

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

[8] 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.

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, and Lone Pine 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 ID.

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 Deschutes Basin HCP, Chapter 3, *Scope of the 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, operational 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.[9] 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 Deschutes Basin HCP, Chapter 3, *Scope of the 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 one species that currently has no formal ESA status (Table 2-3). These four 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 and sockeye salmon.

[9] Only returns flows that occur through drains or canals operated by the applicant irrigation districts are a covered activity. Only temperature and streamflow-related effects on the covered species are covered under the HCP and associated ITPs. The applicants are not seeking take coverage for any other water quality impairments that may be caused or contributed to by return flows.

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

Scientific Name	Common Name	Listing Status: Federal Status	Listing Status: Federal Authority	Listing Status: 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 nerka	Sockeye salmon/Kokanee	None	NMFS	None

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

[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.

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 and rationale for the measures are provided in the Deschutes Basin HCP, Chapter 6, *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. Provides year-round minimum and maximum water surface elevations. Establishes a minimum instream flow of 75 cfs in the Deschutes River below Crane Prairie Dam subject to water availability. Allows for release of up to 5,000 af of stored water for covered species twice per year for the first 7 years and once every 5 years thereafter for the remainder of the permit term.

Conservation Measure	Primary Focus
WR-1: Wickiup Reservoir Operation	Adjusts the timing and volume of flow in the Deschutes River below Wickiup Dam to regulate flows during spring months, increase minimum flows during fall and winter months per the schedule below, decrease flows during summer months according to a flow cap starting in year 8, and limit ramp up and down rates during the irrigation season. Fall and winter (September 16–March 31) minimum flow schedule: • Years 1–7: 100 cfs • Years 8–12: 300 cfs • Years 13–30: 400–500 cfs Variable minimum flow between 400 and 500 cfs in years 13–30 determined based on a tool to be developed collaboratively by FWS and the applicants in consultation with OWRD and Reclamation. Irrigation season flow limits (April 1–September 15): • Years 8–12: Not more than 1,400 cfs for more than 10 days per year • Years 13–30: Not more than 1,200 cfs for more than 10 days per year Fall and winter minimum flows increase above those listed for years 1–12 in proportion to amount of live flow made available to North Unit ID during the prior irrigation season as a result of the piping of Central Oregon ID–owned canals after the date of ITP issuance and once approved by OWRD.
UD-1: Upper Deschutes River Conservation Fund	Provides funds for improving or enhancing habitat in the Upper Deschutes Basin for the Oregon spotted frog and other aquatic species, or otherwise addressing conditions in the Upper Deschutes Basin that affect the conservation and recovery of the Oregon spotted frog in the wild.[a] Within 6 months 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 contribute a combined total of $150,000 annually to the fund. Amount adjusts annually for inflation. Refer to Appendix 2-C, *Implementation of UD-1: Oregon Spotted Frog Conservation Fund*, for more information.
DR-1: Middle Deschutes River Flow Outside of the Irrigation Season	Provides for coordinated livestock diversions November–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 below Crescent Dam of approximately 10–12 cfs from October 1–June 30 over the permit term and approximately 50 cfs from July 1–30 and allows for release of approximately 5,264–11,164 af of stored water to benefit Oregon spotted frog depending on reservoir storage and phase of permit term.
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 no later than October 31 each year.

Conservation Measure	Primary Focus
Whychus Creek	
WC-1: Whychus Creek Instream Flows	Establishes a minimum flow of 34.18 cfs in Whychus Creek past the Three Sisters ID diversion during the permit term to account for all water the district has converted to permanent instream water rights (currently 31.18 cfs) and all water the district is required to pass under Oregon water law to senior downstream water right holders (currently 3 cfs). This minimum flow increases with any future additional conversions of senior water rights to permanent instream use as such rights are converted.
WC-2: Whychus Creek Temporary Instream Leasing	Provides $6,000 per year to fund temporary instream flow leasing during drought years and/or habitat improvement or enhancement work in Whychus Creek. Amount adjusts annually for inflation.[a]
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 5 miles of patron laterals within 5 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 5 cfs per hour when flows below the Three Sisters ID diversion are 30 cfs or less.
WC-6: Whychus Creek Conservation Fund	Provides $10,000 each year in a combination of funding and in-kind services to support the restoration and enhancement of aquatic and riparian habitats in Whychus Creek. The use of the funds and in-kind services to be directed by an entity acceptable to the Services.
WC-7: Plainview Dam Removal	Provides in-kind services for completing the removal of Plainview Dam, restoration of the associated reach of Whychus Creek, and installation of a fish screen at the Runco diversion.
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 to 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 is allowed to flow without diversion by Ochoco ID or its patrons.
CR-4: Crooked River Conservation Fund	Provides $8,000 annually 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	Establishes that North Unit ID will only divert water at the Crooked River pumps when minimum average daily flows, ≥50 cfs, for dry and non-dry years can be maintained downstream of the pumps. Refer to description of CR-6 in the Deschutes Basin HCP, Chapter 6, *Habitat Conservation*, for required minimum flows.
CR-7: Crooked River Downstream Fish Migration Pulse Flows	Requires that Ochoco ID and North Unit ID not divert water from the Crooked River that is part of a downstream fish migration pulse flow. Such flow is defined as a quantity of uncontracted Prineville Reservoir storage that is determined by Reclamation, in consultation with the Services, to be released above and beyond the base release of uncontracted storage for the purpose of facilitating downstream migration of young anadromous salmonids in the Crooked River.

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

cfs = cubic feet per second; af = acre-feet; ITP = incidental take permit; ID = Irrigation District; NMFS = National Marine Fisheries Service; OWRD = Oregon Water Resources Department; Reclamation = Bureau of Reclamation; HCP = Habitat Conservation Plan; the Services = U.S. Fish and Wildlife Service and National Marine Fisheries Service.

[a] Use of these funds will be governed by an implementation committee. The Services will be members of the implementation committee. A third party selected by the Services will hold the funds.

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 and summarized below.

Alternative 3 conservation measures would be the same as the proposed action except as follows:

- On the Upper Deschutes River (Conservation Measure WR-1)
  - Fall and winter flows below Wickiup Dam would increase earlier in the permit term.
  - Minimum flow targets during above-normal and wet years would be higher throughout the permit term.
  - Summer cap on flows would not be included.
- On the Crooked River
  - Uncontracted fish and wildlife storage releases would be protected[10] instream to Lake Billy Chinook (Conservation Measure CR-1).
- On Whychus Creek, Alternative 3 does not include the Whychus Conservation Fund included under the proposed action (Conservation Measure WC-6).[11]

The adaptive management and monitoring program would be the same as under the proposed action.

[10] Assumes that Reclamation has applied for and obtained an instream water right protecting releases from all diversion. See Table 2-5 for more information.

[11] Although Conservation Measure WC-7 is not part of Alternative 3, it is assumed to occur under all alternatives.

Table 2-5. Alternative 3 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. Provides minimum and maximum water surface elevations November 1–July 15. Establishes a minimum instream flow of 75 cfs in the Deschutes River below Crane Prairie Dam, subject to water availability.
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, decreases flows during summer months, and limits ramp down rates at the end of the irrigation season. Fall and winter (September 16–March 31) minimum flow schedule: • 1–5 years: 200 cfs • 6–10 years: 300 cfs • 11–30 years: 400–500 cfs Fall and winter minimum flow targets varies above the minimums identified above, based on monthly fall and winter coordination by FWS, OWRD, and North Unit ID to assess available annual surplus fall storage in Crane Prairie and Wickiup Reservoirs and precipitation forecasts. Annual coordination targets 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*.
UD-1: Upper Deschutes River Conservation Fund	*Same as proposed action*.
Crescent Creek and Little Deschutes River	
CC-1: Minimum Instream Flow below Crescent Dam	Provides for minimum flow below Crescent Dam of at least 20 cfs provided there is sufficient inflow and storage in Crescent Lake Reservoir to support minimum flows.
CC-2: Crescent Dam Ramping Rates	*Same as proposed action*.
CC-3: Crescent Lake Reservoir Irrigation Release Season	Limits the period for ramp down of irrigation releases from Crescent Dam from September 1–October 31 unless an earlier ramp down period is needed to protect infrastructure, avoid draining down the reservoir, or for emergencies.
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*.

Conservation Measure	Primary Focus
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 includes protection of uncontracted (fish and wildlife) releases from diversion from Bowman Dam to Lake Billy Chinook. While Reclamation has not obtained an instream water right for the uncontracted (fish and wildlife) water, Reclamation has contemplated applying for one, and Services and the Bureau have been discussing this concept for several years. Including this provides an opportunity to analyze the ecological consequences with and without the instream protection right.
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 2020.

cfs = cubic feet per second; ITP = incidental take permit; ID = Irrigation District; FWS = U.S. Fish and Wildlife Service; OWRD = Oregon Water Resources Department; Reclamation = Bureau of Reclamation.

[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.

[b] Assumes that Reclamation has applied for and obtained an instream water right protecting releases from all diversion.

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 conservation measures are the same as Alternative 3 except as follows:

- On the Deschutes River, increases in fall and winter flows below Wickiup Dam would occur earlier in the permit term and minimum flow targets during above-normal and wet years would be higher
- On the Crooked River, minimum storage season flows below Bowman Dam would be higher (80 cubic feet per second (cfs) instead of 50 cfs).

The adaptive management and monitoring program would be the same for Alternative 4 as the proposed action.

Table 2-6. Alternative 4 Conservation Measures

Conservation Measure	Primary Focus
CP-1: Crane Prairie Reservoir Operation	*Same as Alternative 3*.
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. Fall and winter (September 16–March 31) minimum flow schedule: • 1–5 years: 300 cfs • 6–20 years: 400–600 cfs Fall and winter minimum flow targets would be variable above the minimums identified above, 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*.
UD-1. Upper Deschutes River Conservation Fund	*Same as proposed action*.
Crescent Creek and Little Deschutes River	
CC-1: Minimum Instream Flow below Crescent Dam	*Same as Alternative 3*.
CC-2: Crescent Dam Ramping Rates	*Same as proposed action*.
CC-3: Crescent Lake Reservoir Irrigation Release Season	*Same as Same as Alternative 3*.
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 MacKay Creek	
CR-1: Crooked River Flow Downstream of Bowman Dam	Same as Alternative 3 but increases storage season minimum flows to 80 cfs (with Ochoco ID responsible for up to 50 cfs).
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.

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, 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; 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.	• Adjusts the range and timing of Crane Prairie Reservoir storage and drawdown rate with year-round minimum and maximum elevation levels. • Establishes a minimum instream flow in the Deschutes River below Crane Prairie Dam	Same conservation measures as proposed action except as follows. • On the Upper Deschutes River: ○ Increases fall and winter flows below Wickiup Dam earlier in the permit term.	Same conservation measures as Alternative 3 except as follows. • On the Deschutes River, increases in fall and winter flows below Wickiup Dam earlier in the permit term and reaches higher minimum flow

Alternative Component	Alternative 1: No Action	Alternative 2: Proposed Action	Alternative 3: Enhanced Variable Streamflows	Alternative 4: Enhanced and Accelerated Variable Streamflows
		• Increases fall and winter Deschutes River flows based on schedule of flow increases. • Limits irrigation season flows (summer flow cap) in years 8–30. • Supplements releases of uncontracted storage from Prineville Reservoir on Crooked River. • Provides for Crooked River, Whychus Creek, and Upper Deschutes River Conservation Funds. • 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. • Includes an adaptive management and monitoring program.	○ Reaches higher minimum flow targets during above-normal and wet years throughout the permit term. ○ Excludes summer cap. • On the Crooked River ○ Uncontracted fish and wildlife storage releases would be protected[a] instream to Lake Billy Chinook (Conservation Measure CR-1). • On Whychus Creek, excludes Whychus Conservation Fund. • Same adaptive management and monitoring program as proposed action.	targets during above-normal and wet years. • On the Crooked River, sets higher minimum storage season flows below Bowman Dam. • Same adaptive management and monitoring program as proposed action.

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

[a] Assumes that Reclamation has applied for and obtained an instream water right protecting releases from all diversion.

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. 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 Deschutes Basin HCP, Chapter 11, *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 ID 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.[12] 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.

[12] 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.

The analysis of effects under the no-action alternative qualitatively considers how continuing current water management operations, described in Chapter 2, *Proposed Action and Alternatives*, could affect study area resources over the analysis period. It also considers how other projects, programs, and changes assumed to occur over the analysis period—including climate change, population growth, water conservation projects, and restoration projects, as described Chapter 2—could affect study area resources. These effects on resources under the no-action alternative are compared to existing conditions.

Effects of the proposed action and Alternatives 3 and 4 are compared to the no-action alternative. The description of effects under Alternatives 3 and 4 may reference and provide comparison to effects under the proposed action. The effects of climate change and other trends, conditions and projects that would occur with or without the proposed action are not repeated for the proposed action and Alternatives 3 and 4. The potential for the proposed action and Alternatives 3 and 4 to contribute to cumulative effects when combined with the effects of past, present, and reasonably foreseeable future projects is addressed in Chapter 4, *Cumulative Impacts*.

Maintenance of covered facilities is a covered activity in the Final Deschutes Basin Habitat Conservation Plan (Deschutes Basin HCP) (Deschutes Basin Board of Control and City of Prineville 2020). These activities would be unchanged under the proposed action, Alternative 3, Alternative 4, and the no-action alternative, compared to existing conditions. Facility maintenance activities include periodic dam inspection, gate tests, and safety compliance; periodic repairs; cleaning of fish screens; and removal of rock from ramp flumes and tailrace, as described in Final HCP Chapter 3, *Covered Activities.* Maintenance activities are required for normal and safe operations; while some of these activities would temporarily interrupt flows, none of the activities would affect the timing or volume of flows or elevation or volume or reservoirs to a degree that could adversely affect the resources evaluated in this chapter. Therefore, effects of reservoir activities would be not adverse and are not analyzed further in this EIS.

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

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

model is informed by existing data sets, water management regimes, and knowledge of the natural system.

Just prior to publication of this Final EIS, an error was identified in the RiverWare model that affected model outputs for the proposed action. The model was corrected and rerun and revised model outputs were compared to the model outputs in the analyses in this chapter. Appendix 3.1-C, *Analysis of RiverWare Model Version 18 Outputs and Implications for Final EIS*, documents this comparative analysis and presents corrections to effect descriptions and conclusions in underline/strikeout. Anywhere the modeling error outputs had implications for the effect descriptions or conclusions in this chapter, a footnote has been added referencing the corrected information in Appendix 3.1-C. In summary, the review resulted in no changes to any of the overall effect conclusions in the Final EIS.

3.1.3.1 Upper Deschutes Flows

The staged increases of releases from Wickiup Reservoir to benefit Oregon spotted frog are a key element of the conservation strategy. The amount of increase and the timing of implementation of increases differ across the alternatives. The effects of flow increases by implementation phase are discussed throughout the analyses in this chapter. A comparison of the implementation phases, year ranges, and minimum flow releases under each phase is presented in Table 3.1-1 by alternative to support the reader's review of the analyses.

Table 3.1-1. Minimum Fall/Winter Flows (cfs) below Wickiup Dam under Proposed Action, Alternative 3, and Alternative 4 Phases

	Proposed Action		Alternative 3		Alternative 4	
Phase	Years	Flows	Years	Flows	Years	Flows
1	1–7	100 cfs	1–5	200 cfs[b]	1–5	300 cfs[b]
2	8–12	300 cfs[a]	6–10	300 cfs[b]	6–20	400–600 cfs[b]
3	13–30	400–500 cfs[b,c]	11–30	400–500 cfs[b]	N/A	N/A

cfs = cubic feet per second; N/A = not applicable

[a] Includes a summer flow cap of 1,400 cfs.

[b] Variable minimum flow depending on amount of water stored in Wickiup Reservoir; refer to Appendix 3.1-B, *RiverWare Model Technical Memorandum*, for how variability was modeled for each alternative.

[c] Includes a summer flow cap of 1,200 cfs.

As shown Table 3.1-1, the proposed action and Alternative 3 each have three phases of flow increases, but these phases have different year ranges and flow levels. Alternative 4, which has a 20-year permit term, has two phases and provides greater flow increases earlier in the permit term compared to Alternatives 2 and 3.

Also shown in the table, minimum flows under the final phases of the proposed action and all phases of Alternatives 3 and 4 are variable, targeting a higher minimum flow (500 cubic feet per second [cfs] under the proposed action and Alternative 3 and 600 cfs under Alternative 4) in above-normal and wet years. Although both the proposed action and Alternative 3 target a higher flow based on contents of Wickiup Reservoir on December 1, Alternative 3 is more aggressive in its attempt to reach 500 cfs and the modeling inputs reflect this intention. Only the proposed action includes a maximum summer flow (summer cap) in this reach. The summer cap decreases from 1,400 cfs under phase 2 to 1,200 cfs in phase 3.

3.1.3.2 Water Conservation Projects

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.The streamflows effects of two of these projects (Swalley Irrigation District [ID] and Tumalo ID project) were quantified outside of the RiverWare model; effects of the Central Oregon ID project were incorporated in RiverWare. The effects of other planned water conservation projects on reservoir storage and streamflows are not captured in the modeling results. These future projects would improve water supply efficiency and streamflow conditions; however, they were not included as assumptions in the RiverWare model because of uncertainty about the location and timing of their implementation and, therefore, the extent, timing, and location of 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 (Section 3.5, *Land Use and 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, *Cumulative Impacts*).

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.

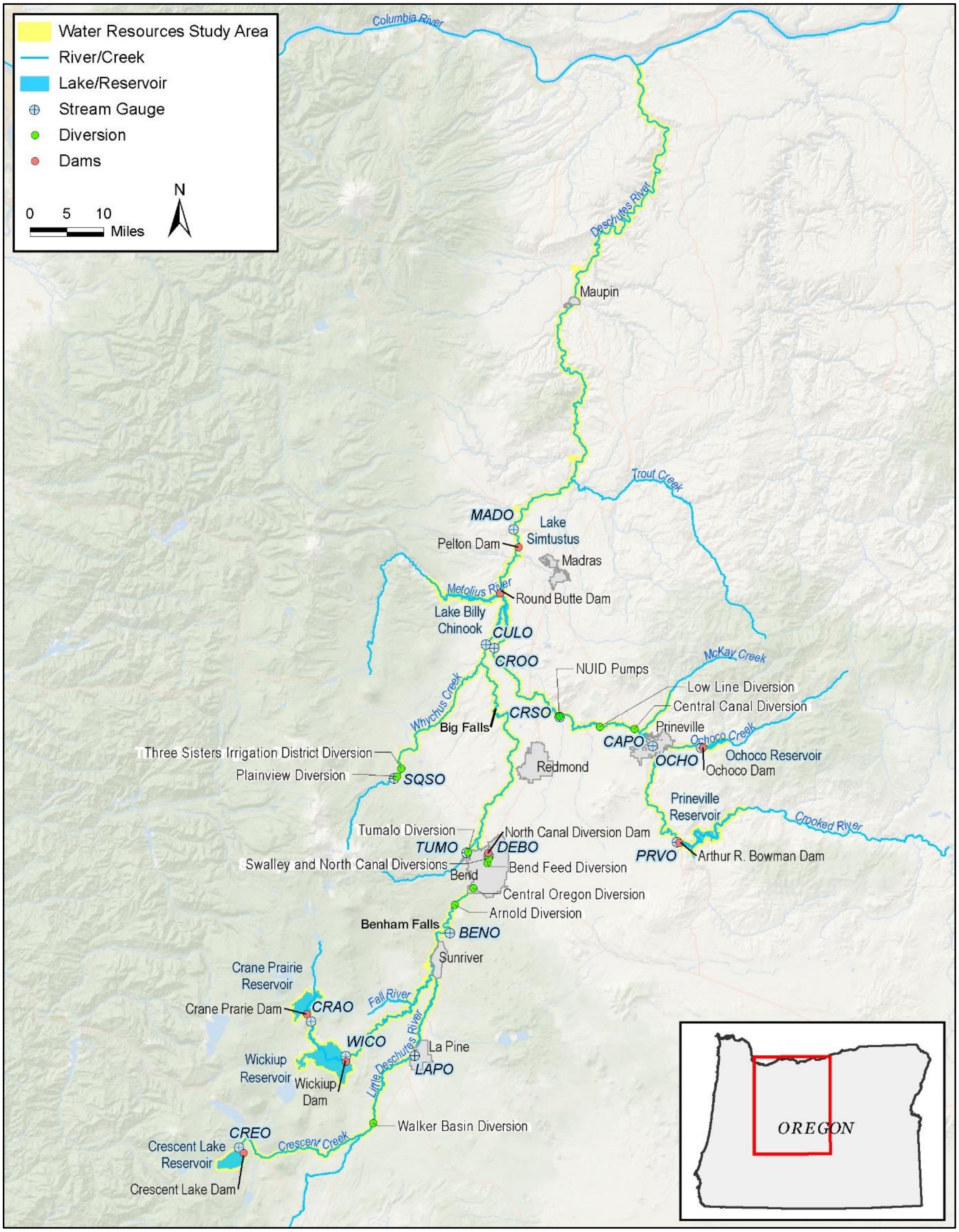
The description of the affected environment for water resources was based on a review of existing publications and data describing water resource conditions in the study area. Online data sources (e.g., river and reservoir gauges) and water resources specialists with expertise in the study area were 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] 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 operations and the natural system and, therefore, does not capture every aspect of operations or 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. Modeled results, therefore, are a representation of what could occur with the logic used, but not necessarily what will occur in any given year. 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 38-year modeling period (1981 to 2018 water years),[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; the one or two driest years in the period of record 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, 2011).
Very wet	>80%	Especially wet years associated with flooding, (e.g., 1983–1984, 1997–1998, 2017).

The addition of 3.0 cubic feet per second (cfs) to Whychus Creek (Conservation Measure 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-7) 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 thresholds. Reservoir managers have the flexibility to manage the reservoirs to minimize flood risk 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

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

[3] 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 Alternatives 3 and 4.

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 (Gannett 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 (Mote et al. 2019) and the Deschutes Basin (Halofsky et al. 2019; Luce et al. 2019).

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.
    - 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.

  The effects of changes in streamflow and surface water elevations on other resources—including biological resources, recreation, and aesthetics—are assessed in those sections.
- 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 the Final Deschutes Basin HCP, Chapter 3, *Scope of the 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.

[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.

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 Arnold ID Lone Pine ID
Wickiup	200,000	200,000	North Unit ID	North Unit ID Oregon Water Resources Department (Instream Water Rights)
Crescent Lake	86,900	51,050; 35,000	Tumalo ID	Tumalo ID 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).

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 (Gannett et al. 2001; Gannett et al. 2017). Most of the 200 inches per year of precipitation that falls in the western portion of the Upper

[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.

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 completed in 1949, 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 (CULO) gauge (RM 120.0) may contribute more than 400 cubic feet per second (cfs) of flow to the lower river. (Gannett et al. 2001)

Crane Prairie Reservoir and Wickiup Reservoir operations are coordinated to meet downstream irrigation use and also currently provide some benefits to Oregon spotted frog, which is covered by FWS under the Deschutes Project 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. The two reservoirs are not Congressionally mandated for flood control, but managers have the flexibility to operate the dams to reduce downstream flooding when necessary.

Lower Deschutes River

Flow in the Deschutes River increases fourfold 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 (Gannett et al. 2017). 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.

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; Gannett et al. 2017). 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 (Gannett et al. 2017). 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 (Deschutes National Forest 2008). However, springs contribute approximately 20 cfs to streamflow and Tumalo Creek baseflows are higher relative to other tributaries in the basin (Gannett et al. 2017). 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 (Deschutes National Forest 2013). 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. Three Sisters ID recently completed the last phase of piping its main canals and OWRD has issued a water right for instream placement of the conserved water, bringing the total instream water right in Whychus Creek to 31.18 cfs. Flow increases downstream of Sisters are influenced by a single tributary, Indian Ford Creek, and multiple small springs (Deschutes National Forest 2013).

Crooked River, Ochoco Creek, and McKay Creek

The Crooked River Subbasin upstream from Smith Rock 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 Rock 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 af of storage between November 15 and February 15. Bowman Dam and Ochoco Dam are operated to minimize flooding on the Crooked River and Ochoco Creek.

Stored water is released from Prineville Reservoir to provide mitigation for groundwater pumping by the City of Prineville (starting in 2018), fish and wildlife water, and irrigation water to water users downstream from Prineville Reservoir and the North Unit ID pump station on the lower Crooked River. The Crooked River Collaborative Water Security and Jobs Act of 2014 (Crooked River Act) made up to approximately 62,000 af of uncontracted storage in Prineville Reservoir available to benefit downstream fish and wildlife. 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. 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 Rock stream (CRSO) gauge. 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, leading to stable flow regimes and infrequent flooding (Yake 2003). 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).

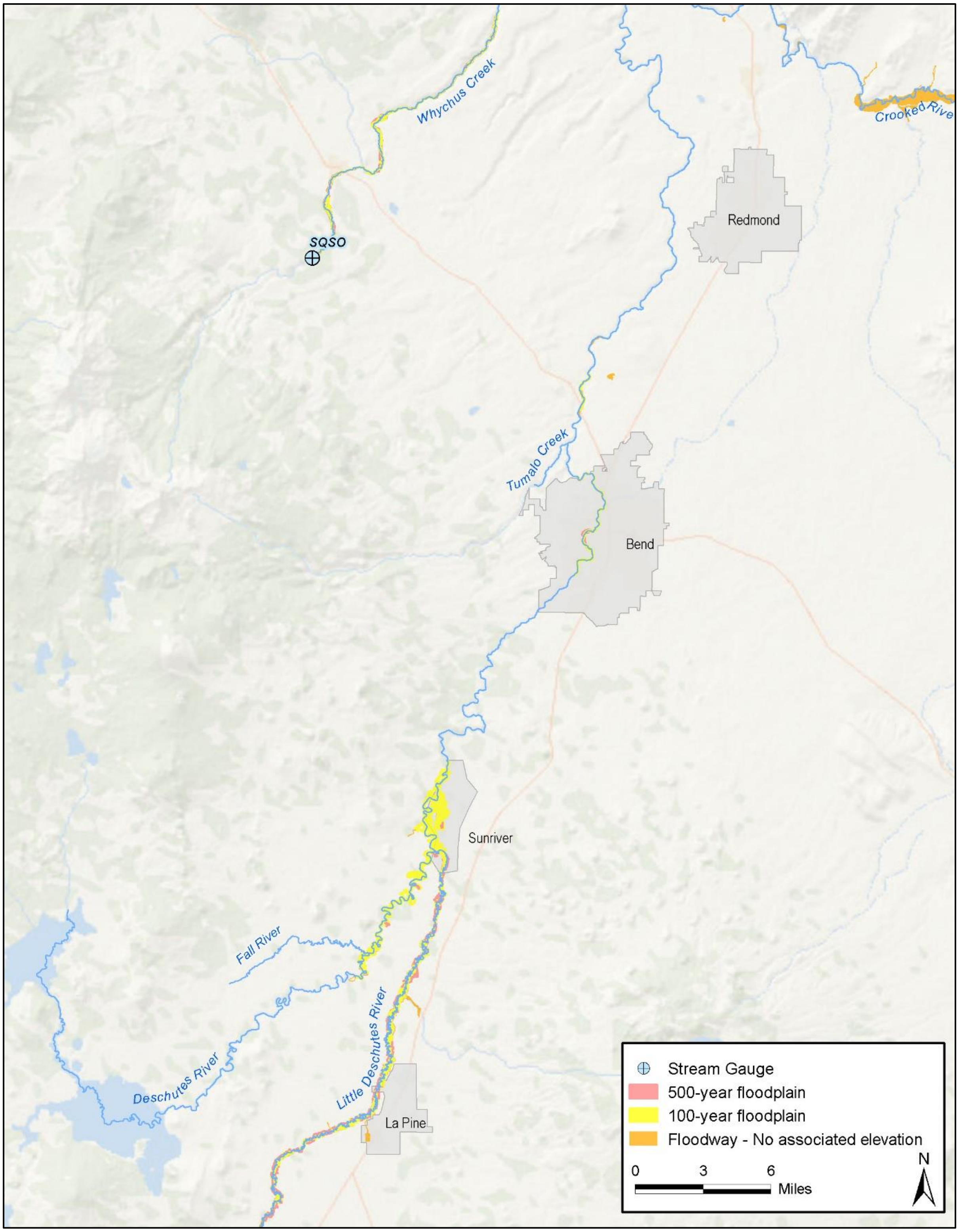
- Whychus Creek from the Jefferson County line upstream to the OWRD stream gauge at RM 26.6 (18.6 miles).

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 pers. comm. [a]), 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 Rock 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 Ochoco Creek.

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



Source: Federal Emergency Management Agency 2019.

3.2.2.3 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 (Gannett 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 (Gannett 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 (Gannett et al. 2001:44–46). Climate oscillations and canal seepage are two variables that influence groundwater levels in this part of the study area. Climate oscillations remain the largest influence on water level fluctuations on the aquifers in the study area (Gannett et al. 2001:2; Gannett and Lite 2013:1). With 60 to 70% of the recently observed groundwater decline attributed to climate change, these basin-scale natural fluctuations in groundwater levels largely mask small or minor changes in the study area groundwater levels caused by changes in river flows. However, the central part of the basin is also susceptible to additional groundwater level fluctuations associated with increases in pumping and canal lining and piping (Gannett and Lite 2013:33). Canal seepage impacts can be found in the ***hydrograph*** of the lower Crooked River, near the confluence with the Deschutes River, that show an overall increase in groundwater discharge to the river between 1918 and early 1994. The increase in flow is approximately equivalent to the estimated canal losses from within the study area

[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.

(Gannett et al. 2017: 26, 52). Based on this data, groundwater discharges in the Lower Crooked River have been artificially increased by an amount similar to the irrigation canals annual leakage rate. The recent study estimates the canal losses in 2013 at about 420 cfs per year (Gannett et al. 2017: 24).

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 (La Marche pers. comm. [b]).

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 (Three Sisters ID). Groundwater discharges into the creek significantly increasing flows near the Deschutes River confluence.

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 Rock State Park (La Marche pers. comm. [b, c]).

Additional details and supporting information about groundwater in the study are can be found in Appendix 3.2-A, *Water Resources Technical Supplement*.

3.2.3 Environmental Consequences

The presentation of direct RiverWare outputs (without rounding) is not intended to imply exact predictions of future conditions, but provide a basis for 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, 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 degrees Celsius (°C) by 2050, and from 2.7 to 4.8 °C by 2080 (Halofsky et al. 2019). Climate change effects on hydrology vary across the study area due to basin geography, precipitation patterns, and underlying geology (Luce et al. 2019). Generally, anticipated climate change effects will include decreased snowpack, earlier snowmelt and runoff, lower summer streamflow, and more frequent high-magnitude storm and runoff events (Luce et al. 2019). 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 (Luce et al. 2019). 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 (Luce et al. 2019; Mote et al. 2019).

Extreme climate events, such as drought, and ecological disturbances, such as flooding and wildfire, are forecast to increase with climate change (Case et al. 2019). These events could alter streamflow throughout the study area (Luce et al. 2019). Upper Deschutes River tributaries are likely to experience more rain and less snowfall with a warming climate. Tributaries, especially those in the Crooked River Basin with older and less permeable geologies, will experience greater hydrological changes due to the greater influence of surface water runoff. Tributaries draining the east side of the Cascade Range are influenced by younger geologies and groundwater inputs.

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 (River Management Joint Operating Committee 2011; Luce et al. 2019). Earlier runoff would be expected to reduce water supply later in the season, although earlier runoff upstream of Crane Prairie Reservoir and Wickiup Reservoir would increase inflows and storage potential in the two reservoirs. 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. Earlier runoff regimes, more precipitation falling as rain than snow, and increased environmental variability could increase the frequency of rain-on-snow and spring flood events on the Crooked River and Little Deschutes River as these systems are more sensitive to surface water runoff compared to the Upper Deschutes River. Depleted reservoir storage later in the summer would potentially reduce irrigation season flooding that is currently attributed to high irrigation flows and decreased channel capacity due to aquatic vegetation growth.

Crooked River reservoirs are Congressionally authorized for flood control and any changes in increase in reservoir inflows during fall and winter storage due to climate change effects would be addressed as part of this management. However, the Upper Deschutes reservoirs are not authorized for flood control, and flood control management is infrequently employed. If reservoir inflows increased due to climate change effects, managers may have to manage reservoir stage more frequently.

Water supply from snowmelt 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. Most commonly, permanent mitigation credits are created through permanent transfer of an existing out-of-stream water right to instream use. 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 to 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 in-progress 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 Central Oregon ID Smith Rock-King Way Infrastructure Modernization Project.[9] Swalley ID and Tumalo ID projects would increase instream flows below irrigation diversions in the Deschutes River and Tumalo Creek during the irrigation season (Farmers Conservation Alliance 2018a, 2018b). The Central Oregon ID project would also increase flows below Wickiup in the storage season. Changes would occur 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) in the proposed action and Alternatives 3 and 4 for the affected reaches. The Swalley ID and Tumalo ID projects would also result in an increase in water supply for the respective irrigation districts.

These water conservation projects would also result in slightly lower groundwater levels and subsequent spring discharge in the lower portion of the basin above the confluence of the rivers at Lake Billy Chinook. The projects are projected to reduce canal losses 44 cfs per year, a 10% decrease in the estimated 420-cfs-per-year canal losses in 2013 (Gannett et al. 2017: 24). Eventually, this results in an equivalent change in groundwater discharge in the lower portion of the basin as the artificially elevated discharges return to their natural discharges. The magnitude of change from these projects will be masked by the larger groundwater level fluctuations associated with climatic oscillations. However, 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

[9] Effects of water conservation projects completed prior to 2017, and the addition of 3.0 cfs to Whychus Creek (under Conservation Measure WC-1) on water supply and streamflow and effects of Central Oregon ID's Smith Rock-King Way Infrastructure Modernization Project on water supply are accounted for in the RiverWare model for the no-action alternative, as well as the proposed action and Alternatives 3 and 4. Water saved through the Swalley ID, Tumalo ID, and Central Oregon ID projects would protect a percentage of water instream.

resources over the permit term in combination with the proposed action and alternatives are addressed in Chapter 4, *Cumulative Effects*.

Effect Conclusion: Continuation of existing water management operations 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 and water conservation would affect water resources over the analysis period. Climate change could have an adverse effect on water supply and surface water. Climate change is expected to result in decreases in natural flow from snowmelt during the irrigation season, which would reduce total water supply available to water users throughout the basin. 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 in the Deschutes River below Wickiup in the storage season and in Tumalo Creek and the Deschutes Rivers below Bend during the irrigation season. There would also be an increase in water supply for irrigation districts. The planned water conservation projects would also result in minor local-scale declines in the groundwater levels. These effects are considered not adverse because they 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

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 6 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 5.4%, while maximum irrigation season storage would decrease by 1.7%. 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. Depending on water supply conditions, Conservation Measure CP-1(H), which requires release of additional stored water from Crane Prairie Reservoir downstream of Wickiup Dam, may further reduce Crane Prairie water supply storage in some years.

Wickiup Reservoir. As winter flow releases from Wickiup Reservoir increase above no-action levels at year 8 (Conservation Measure WR-1), Wickiup Reservoir storage would decline, with the greatest declines observed in years 13 through 30 of the permit term (Tables 7 and 8 and Figure 7 in Appendix 3.2-A). In a normal water year during years 13 through 30, water supply storage would be reduced by 75,334 af (a 40% reduction).

Crescent Lake Reservoir. Reduction of minimum flows below the Crescent Lake Dam from 20 to 30 cfs under the no-action alternative to a variable minimum flow between 10 and 12 cfs with additional supplemental releases that increase over the permit term (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 7 of the permit term, the maximum storage volume attained would increase by approximately 100% in a dry year, from 27,006 af to 54,003 af (Table 10 in Appendix 3.2-A). This increase in storage would decrease slightly over the permit term because increased winter releases from Crescent Lake (Conservation Measure CC-1) and Wickiup Reservoir (Conservation Measures

WR-1, D-G), and the requirement to maintain Crane Prairie storage elevations (Conservation Measure CP-1). This 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 per year.[10] Appendix 3.2-A (Impact WR-1) provides an expanded discussion of Crescent Lake Reservoir storage rights.

Prineville Reservoir. As winter flow releases out of Wickiup Reservoir increase starting in year 8 of the permit term, reducing North Unit ID's stored water supply in the Deschutes, North Unit ID would use its available stored water from Prineville Reservoir (up to 10,000 af) more frequently and to a greater extent. This, combined with increased winter minimum flows in the Crooked River (Conservation Measure CR-1), would result in reduced Prineville Reservoir storage in dry and very dry years. In years 13 through 30 of the permit term, changes in storage would range from a decrease of 7,946 af in a dry year to 14,328 af in 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 2,000 af, equivalent to less than 2% of total storage. Figure 9 in Appendix 3.2-A, compares Prineville Reservoir storage during years 13 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 non-irrigation season in Ochoco Creek (Conservation Measure CR-2) would reduce Ochoco Reservoir storage by up to 1,500 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: 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, dry, and very dry years over the permit term in in Wickiup Reservoir; increase in Crescent Lake Reservoir; decrease in dry and very dry years 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

Changes in reservoir storage described in Impact WR-1would reduce water supply for irrigation districts and other surface water users by reducing the availability of stored water from Wickiup

[10] 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 Tumalo ID 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.

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.[11] 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 IDs and other water users.

Irrigation season diversions (as irrigation season volumes) in normal, dry, and very dry years as a percentage of diversions under the no-action alternative are presented for North Unit ID, Central Oregon ID, Arnold ID, Lone Pine ID, Ochoco ID, and Tumalo ID. Values are presented for the entire irrigation season, but effects would be concentrated from June through September. The comparison considers the three phases of implementation of minimum fall and winter flows below Wickiup Reservoir over the permit term (Table 3.1-1). Comparing diversions in the first phase, 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 Conservation Measure WC-1 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, would reduce water supply available to North Unit ID starting in year 8 of the permit term in normal to very dry years and in year 13 in all water year types. (Figures 10 and 15 in Appendix 3.2-A). In a dry year, North Unit ID diversions would increase by 10,334 af in years 1 through 7 of the permit term and decrease by 34,691 af in years 8 through 12, and 56,580 af in years 13 through 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 pers. comm. [a, b]). Effects of the increase in these regulatory calls on water supply for other Deschutes River water users with junior water rights are described further for each irrigation district. It is also expected that North Unit ID would increase use of its Crooked River pumping plant to partially offset reduced water supply from Wickiup Reservoir storage beginning in year 8.[12] During years 13 through 30, when Crooked River water use would be highest, North Unit ID would increase use of the Crooked River pumping plant by 13,116 af in a normal year. However, in a very dry year, decreased Prineville Reservoir storage due to Conservation Measure CR-1 would reduce North Unit ID's Crooked River water supply by 2,315 af and would reduce its ability to offset water supply shortages 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 11, 12, and 13 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 very dry year, Central Oregon ID's diversions would decline by

[11] 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.

[12] 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.

3,248 af starting in year 13. This represents approximately 1.15% of diversions under the no-action alternative.

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 very dry year, Arnold ID's diversions would decline by 255 af starting in year 1 of the permit term and by 3,501 af starting in year 13. This represents approximately 1 and 14% 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 12 and 16 in Appendix 3.2-A).[13]

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 13 and 16 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 917 af starting in year 1 and by 1,734 af starting in year 13. Reductions would be similar during very dry years. This represents approximately 8 and 12% of diversions, respectively.

Ochoco Irrigation District. Decreased storage in Prineville Reservoir, described in Impact WR-1, 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 16 in Appendix 3.2-A). In very dry water years, Ochoco ID water supply would be reduced by 7,443 af starting in year 1 and by 12,318 af starting in year 13. This represents approximately 12 to 20% of Ochoco ID 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. The impact of instream leasing under Conservation Measures CR-2, CR-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, is expected to increase Tumalo ID stored water supply. However, increased regulatory calls on Tumalo ID's live flow Deschutes River water right are expected to decrease water supply. As a result, in a very dry year, Tumalo ID diversions would increase by 13,716 (45%) beginning in year 1 and 7,851 af (25.8%) in years 13 through 30 compared to the no-action alternative (Figure 17 in Appendix 3.2-A).

Three Sisters Irrigation District. Conservation Measures 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.

[13] Lone Pine ID 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.

Other Deschutes River Water Users. Other Deschutes River 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 frequency of regulatory calls by North Unit ID compared to the no-action alternative beginning in year 8 of the permit term as storage season minimum flows below Wickiup Reservoir increase to 300 cfs. Water supply conditions would be the same or nearly the same for water users with water rights junior to Central Oregon ID, Arnold ID, and Lone Pine ID (Figure 18 in Appendix 3.2-A).

Other Crooked River Water Users. Other Crooked River water users, including small irrigation districts, private irrigators using shared conveyance systems, and private irrigators with individual diversions (Tables 3 and 4 in Appendix 3.2-A), could experience reduced water supply in 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 3% (Figure 19 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 and Three Sisters ID would experience relatively minor water supply reductions. Tumalo ID would experience an increase in water supply. Swalley ID would not be affected. Other Crooked River water users would experience reduced supply in very dry years. Other Deschutes River water users junior to North Unit ID would experience no change in water supply. The effects of these water supply changes are addressed in Section 3.5, *Land Use and Agricultural Resources*, and 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. 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. Flood control is one of the Congressionally authorized purposes of Prineville Reservoir and Ochoco Reservoir. Crane Prairie and Wickiup Reservoirs are not Congressionally authorized flood-control projects, although managers may operate the respective dams and reservoirs to reduce downstream flooding.

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 20 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 December (Figure 21 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 0.4 foot higher over the permit term. In years when additional stored water from Crane Prairie Reservoir is released for Oregon spotted frog under Conservation Measure CP-1(H), Crane Prairie water surface elevation may be further reduced in relation to the 90% reservoir capacity water surface elevation. Days of 90% reservoir capacity exceedance would decrease from 5 days per year under the no-action alternative, to no days under the proposed action.

Wickiup Reservoir. Of the five reservoirs in the study area, 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 downstream from Wickiup Dam (Conservation Measures CP-1 and WR-1). These measures would result in Wickiup Reservoir median water surface elevations becoming more variable and lower in years 13 through 30 as less water would be stored year-round compared to earlier periods of the permit term. However, the peak flow cap of 1,200 cfs during irrigation season in years 13 through 30 would increase median reservoir water surface elevations in September and October, compared to water surface elevations over the same months in years 8 through 12 when the peak flow cap is set at 1,400 cfs (Figure 22 in Appendix 3.2-A). Median reservoir water surface elevations would, on average, be 4.3 feet lower during the storage season and 0.8 foot lower during the irrigation season over the permit term. Average median annual water surface elevations would be approximately 2.2 feet lower over the permit term. Maximum reservoir water surface elevations would be similar (Figure 23 in Appendix 3.2-A).

Flood risk would remain the same over the permit term as the number of days of the reservoir exceeding 90% of reservoir capacity would increase and then decline. Exceedances under the proposed action in years 13 through 30 would be the same as no-action alternative: 64 days per year. In years 1 through 7 of the proposed action, exceedance would increase to 85 days per year.

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) (Figure 24 in Appendix 3.2-A). Exceedances of 90% reservoir capacity elevation would occur 50 days per year under the proposed action in years 1 through 7, and 49 days per year in years 13 through 30, compared to 20 days per year under the no-action alternative. Therefore, flood risk would increase under the proposed action.

Prineville Reservoir. Prineville Reservoir would experience similar median water surface elevations from February through May, but lower median water surface elevations through irrigation season and early in winter storage season in years 8 through 30 (Figure 26 in Appendix 3.2-A). Lower median reservoir water surface elevations would result from releasing stored water to meet North Unit ID water needs and meeting minimum instream flow requirements downstream from Prineville Reservoir (Conservation Measure CR-1). Maximum reservoir water surface elevations would be similar year-round (Figure 27 in Appendix 3.2-A). Average median and maximum water surface elevations would be approximately 0.4 foot lower and 0.2 foot higher, respectively, over the permit term. Days of 90% reservoir capacity exceedance would increase from 0 days under the no-action alternative, to 1 day under the proposed action. However, because Ochoco and Prineville Reservoirs 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 flood storage, the proposed action is not expected to affect reservoir flood storage capacity.

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 (Figures 28 and 29 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 result in more days of 90% reservoir capacity exceedance at Crescent Lake Reservoir, but the same or a similar number of exceedance days at the other reservoirs. 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. 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 7 and years 13 through 30 of the permit term; wet years generally have fewer streamflow differences. Results for years 8 through 12 are typically bracketed by results for the first and last phases of the permit term. Appendix 3.2-A includes additional explanation for water year types and the second phase of the permit term.

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 along with and a cap on peak flows during irrigation season would result in lower flows on the Upper Deschutes River during the April 1 to October 31 irrigation season. The effects would be most apparent in a dry water year during years 13 through 30 when fall/winter releases are at their highest and the summer flow cap is at its lowest. The cap on flows during irrigation season would retain storage water but may also increase the North Unit ID demands on Crooked River flows to provide irrigation water.

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, early May, and mid-July through mid-August), lower 5 months of the year (March through April, and mid-August through September) and unchanged for 3 months (April, mid-May through June, and October) (Figure 30 in Appendix 3.2-A). Irrigation season flows would increase 2% in a normal year and decrease 1% in a dry year (Table 14 in Appendix 3.2-A). Total flow volume in this reach would decrease 3% in normal years and decrease 4% 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 starting in year 8. Increased minimum fall/winter flows and the irrigation season flow cap would result in reduced irrigation season flows in this reach, with the greatest changes occurring in years 13 through 30 (Figure 32 in Appendix 3.2-A). Irrigation season flows would decrease 15% in a normal year and 23% in a dry year (Table 16 in Appendix 3.2-A). Winter storage flows would increase 42% in a normal year and 295% (30,367 vs. 119,802 af) in a dry year. Total flow volume in this reach would decrease 4% in normal years and be unchanged in a dry year in years 13 through 30. 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 minimum fall/winter flows and decrease irrigation season flows (early April through mid-September) in this reach, starting in year 8, but effects would be greatest in years 13 through 30 (Figure 34 in Appendix 3.2-A). In a dry year, the sequentially higher winter storage season minimum flows would result in varied irrigation season flows ranging from an increase of 1% in years 1 through 7, to a reduction of 13% in years 13 through 30 (Table 18 in Appendix 3.2-A). Conversely, winter storage season flows would increase up to 29 and 46% in a normal 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 starting in year 8 but with greatest effects starting in year 13. In years 13 through 30, winter storage flows would be higher and irrigation season flows would be lower or similar compared to no-action alternative flows (Figure 36 in Appendix 3.2-A). Irrigation season flows in this reach would increase by up to 14% in a normal year and increase by up to 17% in a dry year (Table 20 in Appendix 3.2-A). Winter flows would increase up to 46% in a normal year and up 52% in a dry year. Total flow volume in this reach would increase by 34% and 40% 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 and Conservation Measure DR-1[14] would result in higher winter flows in this reach, similar to upstream reaches (Figure 44 in Appendix 3.2-A). Irrigation season flows would be negligibly different, increasing up to 3% in a normal year and up to 2% in a dry year over the permit term (Table 26 in Appendix 3.2-A). Total flow volume would increase up to 13% in a normal year and up to 14% in a dry year starting in year 13. 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 observed at the CULO gauge. No additional gaging stations are located between the CULO 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 fourfold between Culver and Madras because of inflow that originates as spring discharge to the Deschutes River, Metolius River, and lower Crooked River (Figure 46 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 13 through 30, winter flows would increase up to 3% in a normal year and up to 6% in a dry year (Table 28 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 6 and 30% more variable in years 13 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[15] 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 during winter in response to lower minimum flows intended to better utilize storage water at times of the year to benefit Oregon

[14] Minimum 250 cfs stockwater target for the Middle Deschutes River (Bend to Lake Billy Chinook) from November 1 to March 31.
[15] The Madras gauge is the furthest downstream gauge in the RiverWare model.

spotted frog. Flows over the permit term are more variable from mid-April through mid-July as water is released to meet irrigation demand and to augment flows for Oregon spotted frog habitat (see Appendix 3.2-A, Conservation Measure CC-1 for more discussion). Median flows from mid-July through the end of September are consistent over the permit term and tend to be less than the no-action alternative (Figure 38 in Appendix 3.2-A). Irrigation season flows decrease 12% and winter storage flows decrease 48% compared to the no-action alternative in a normal year (Table 22 in Appendix 3.2-A). In a dry year, irrigation season flow volumes would range from a reduction of 2% to an increase of 4%, and winter storage flow volumes would decrease 40% over the permit term. Total flow volumes in this reach would decrease between 26% and 19% in a normal water year and decrease from 11% (years 1–7) to 4% (years 13–30) in a dry year. Monthly total flow volumes are more variable in both normal and dry years because of the lower winter minimum flows. Storage for Oregon spotted frog habitat flow augmentation would provide managers with water management flexibility.

Little Deschutes River from Crescent Creek Confluence to the Deschutes River. Flows in this reach would experience minimal changes. In years 13 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 and to address Oregon spotted frog habitat needs (Figure 40 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 permit term, irrigation season flows would increase 17% in normal years and 12% in dry years, and total flow volume would increase 14% in a normal water year and 8% in a dry year (Table 24 in Appendix 3.2-A). Over the permit term, winter storage flows would increase 9% in normal years and 1% in dry years. Monthly total flow volumes would be less variable (decrease up to 20%) 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 stream flows in Whychus Creek.

Crooked River outflow from Bowman Dam. Increases in Upper Deschutes River minimum fall/winter flow starting in year 8 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 48 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 13 through 30 of the permit term, flow releases to meet North Unit ID demand in a dry year would occur from mid-April through late May, whereas no such releases would occur under the no-action alternative. However, North Unit ID's pattern of use in 2018, 2019, and 2020 reflected this earlier use of Crooked River water; therefore, it is unclear if this is truly an effect of the proposed action or changes in water management practices. However, the model indicates that irrigation season flows would increase 5% during years 13 through 30 for a dry year (Table 32 in Appendix 3.2-A). Total flow volume in this reach would increase 3% in a dry year. Monthly total flow volumes would be more variable in a typical dry year because of higher flow releases in April and May 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 [CAPO] gauge). The primary diversions in the reach are the Rice Baldwin, Peoples, and the Crooked River Feed Canals, in addition to several smaller, secondary diversions. In a normal year, irrigation season flows would increase up to 11% and storage season flows would decrease 6%. In a dry year, starting in year 13 of the permit term, streamflow would increase from mid-April through late May and then decrease back to the no-action alternative level in before June (Figure 51 in Appendix 3.2-A). Irrigation season flows would increase up to 10% and total streamflow would increase 3% in a dry year (Table 34 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. Starting in year 13, the median flow from mid-June through early August would decrease (Figure 54 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 Wickiup Reservoir storage and Deschutes River irrigation flows. Irrigation season flows would decrease 18% for normal and 13% for dry years (Table 36 in Appendix 3.2-A) in years 13 through 30. Total flow volume in this reach would also decrease up to 9% in normal years and 8% in dry years. Flows would be more variable in normal years (4%) and dry years (9%) compared to the no-action alternative.

Crooked River from Smith Rock State Park to Opal Springs Dam. Median summer flows would decrease from mid-April to early May and then from mid-June through the start of August in years 13 through 30 as the upstream North Unit ID pump station withdraws water (Figure 56 in Appendix 3.2-A). Irrigation season flows would decrease by 1 to 2% starting in year 13 for normal and dry years as water use is in part masked by the large volume of groundwater that enters this reach (Table 38 in Appendix 3.2-A). Total flow volume in this reach would decrease by similar amounts in both normal and dry years. Monthly total flow volumes would be similar in a normal year and a dry year compared to the no-action alternative.

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 (DEBO) gauge. To assess flooding in the vicinity of the Town of Tumalo, the summation of the DEBO gauge and the TUMO Creek (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 `modeling period was determined. The average number of days of flood flow exceedance for the modeling period is reported for the proposed action compared to the no-action alternative (Table 29 in Appendix 3.2-A).

Over the permit term, there would be a reduction in the number of days of flood flow exceedance based on the modeled flows. The reduction in flood flows on the Upper Deschutes River is due to increased winter storage season flows, which decrease stored water availability during irrigation season. Beginning in year 8 days of flood flow exceedance decrease from 3.1 days per year at the WICO gauge and 12.2 days per year at the BENO gauge, to 0 days and 3.9 days for the gauges, respectively. There is a slight increase in the number of days of flood flow exceedance using the summation of the DEMO and Tumalo gauges at the 1,400 cfs threshold in early phases of the permit term, but by year 13, there are 0 days of flood flow exceedance. A similar pattern occurs using the two gauges and a higher flood flow threshold of 2,000 cfs. Days of exceedance remain at 1.1 day per year until year 13 when the anticipated number of days of exceedance drops to 0 days. Proposed action irrigation season peak flow caps instituted in year 8 (1,400 cfs cap) and in year 13 (1,200 cfs cap) result in fewer days of flows exceeding the respective flow cap target values at the WICO gauge.

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 seasonal 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 the 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 and caps on maximum daily flows. 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 more variable, especially during dry years as irrigation season flows increase to meet North Unit ID irrigation demands that are not satisfied by stored Deschutes River water. 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 (Gannett 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

Crane Prairie Reservoir. Modeled changes in reservoir storage for Crane Prairie Reservoir under Alternative 3 would be the same or nearly the same as described for the proposed action.

Wickiup Reservoir. As winter flow releases from Wickiup Reservoir increase above no-action levels in year 1 (Conservation Measure WR-1), Wickiup Reservoir storage would decline, with the greatest declines observed in years 11 through 30 of the permit term (Tables 39 and 40, and Figure 58 in Appendix 3.2-A). In a normal water year during years 11 through 30, water supply storage would be reduced by 99,986 af (a 53% reduction).

Crescent Lake Reservoir. Conservation Measure CC-1, under Alternative 3, would reduce minimum flows downstream from Crescent Lake Dam to 20 cfs year-round compared to 30 cfs from March 15 through November 30 and 20 cfs during the rest of the year under the no-action alternative. Therefore, Alternative 3 would generally result in an increase in Crescent Lake storage (Table 41 and Figure 59 in Appendix 3.2-A). During years 11 through 30 of Alternative 3, maximum storage between April and August would increase by approximately 5,000 af in normal or dry years. During very dry years, there would be a limited increase or a slight decline in storage.

Prineville Reservoir. As winter flow releases out of Wickiup Reservoir increase starting in year 1 of the permit term, reducing North Unit ID stored water supply from the Deschutes River, North Unit ID would use its available stored water from Prineville Reservoir (up to 10,000 af) more frequently and to a greater extent. This, combined with increased winter minimum flows in the Crooked River (Conservation Measure CR-1), would result in reduced Prineville Reservoir storage, particularly in dry and very dry years. In years 11 through 30 of the permit term, changes in storage would range from a decrease of 4,758 af in dry years to 19,367 af in a very dry year (Table 42 and Figure 60 in Appendix 3.2-A). Although the reduction in Prineville Reservoir storage is high during dry and very dry years, the average reduction in storage would be approximately 3,407 af, equivalent to less than 3% of total storage. 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. Modeled changes in reservoir storage for Ochoco Reservoir under Alternative 3 would be the same or nearly the same as described for the proposed action.

Effect Conclusion: Reservoir storage under Alternative 3 would increase slightly during the storage season and decrease slightly during the irrigation season in Crane Prairie; progressively decrease in normal, dry, and very dry years over the permit term in in Wickiup Reservoir; increase slightly in Crescent Lake Reservoir; decrease in dry and very dry years in Prineville Reservoir; and decrease slightly in Ochoco Reservoir compared to the no-action alternative. 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

North Unit Irrigation District. Reduced storage in Wickiup Reservoir, described in Impact WR-1would reduce water supply available to North Unit ID starting in year 1 of the permit term in normal to very dry years. (Figures 61 and 65 in Appendix 3.2-A). It is also expected that North Unit ID would increase use of its Crooked River pumping plant to partially offset reduced water supply from Wickiup Reservoir storage beginning in year 1.[16] During years 11 through 30, when Crooked River water use would be highest, North Unit ID would increase use of the Crooked River pumping plant by 10,546 af in a normal year. However, in a very dry year, decreased Prineville Reservoir storage due to Conservation Measure CR-1 would reduce North Unit ID Crooked River water supply by 2,800 af and would reduce its ability to offset water supply shortages 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 62, 63, and 64 in Appendix 3.2-A. Water supply available to Central Oregon ID would decrease slightly beginning in year 1 of the permit term in all water year types, but the effects would be small relative to Central Oregon ID diversions. In a very dry year, Central Oregon ID diversions would decline by 3,248 af beginning in year 11. This represents approximately 1.15% of diversions under the no-action alternative.

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 very dry year, Arnold ID diversions would decline by 6,640 af starting in year 1 of the permit term and by 7,753 af starting in year 11. This represents approximately 27 and 32% of diversions under the no-action alternative, respectively (Figures 63 and 66 in Appendix 3.2-A).

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 64 and 66 in Appendix 3.2-A). In a dry year, Lone Pine ID diversions would decline by 1,212 af starting in year 1 and by 1,338 af starting in year 11. Reductions would be greater during dry years, with reductions of 1,920 af beginning in year 1 and 2,491 af in year 11. This represents approximately 15 and 23% of diversions, respectively.

Ochoco Irrigation District. Reduction in water supply for Ochoco ID would be the same or nearly the same as under the proposed action, but would occur earlier in the permit term and would be slightly greater than under the proposed action. Ochoco ID water supply would be reduced by approximately 24% in very dry water years beginning in year 11 of the permit term (Figure 66 in Appendix 3.2-A) compared to approximately 20% under the same conditions beginning in year 13 of the permit term under the proposed action.

Tumalo Irrigation District. Increased storage in Crescent Lake Reservoir, described in Impact WR-1, is expected to increase Tumalo ID stored water supply. However, increased regulatory calls on the Tumalo ID live flow Deschutes River water right are expected to decrease water supply. As a result, Tumalo ID diversions would increase slightly in dry and very dry years compared to the no-action

[16] 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.

alternative, with a maximum of increase of 679 acre-feet in very dry year, an increase of 2.2% of Tumalo ID supply under the no-action alternative (Figure 67 in Appendix 3.2-A).

Three Sisters Irrigation District. Conservation Measures 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 under Alternative 3.

Other Deschutes River Water Users. Reduction in water supply for other Deschutes River water users junior to North Unit ID (Table 2 in Appendix 3.2-A) would be the same or nearly the same as described for the proposed action, but would occur earlier in the permit term. Reduction in water supply for other Deschutes River water users junior to Central Oregon ID, Arnold ID, and Lone Pine ID would be slightly greater than described for the proposed action, but slightly greater in very dry years. (Figure 68 in Appendix 3.2-A).

Other Crooked River Water Users. Reduction in water supply for other Crooked River water users, including small IDs, private irrigators using shared conveyance systems, and private irrigators with individual diversions would be nearly the same as described for the proposed action, but would occur earlier in the permit term, and would be slightly greater, approximately 5% in very dry years under Alternative 3 (Figure 69 in Appendix 3.2-A), compared to 3% in very dry years under the proposed action.

Effect Conclusion: Overall, changes in reservoir storage under Alternative 3 would result in varying degrees of water supply reductions for DBBC irrigation districts and other live flow diverters compared to the no-action alternative. Reductions in water supply would generally be greater than under the proposed action and would occur earlier in the permit term. 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 and Three Sisters ID would experience relatively minor water supply reductions. Tumalo ID would experience a slight increase in water supply. Swalley ID would not be affected. The effects of these water supply changes are addressed in Sections 3.5, *Land Use and Agricultural Resources*, and 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 Crane Prairie and Ochoco Reservoirs, but differ for Wickiup, Crescent Lake, and Prineville Reservoirs as described below. Elevation changes in Wickiup Reservoir and Crescent Lake Reservoir would occur earlier in the permit term (Table 3.1-1).

Wickiup Reservoir. Wickiup Reservoir water surface elevations under Alternative 3 would be drawn down lower compared to the no-action alternative due to the higher storage flows (Figure 70 in Appendix 3.2-A). Lower median water surface elevations would occur in every month and the vertical distance between the 90% reservoir capacity and the median water surface elevation would increase. On average, median water surfaces would be 9 feet lower than the no-action alternative over the permit term. Days of 90% reservoir capacity exceedance would decline from 64 days per year under the no-action alternative, to 49 days per year (years 1–5) and 40 days per year (years 11–30) under Alternative 3.

Crescent Lake Reservoir. Although Crescent Lake Reservoir median water surface elevations under Alternative 3 would be higher compared to the no-action alternative, median water surface elevations would remain below the 90% reservoir capacity elevation (Figure 71 in Appendix 3.2-A).

Days of 90% reservoir capacity exceedance would increase from 20 days per year under the no-action alternative, to 28 days per year under Alternative 3 in years 11-30.

Prineville Reservoir. 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, although median water surface elevations during the irrigation season would be lower compared to the no-action alternative as additional water is released from Prineville Reservoir to meet North Unit ID demand (Figure 71 in Appendix 3.2-A). Median and maximum monthly water surface elevations would remain under the 90% flood storage capacity and exceedance of the 90% reservoir capacity elevation would occur less than 1 day per year.

Effect Conclusion: Changes in reservoir water surface elevations and flood storage capacity under Alternative 3 compared to the no-action alternative would be similar to or result in lower flood risk than 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 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 would be similar as described under the proposed action, except for the following:

- Flows would differ on the Deschutes River downstream from Wickiup Dam without the irrigation season flow cap included under the proposed action.
- Flows would differ in Crescent Creek and the Little Deschutes River due to a higher minimum flow requirement from October 1 through June 30 (20 cfs vs. 10 to 12 cfs), and a lower minimum flow requirement from July 1 through September 30 (20 cfs vs. 50 cfs). Alternative 3 also does not include the Oregon spotted frog stored water account that provides water management flexibility.
- Irrigation season flows on the Crooked River would differ due to protection of uncontracted fish and wildlife releases from Prineville Reservoir to Lake Billy Chinook and increased releases from Prineville Reservoir to meet increasing irrigation demand in response to higher minimum fall/winter flows on the Upper Deschutes River.
- Additionally, flow changes in the Upper Deschutes River and Crooked River would occur earlier in the permit term (Table 3.1-1).

Deschutes River from Wickiup Dam to the Little Deschutes River. Implementation of Conservation Measure WR-1 would have a similar effect on flows as described for the proposed action (Figure 73 in Appendix 3.2-A). However, increases in fall/winter minimum flows would start in year 1 and irrigation period flows would not be capped. Irrigation period flows would decrease 13 and 23% during normal and dry years, respectively, compared to the no-action alternative (Table 44 in Appendix 3.2-A). Storage flows would increase 43 and 295% in normal and dry years, respectively, during the last phase of the permit term. Annual flows would also be more variable as irrigation flows decrease and storage flows increase.

Deschutes River from the Little Deschutes River to Benham Falls. The flow pattern would be similar to the Deschutes River from Wickiup Dam to the Little Deschutes River (Figure 75 in Appendix 3.2-A). Irrigation season flows would decrease 10 and 15% during normal and dry years, respectively, in response to increased minimum storage flows, which would increase up to 46% in a dry year (Table 46 in Appendix 3.2-A).

Deschutes River from Benham Falls to Bend. Conservation Measure WR-1 would also influence storage season streamflow in this reach. Fall/winter flows would be higher under Alternative 3 but irrigation season flows would be similar compared to the no-action alternative (Figure 77 in Appendix 3.2-A). Median flows from mid-April to early May decrease relative to the median no-action flow level before stabilizing to a similar level in mid-May. Irrigation season flows would be 11 and 13% greater in normal and dry years, respectively, while winter storage flows would be 45 and 52% greater over the same year types compared to the no-action alternative (Table 48 in Appendix 3.2-A).

Deschutes River from Bend to Culver. Like the DEBO gauge, the CULO gauge shows the effects of higher fall/winter minimum flows associated with Alternative 3, primarily on winter flows (Figure 83 in Appendix 3.2-A). Irrigation season flows are similar to the no-action alternative. Groundwater inputs to this reach also contribute to streamflow, increasing the year-round magnitude of flows. While irrigation period flows only increase up to 2%, winter storage flows increase 23% in a normal year and 25% in a dry year. Annual flow variability also increases up to 64% in a dry year as fall/winter minimum flows substantially increase relative to irrigation season flows (Table 54 in Appendix 3.2-A).

Deschutes River from Culver to Lake Billy Chinook. Flows in this reach would be similar to the Deschutes River observed at the CULO gauge. No additional gaging stations are located between the CULO 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. Spring inputs in this reach reduce the effect of upstream diversions on stream flows. Alternative 3 winter flows are slightly greater and irrigation season flows are slightly less than the no-action alternative (Figure 85 in Appendix 3.2-A). Winter storage flows increase up to 6% and irrigation period flows decrease 1% in a dry year (Table 56 in Appendix 3.2-A). Alternative 3 has minimal flow differences in wet and normal years.

Deschutes River from Madras to the Mouth of the Deschutes River. Tributary and groundwater inputs downstream of the Madras gauge[17] 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. Conservation Measure CC-1 would cause flows in this reach to decrease during winter in response to lower minimum flow targets (and would generally be slightly higher during the early irrigation season). Flows are similar from mid-August through the end of September when minimum flow management is instituted (Figure 79 in Appendix 3.2-A). Irrigation season flows decrease 8% in a normal year but are comparable in a dry year to the no-action alternative. Winter storage flows decrease 13 and 11% in normal and dry years, respectively (Table 50 in Appendix 3.2-A). Flow variability increases slightly with the lower storage minimum flows and the higher flows early in the irrigation season.

Little Deschutes River from Crescent Creek Confluence to the Deschutes River. Flows in this reach would experience minimal changes, mainly in winter as a result of reduced minimum flow requirements on Crescent Creek (Figure 81 and Table 52 in Appendix 3.2-A).

Tumalo Creek. Tumalo Creek flows would be unchanged.

Whychus Creek. Whychus Creek flows would be unchanged as described for the proposed action.

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

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 87 in Appendix 3.2-A). To meet North Unit ID demand, additional water would be released from Prineville Reservoir earlier in the irrigation season. In years 1 through 5, additional flow releases begin in mid-May and continue through mid-June when flows decline to marginally greater than the no-action alternative. In years 11 through 30, supplemental flow releases are greater and continue through late June. Similar water management has occurred in recent years (2018–2020) in response to drought conditions. Irrigation season flows increase up to 7% in a normal year and 5% in a dry year (Table 59 in Appendix 3.2-A). Winter storage flows decrease 4% in normal and dry years and decline 13% in wet years. Flows are most variable in a dry year. Similar to the no-action alternative, flows are released to meet irrigation demand from mid-April through June in a dry year. Winter flows remain consistent through the season and similar to the no-action flows.

Crooked River from Bowman Dam to OR 126 Crossing. Flow follows a similar pattern at the CAPO gauge with lower winter flows and higher irrigation flows (Figure 89 in Appendix 3.2-A). Irrigation period flows increase up to 15% in a dry year and 8% in a normal year (Table 61 in Appendix 3.2-A). Winter storage flows decline up to 13% in a wet year as storage is prioritized to summer demand.

Crooked River from North Unit ID Pump Station to Smith Rock State Park. Alternative 3 median flows decline below the no-action flow level by mid-May in years 11 through 30 and remain below the no-action alternative through early August as more water is diverted at the North Unit ID pump station (Figure 91 in Appendix 3.2-A). Annual flows decline over the permit term and irrigation season flows decrease up to 13% in a dry year while winter storage flows decline up to 13% in a wet year (Table 63 in Appendix 3.2-A).

Crooked River from Smith Rock State Park to Opal Springs Dam. Substantial groundwater inputs mask upstream water management-related changes to Crooked River flows (Figure 93 in Appendix 3.2-A). Flows decline slightly in the last period of the permit term under all water year types (Table 65 in Appendix 3.2-A).

Effect Conclusion: Changes in seasonal streamflows under Alternative 3 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. However, Alternative 3 does not cap maximum daily irrigation flows and, therefore, Wickiup Reservoir may be drawn down more from July through September compared to the no-action alternative and the proposed action. On the Crooked River, flows below Bowman Dam (PRVO and CAPO gauges) would become more variable, especially during dry years as irrigation season flows increase to meet North Unit ID irrigation demands that are not satisfied by stored Deschutes River water. 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.*

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 or Alternative 3, the previous descriptions 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 or nearly the same as described for Alternative 3 for Prineville, Crane Prairie, Ochoco, and Crescent Lake Reservoirs, but would occur earlier in the permit term (Table 3.1-1). Changes in Wickiup Reservoir 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 (Tables 66 and 67, and Figure 95 in Appendix 3.2-A). In a normal water year, at full implementation (years 6–20), water supply storage would be reduced by 104,364 af, a reduction of 56% compared to the no-action alternative. The increased reduction in water supply storage compared to Alternative 3 is attributable to greater increases in storage season releases during wet and very wet years.

Effect Conclusion: Changes in reservoir storage under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for Alternative 3 for all reservoirs except for Wickiup Reservoir. Reductions in Wickiup Reservoir storage in normal and wet years would be 2.3 and 11% greater than under Alternative 3 at full implementation. Changes in water supply storage in Wickiup, Prineville, and Crescent Lake Reservoirs would occur earlier in the permit term compared to 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 Alternative 3 for all users except North Unit ID; however, the changes would occur earlier in the permit term than under Alternative 3 and the overall permit term would be of shorter duration (Table 3.1-1).

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 diversions would decline by 53,627 af in dry years (Figure 98 and Table 70 in Appendix 3.2-A). Beginning in year 6, North Unit ID's diversions would decline by 79,263 af in dry years (approximately 16% more than under Alternative 3 in years 11 through 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 pers. comm. [a, b]). Effects of the increase in these regulatory calls on water supply for other Deschutes River water users with junior water rights are described further for each irrigation district. It is also expected that North Unit ID would increase use of its Crooked River pumping plant to offset reduced water supply from Wickiup Reservoir storage beginning in year 1.[18] 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 16,134 af in normal years. However, in very dry years, decreased Prineville Reservoir storage due to Conservation Measure CR-1 would reduce North Unit ID's Crooked River water supply by 2,846 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 Alternative 3 for all users except North Unit ID, but the changes would occur earlier in the permit term than under 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 16% greater in magnitude during a dry water year than described for Alternative 3. The effects of these water supply changes are addressed in Sections 3.5, *Land Use and Agricultural Resources*, and 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 4 compared to the no-action alternative would be the same or nearly the same as described for Alternative 3 for Crane Prairie, Crescent Lake, Prineville, and Ochoco Reservoirs, but would occur earlier in the permit term (Table 3.1-1). Changes in Wickiup Reservoir storage under Alternative 4 compared to the no-action alternative are described below.

Wickiup Reservoir. Wickiup Reservoir water surface elevations would experience the greatest change due to 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 substantially lower compared to the no-action alternative, especially in years 6 through 20 as less water would be stored year-round (Figure 99 in Appendix 3.2-A). Median reservoir water surface elevations would, on average, be 11.4 feet lower during the storage season and 14.3 feet lower during the irrigation season over the permit term. Average median annual water surface elevations would be approximately 15.8 feet lower in years 6 through 20. Days of 90% reservoir capacity exceedance would decline from 64 days per year under the no-action alternative to 36 days per year (years 1–5) and 32 days per year (years 6–20) under Alternative 4.

Effect Conclusion: Changes in reservoir water surface elevation and flood storage capacity under Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for Alternative 3 for all reservoirs except for Wickiup Reservoir. 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,

[18] 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.

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. 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 Alternative 3 in the following reaches: Deschutes River between Crane Prairie and Wickiup Reservoirs and below Culver, the Crooked River, and Crescent, Whychus, Tumalo, Ochoco, and McKay Creeks. Therefore, no additional analysis is provided for these locations in the following section.

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 102 in Appendix 3.2-A). Irrigation season flows would decrease 13% in a normal year and 23% in a dry year (Table 72 in Appendix 3.2-A). Winter storage flows would increase 50% in normal years and 295% (30,367 vs. 119,801 af) in dry years. Total flow volume in this reach would decrease 1% 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 increase and irrigation season flows decrease. Streamflows under Alternative 4 would be proportionally greater in the winter (30%) and lower (23%) 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, especially in a dry year.

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 beginning in mid-April (Figure 104 in Appendix 3.2-A). Irrigation season median flows differ from the no-action alternative most substantially beginning in year 6. In dry years, the sequentially higher winter storage season minimum flows would result in a decrease of irrigation season flow of 15% (Table 74 in Appendix 3.2-A). Fall/winter flows would increase 9 and 46% in a normal year and a 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, decreasing by 21% and 59%, respectively. The reduced variability is due to higher winter flows and lower irrigation season flows.

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, but unlike the upstream gauges, irrigation season flows also increase under Alternative 4 compared to the no-action alternative (Figure 106 in Appendix 3.2-A). Irrigation season flows in this reach would increase by up to 11% in a normal year and increase by up to 14% in a dry year (Table 76 in Appendix 3.2-A). Fall/winter flows would increase up to 45% in a normal year and up 52% in a dry year. Total flow volume in this reach would increase by 32 and 40% in normal and dry years, respectively.

Deschutes River Flood Flows. Alternative 4 would result in fewer days of flows exceeding flood flow thresholds measured at the WICO and BENO gauges compared to the no-action alternative (Table 77 in Appendix 3.2-A). The flood flow threshold would be exceeded approximately 2 more days per year in the vicinity of Tumalo at the lower flood threshold of 1,400 cfs and remain at 1 day at the 2,000 cfs flood threshold.

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). 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 similar to Alternative 3. As such, modeled flows would be the same or nearly the same as described for Alternative 3 in all reaches except the Upper and Middle Deschutes 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 (Figure 3.2-1).

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. 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.

Changes in water quality from the proposed action and action alternatives were evaluated qualitatively based on the timing, intensity, and duration of modeled changes in reservoir levels and stream and river flows. While water quality is influenced by a vast number of variables—including sources, inputs, and precipitation patterns—overall effects can be reasonably identified based on widely accepted relationships between reservoir levels, stream flows, and water quality (Schnoor 1996; Wetzel 2001). In addition, a quantitative analysis was conducted on the Upper Deschutes River due to the availability of data and the relative high magnitude of projected changes in Upper Deschutes River flows.[1] The quantitative analysis of the Upper Deschutes also informed the ualitative effects analyses conducted for other surface waters.

The quantitative analysis 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 modified to use input data from the RiverWare model (Zagona et al. 2001), described in Section 3.2, *Water Resources,* along with local climate data and water quality data provided by the Bureau of Reclamation, ODEQ, and the City of Bend. Flow and related water quality parameters were modeled at the BENO gauge (Deschutes River at Benham Falls) and DEBO gauge (just north of Bend and after major irrigation withdrawals have reduced streamflow).

One of the most comprehensive data sets within the study area was the water quality data collected by the City of Bend from 2008 to 2017 at 11 sites on the Deschutes River (river miles 163 to 172). This data set includes data from multiple ***sondes***[2] (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 and *E.*

[1] 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.

[2] An instrument probe that was used to automatically transmits data from underwater.

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

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 (unpublished data). These data sets include an extensive list of parameters. The QUAL2Kw model was calibrated to be consistent with the RiverWare flow calculations. Guidance for selection of the calibration parameters was assisted by results from similar modeling conducted on the Lower Deschutes River (Eilers and Vache 2019).

To assess potential effects of changes to the operation of Wickiup Reservoir on the Deschutes River reaches below, limited available water quality samples collected from Wickiup Reservoir were input to the QUAL2Kw model runs.

Water quality effects in the remainder of the study area were assessed qualitatively 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.

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 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 between Osborne Canyon and Opal Springs just before the confluence with Lake Billy Chinook (Stearns 1930). The three major rivers in the basin, Metolius, Crooked and Deschutes, are impounded and form Lake Billy Chinook, the uppermost impoundment of the Pelton–Round Butte Hydroelectric Project. Lake Billy Chinook discharges into Lake Simtustus, which then discharges into the Reregulating Reservoir. The Reregulating Reservoir forms the “headwaters” for the Lower Deschutes River, a 100-mile river reach before its confluence with the Columbia River. The flow in the Lower Deschutes River is augmented by flows from tributaries in the upper one-half of the Lower Deschutes River and includes Trout Creek, the Warm Springs River, and several other tributaries.

Constituents of concern in the study area are identified in Table 3.3-1 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 Lakes drainage is noteworthy because of the naturally high phosphorus concentrations and frequent cyanobacterial blooms (Eilers et al. 2005). As shown in Table 3.3-1, 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-spine stickleback, tui chub, black crappie and bullhead (ODFW, unpublished data). 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. However, monitoring by the U.S. Forest Service indicates additional cyanobacteria blooms have occurred (Deschutes National Forest, unpublished data).

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 (Johnson et al. 1985). Wickiup Reservoir has been subject to cyanobacteria blooms (Schaedel 2011). in the months of September and October (Schaedel 2011), 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 (Bureau of Reclamation, unpublished data) were collected during July of different years and provide little indication regarding how the water chemistry in Wickiup Reservoir changes throughout the summer and fall.[4]

Water quality data available for Wickiup Reservoir (depicted in Table 3.3-2 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, other reservoirs with these types of conditions

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

Table 3.3-1. Water Quality Impairments in the Study Area

Location	Temperature	Dissolved Oxygen	pH	Chlorophyll[a]	Turbidity	Sedimentation	Total Dissolved Gas	Nuisance Algae	Biological Impairment
Deschutes River Subbasin									
Crane Prairie Reservoir	-	-	-	-	-	-[b]	-	X	-
Wickiup Reservoir	-	-	-	-	-	-[b]	-	X	-
Upper Deschutes River[c]	X	X	X	-	X	X[d]	-	-	-
Middle Deschutes River	X	X	X	X	X	-	-	-	-
Lake Billy Chinook	-	X	X	X	-	-	-	-	-
Lake Simtustus	-	X	X	X	-	-	-	-	-
Lower Deschutes River	X	X	X	-	-	-	-	-	-
Whychus Creek	X	-	-	-	-	-	-	-	X
Little Deschutes River[e]	X	X	-	-	-	-	-	-	-
Tumalo Creek	X	-	-	-	-	-	-	-	-
Crescent Lake[f]	-	-	-	-	-	-	-	-	-
Crescent Creek	X	-	-	-	-	-	-	-	-
Crooked River Subbasin									
Prineville Reservoir[f]	-	-	-	-	-	-[b]	-	-	-
Ochoco Reservoir	-	-	-	-	-	-[b]	-	-	X
Crooked River	X	X	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] No water quality standard exists for Chlorophyll. This table identifies impairments based on the guideline for Chlorophyll *a*.
[b] No quantitative sediment surveys are available to assess sedimentation.
[c] Although information on water quality impairments for the Deschutes River reach between Crane Prairie and Wickiup Reservoirs was available, it was assumed based on conditions in Crane Prairie Reservoir that this reach would also experience impairments for pH, dissolved oxygen, and chlorophyll, nuisance algae.
[d] Sedimentation is present in Mirror Pond, an impoundment of the Deschutes River in Bend, Oregon.
[e] Does not include post-2012 data.
[f] No Category 5 listings.

generally behave in a predictable manner. As shown in Table 3.3-2 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 milligrams per liter (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).
- 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.

Table 3.3-2. Water Quality Measurements for Wickiup Reservoir, Based on Samples Collected 200 Meters South of Wickiup Dam (All samples collected in July), 2007–2016

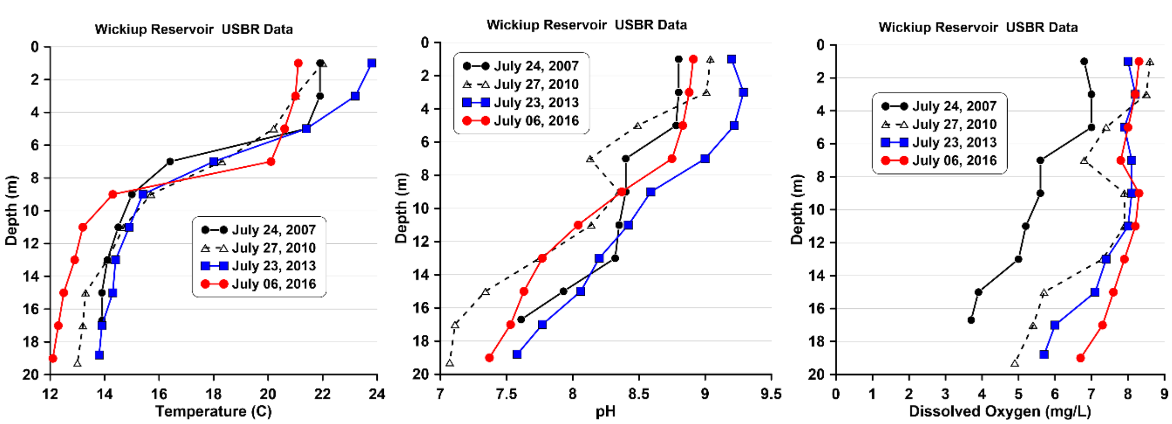
Parameter	Units	2007		2010		2013		2016	
Depth	m	1	16.7	1	19.3	1	18.8	1	19
Temp	°C	21.9	13.9	22	13	23.8	13.8	21.1	12.1
pH	su	8.8	7.61	9.04	7.07	9.2	7.58	8.91	7.37
Dissolved oxygen	mg/L	6.8	3.7	8.6	4.9	8	5.7	8.3	6.7
Chlorophyll[a]	µg/L	6.3	-	9.3	-	6	-	7.3	-
Secchi[a]	m	3	-	4.4	-	3.3	-	3.2	-
TP	mg/L	0.018	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.

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

[a] Values apply to the entire water column.

Figure 3.3-1. Temperature (C), pH, and Dissolved Oxygen (mg/L) Levels in Wickiup Reservoir, based on Data Collected 200 meters South of Wickiup Dam, 2007–2016



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 comprises 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 in the Little Deschutes River showed that concentrations of inorganic nitrogen were relatively low. Despite the elevated nitrogen concentrations in the underlying aquifers, the concentrations of inorganic nitrogen in the Upper Deschutes River are consistent with nitrogen-limited systems (Allan 1995). The Upper Deschutes River currently experiences periods of elevated pH (above the water quality standard of 8.5) and low dissolved oxygen (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, this reach of the river 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 on the 303(d) list for pH.

Lake Billy Chinook and Lake Simtustus. Lake Billy Chinook and Lake Simtustus are operated as near run-of-the-river systems and as such do not experience the large seasonal variations in lake stage associated with the irrigation impoundments upstream. Lake Billy Chinook experiences a complex mixing dynamic from the three tributaries, but much of the surface inflow from the Crooked River remains on the surface and is discharged from the lake through the selective water withdrawal that began operating in 2010. The selective water withdrawal allows for creation of an attractant flow for migrating salmonids that are collected in the device and transported downstream. Water from Lake Billy Chinook passes through the hypolimnion of Lake Simtustus during warmer months and is released into the Reregulating Pool from the bottom outlet on Pelton Dam. Hydraulic residence time in the Reregulating Pool is generally less than 12 hours. Additional details of the impoundments and their water quality characteristics are available in Eilers and Vache (2019). Both impoundments are on the 303(d) list for pH and dissolved oxygen and exceed guidelines for chlorophyll *a*.

Lower Deschutes River. Flows in the Lower Deschutes (downstream of Lake Billy Chinook) 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 (Gannett et al. 2017). This large, stable inflow decreases the influence of upstream irrigation activities, including the covered activities of the HCP. Because of this, the Lower Deschutes has much less seasonal flow fluctuation compared to upstream reaches. This reach of the Deschutes River is on the 303(d) list for pH, dissolved oxygen, and temperature.

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, passing through Sisters, 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 that has raised the lake stage to allow for additional storage and provide controlled discharge into Crescent Creek. Crescent Lake is deep (285 feet) and low in nutrients with no reported water quality issues (Johnson et. al 1985).

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, the lake appears 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 (70.5 miles). The Crooked River is described by ODEQ as having poor water quality and is on the 303(d) list for impairment related to dissolved oxygen, temperature, biological criteria, flow modification, *e. coli*, pH, and total dissolved gas (ODEQ 2011). Additionally, the Crooked River has high concentrations of nitrogen and phosphorus (Noone 2020; Oregon Department of Environmental Quality 2012). The combination of higher-than-desired temperature and nutrients results in increased algae and aquatic plan biomass also leads to daily fluctuations in pH. Sources of nutrients and other pollutants include return flows from agricultural fields, drains, or canals and discharges from the City of Prineville’s wastewater treatment facility. The City’s treatment facility was replaced in 2016 with a wetland-based system, the Crooked River Wetland Complex, which has increased treatment capacity and effectiveness. Pollution outputs of the facility are managed under a National Pollution Discharge Elimination System (NPDES) permit, which is independent of the HCP.

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 3.3-1.

Effects of climate change, ongoing development, river restoration actions, and water conservation under the no-action alternative would affect water quality over the permit duration.

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 and less low groundwater recharge (Gannett et al. 2001). Also, because the subbasin has less precipitation than the western portion of the Deschutes Basin, relatively small increases in annual air temperature (and associated increases in evaporation) and decreases in summer precipitation could result in greater effects on water temperature and streamflow. The overall effect of forecasted changes in climate are expected to have negative effects on water quality in the basin.

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. As shown in Table 3.9-1 in Section 3.9, *Socioeconomics and Environmental Justice*, the study area population as a whole projected to grow by 68% by 2050. Increased delivery of nutrients, particularly nitrogen, is expected to increase the algal growth in study area waters (Gannett et al. 2001, Caldwell and Truini 1997, Allen 1995). 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 decline with anticipated improvements and efficiencies in agricultural practices in the basin. Although substantial efforts are being made to minimize the effects of population growth on water quality in the basin, most basins experiencing this magnitude of growth experience negative effects on water quality.

Increased development often results in increased demand for water associated with industrial/commercial operations and residential use for household and landscaping applications. However, as described in Section 3.2, with mitigation required under the Deschutes Groundwater Mitigation Program, future groundwater pumping is not expected to affect streamflows. Therefore, increased regional water demand and associated groundwater pumping is not anticipated to have effects on water quality.

Water conservation projects assumed under the no-action alternative, described in Chapter 2, would increase flows to the Middle Deschutes River compared to existing conditions, as described for the no-action alternative in Section 3.2. Increased flows could reduce river temperature and improve other water quality constituent conditions.

Projects completed in 2016 for the City of Prineville wastewater treatment wetlands would improve water quality in the Crooked River as the wetland system develops over the analysis period by reducing the discharge of nitrogen, phosphorus, suspended solids (contributing to turbidity), and biochemical oxygen demand. Reduction in discharge of nutrients can reduce 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.

Effect Conclusion: Continuation of existing water management operation 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 3.3-1 would continue in basin waterbodies. Potential negative effects on water quality associated with climate change and ongoing development in the basin could be compensated somewhat by beneficial effects associated with water conservation and restoration projects assumed under the no-action alternative over the analysis period. Overall, the effect on water quality could be adverse.

3.3.3.2 Alternative 2: Proposed Action

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

Changes in seasonal stream flows can 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 (Schnoor 1996). Reductions in flow that occur during summer are generally more likely to cause water quality degradation associated with increased temperature, increased pH and lower levels of dissolved oxygen. This is because of summer heat and because reducing flow reduces the amount of water that needs to be heated and slows the water down, increasing the time it is exposed to sunlight. As streams increase in temperature, the water is able to hold less oxygen.

Changes in water input also have a major influence on stream water quality. For example, water quality in Wickiup Reservoir greatly influences water quality in the Upper Deschutes River, which is composed of a combination of flows from Wickiup and groundwater.

The factors affecting the reservoirs include some of the same factors that affect rivers, including nutrient and organic loading (Wetzel 2001). However, deeper reservoirs such as Wickiup Reservoir, 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 (Paerl and Fulton 2006). This assumes that there are sufficient nutrients available to support phytoplankton growth.

The analysis of effects of the proposed action and action alternatives on water quality focuses on whether proposed changes in reservoir levels and discharges and associated river and stream flows would adversely affect the following key indicators of water quality:

- **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, water temperatures are closely correlated with flow levels. In warmer months, reduced flows can increase temperatures (Schnoor 1996). In the cold months, changes in streamflow have a more muted effect on water quality because primary production (e.g., algae and plankton growth) is greatly reduced and deviations in dissolved oxygen or pH are seldom a problem.

  Reservoirs can exert considerable impacts on the temperature of downstream waters (Wetzel 2001). 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 algae growth. In slow-moving rivers dissolved oxygen can be removed from the water column through respiration and decomposition causing dissolved oxygen to decrease.

  For reservoirs, pH and dissolved oxygen in the surface waters are driven largely by primary production[5] associated with phytoplankton, which is described below. If a lake thermally stratifies[6] in the summer, the bottom waters can become depleted in oxygen. These anoxic[7] waters promote release of nutrients back into the water column.

- **Chlorophyll *a*, Cyanobacteria and Plankton.** Chlorophyll *a* is a pigment in plants, including algae and phytoplankton. Moderately low concentrations of chlorophyll are generally deemed desirable because they indicate that food is present for aquatic organisms to consume. However, high concentrations of chlorophyll can become a nuisance for recreation. Cyanobacteria (blue-green algae) species can also produce cyanotoxins that pose a threat to wildlife that reside in or

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

[6] 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.

[7] Absent of oxygen

drink from affected waterbodies. Cyanobacteria have the capability to move within the water column, often accumulating near the surface. This leads to conditions where reservoirs might require public warnings and, in some cases, closures. Algae and phytoplankton growth in reservoirs 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. 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.

- **Turbidity and Sedimentation.** Turbidity a measure of water clarity, with high turbidity meaning low clarity. Turbidity is important because if great enough, it may harm aquatic organisms by reducing light transmission and inhibiting the growth of aquatic plants, which in turn can affect aquatic animal species. If primary production in the reservoir increases, it will promote greater turbidity for transport downstream. Sedimentation is the process whereby suspended particles settle out and accumulate on the lake or river bottom. Too much sedimentation can bury organisms found in the stream or reservoir bottom (benthic organisms).
- **Agricultural Pollution and Return Flows.** Return irrigation flows are of concern because they often contain high concentrations of phosphorus, nitrogen and other pollutants. Additionally, they may contain elevated concentrations of organic matter (naturally occurring compounds subject to decomposition) and anthropogenic compounds such as pesticides.

WQ-1: Affected Water Quality in Deschutes River Subbasin

Crane Prairie Reservoir. Under the proposed action, 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). Lower pool levels during summer could increase water temperature and associated effects, including increased algae growth as well as cyanobacteria growth (Paerl and Huisman 2008). However, the level of changes in pool evaluations changes are relatively minor and not expected to further degrade this existing impairment by measurable levels on a long-term basis. Therefore, water quality effects on Crane Prairie Reservoir are expected to be not adverse.

Deschutes River between Crane Prairie Reservoir and Wickiup Reservoir. River flows in this reach are not expected to substantially change (see Impact WR-4 in Section 3.2, *Water Resources*), although lower flows in late summer could increase stream temperatures. The potential for increased summer water temperatures in Crane Prairie Reservoir and associated growth of algae and cyanobacteria could affect water quality in this reach, including increased turbidity and increased daily variations in pH and dissolved oxygen. However, due to the relatively minor surface elevations change sin Crane Prairie reservoir and minor altered flow regimes in this reach, potential water quality effects are not likely to be adverse.

Wickiup Reservoir. Drawdowns earlier in the summer and for longer durations under the proposed action starting in year 8 would likely increase the severity of existing low concentrations of dissolved oxygen in the bottom waters, eventually leading to complete loss of oxygen in these water, and warming of surface waters. Both would affect fish habitat as described in Section 3.4, *Biological Resources* (Impacts BIO-12, 13, 15, and 16). In addition, effects on dissolved oxygen in the bottom waters would increase the release of phosphorus from the sediments, which could increase the intensity and duration of existing cyanobacteria blooms in the reservoir during the summer and into early fall. Overall, because the proposed action would further degrade water quality for an existing nuisance algae impairment by measurable levels on a long-term basis in Wickiup Reservoir and would potentially create a new impairment for dissolved oxygen, the proposed action would have an adverse effect on water quality in Wickiup Reservoir.

Upper Deschutes River. The adverse effects on water quality described for Wickiup Reservoir starting in year 8 may reduce the quality of water discharged into the Upper Deschutes, potentially exacerbating existing impairments for temperature, dissolved oxygen, pH, turbidity, and sedimentation. In addition, cyanobacteria in Wickiup Reservoir is expected to be discharged to the upper Deschutes River (Eilers and Vache 2019) below the dam to Bend. However, increased releases from Wickiup Reservoir in the colder fall/winter months starting in year 8 may improve dissolved oxygen levels in the Upper Deschutes River due to the higher oxygen levels in colder water. Greater fall/winter flows would increase stream velocity, which reduces sedimentation and promotes greater rates of oxygen absorption.

Decreased summer flows in the Upper Deschutes River starting in year 8 would increase water temperature and promote greater daily increases in pH and dissolved oxygen because of increased algae growth. A reduction in peak flows during the irrigation season could promote algae growth (Biggs 2000). However, the irrigation season flow caps in the Upper Deschutes is expected to substantially reduce bank erosion, turbidity, and sediment transport caused by extreme flows, and the reduced extremes in seasonal flows under the proposed action are expected to have an overall beneficial effect on water quality.

Downstream of the confluence with Fall River, the river gains additional flow and effects from Wickiup Reservoir discharge would decline (Figure 3.3-2). Though there may be a net loss of flow during dry years, the stabilizing effect of groundwater input would maintain a reasonably stable water temperature, pH and dissolved oxygen.

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 through December

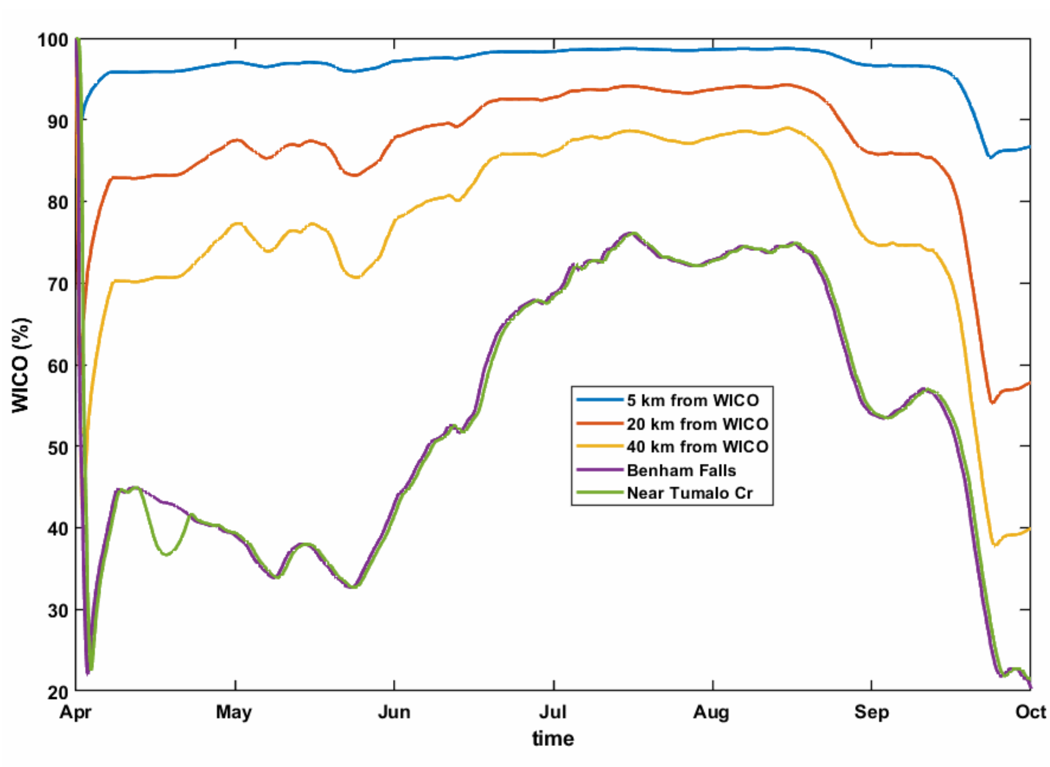
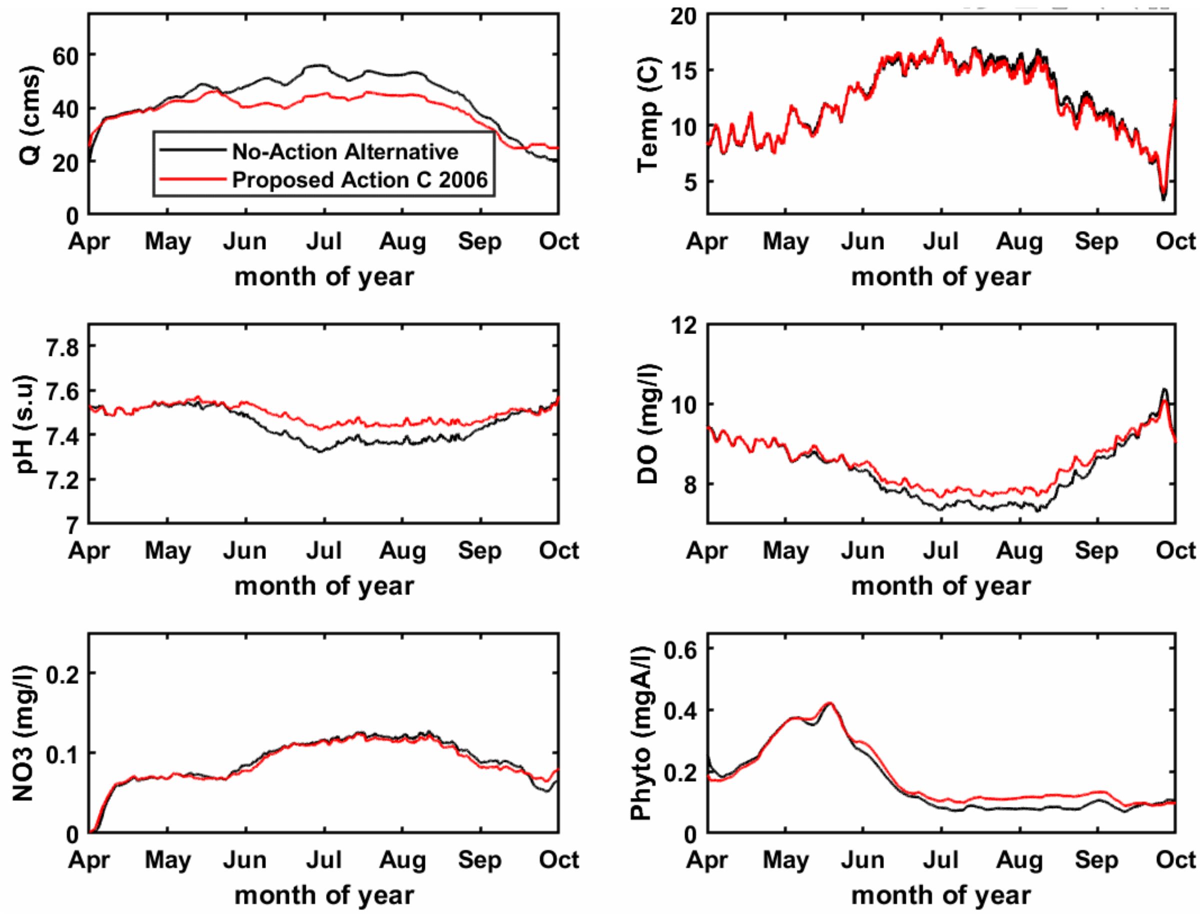


Figure 3.3-3 presents model results for the BENO gauge (Deschutes River at Benham Falls) in a dry year under the proposed action in years 13 to 30 when simulated effects on water quality would be greatest. As shown in Figure 3.3-3, the changes in summer discharge to the Upper Deschutes River would not markedly alter temperature, but would result in small increases in pH and dissolved oxygen and algae as flows increase.

Figure 3.3-3. Simulated Stream Discharge (Q), Water Temperature, pH, Dissolved Oxygen (DO), Nitrate/Nitrite (NO_3), and Phytoplankton (Phyto), for the Deschutes River at Benham Falls (BENO Gauge) under the Proposed Action in Years 13–30 Compared to No-Action Alternative



Water quality modeling results are presented for the BENO gauge because they are informed by the most robust dataset and are, therefore, the most accurate. Effects would likely be greater in the reaches just below Wickiup Reservoir, which would experience a higher percentage of discharge from the reservoir and those flows would not be diluted by groundwater inputs. Although the reach of the river closer to Bend would have lower flows as a result of withdrawals for irrigation further upstream, the beneficial impacts of considerable groundwater influx would help to maintain better water quality in this reach.

Overall, while the proposed action would result in a mix of effects on water quality in the Upper Deschutes River, depending on location, season, and year, these effects are not expected to exceed any of the thresholds identified in Section 3.3.1, *Methods*. Reducing extreme high flows and extreme seasonal variations in flows is expected to benefit water quality by reducing shoreline erosion and improving shoreline vegetation. Therefore, overall effects on water quality in the Upper Deschutes River would be not adverse.

Middle Deschutes River. Changes under the proposed action that would affect water quality in the Upper Deschutes River would have diminished effects in the Middle Deschutes River, because of the greater distance from Wickiup Reservoir and the considerable groundwater inputs, particularly in the lowest (northern) portion of the reach. The upstream reach of the Middle Deschutes River may experience a small decrease in water quality during the summer related to increased daytime temperature, pH and dissolved oxygen. Although these are existing impairments, these are small increase and are not expected to further degrade water quality by measurable levels on a long-term basis. Therefore, effects on water quality in the Middle Deschutes River are expected to be not adverse.

Lower Deschutes River. Water quality on the Lower Deschutes River is mostly influenced by groundwater (approximately 800 cubic feet per second [cfs]), the Crooked River (1,000 cfs), and the Metolius River (1,500 cfs). Water quality effects in the lower river due to the proposed action would influence only a small proportion of water inputs and would have a proportionately low effect on water quality. Therefore, overall effects on water quality in the Lower Deschutes River would be not adverse.

Crescent Lake Reservoir. Under the proposed action, pool elevations compared to the no-action alternative are projected to increase by about 5 feet year-round but would follow the general pattern of higher elevations during the irrigation season. Because effects on water quality of reservoirs generally increase with higher elevations (Wetzel 2001), the overall effect of increased water elevations would not likely result in any exceedance of applicable state or federal numeric or narrative water quality objectives or standards or otherwise cause long-term degradation of water quality and, therefore, would be not adverse.

Crescent Creek. Starting in year 8, changes in flows and flow variability in Crescent Creek would be minor with a general pattern of small winter increases and small summer decreases. As described above, water quality of input water from Crescent Lake Reservoir is not likely to be impaired by the proposed action. Reduced summer flows could result in increased water temperatures, but would not exacerbate any water quality stressors to the extent that water quality standards would be exceeded, so overall effects would be not adverse.[8]

Tumalo and Whychus Creeks and Little Deschutes River. The proposed action would have no effect on flows and associated water quality conditions in Tumalo Creek. Potential small, unquantifiable effects on flows in Whychus Creek would have small beneficial effects on water quality. Increased irrigation season flows in the Little Deschutes River could reduce stream temperatures, resulting in a minor beneficial effect on water quality.

Effect Conclusion: The proposed action would result in adverse effects on water quality in Wickiup Reservoir due to earlier and more extended drawdowns in the summer. Lower surface water levels in Wickiup would decrease oxygen levels and increase phosphorous levels, which in turn could increase intensity and duration of algae and cyanobacteria blooms in the reservoir during the summer and into early fall. Reduced water quality in Wickiup would also affect the Upper Deschutes River below Wickiup Dam, including increased turbidity from organic matter and increased levels of cyanobacteria. However, the degree of this effect would be somewhat offset by a higher percentage of flow from springs and groundwater input. In addition, a reduction in peak flows and overall more stable river levels would be expected to reduce streambank erosion along the Upper Deschutes River and associated turbidity. Therefore, overall effects on water quality in the Upper Deschutes River are expected to be not adverse. There would be no effect on water quality in Tumalo Creek and

[8] See Appendix 3.1-C, *Analysis of RiverWare Model Version 18 Outputs and Implications for Final EIS*, for corrections due to modeling update.

potential minor beneficial effects in the Little Deschutes River and Whychus Creek.[9] Changes in seasonal water regimes in other reservoirs, rivers, and streams in the Upper Deschutes Subbasin would be minor and water quality effects would be not adverse. Overall, effects on water quality in the Upper Deschutes Subbasin under the proposed action would be adverse because of adverse effects in Wickiup Reservoir due to further degradation of water quality in late summer and fall.

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 (Johnson et al. 1985), which would moderate solar warming and associated water quality issues related to reduced reservoir elevations. Consequently, effects of the reduced elevation on water quality are expected to be not adverse.

Crooked River. Increased minimum flows downstream of Bowman Dam during the storage season due to Conservation Measure CR-1 would reduce extreme low-water events during winter and associated effects on fish habitat but would not address water quality impairment that occurs primarily during the summer months, including temperature, dissolved oxygen, pH, and chlorophyll impairments. Temperature modeling (see Appendix 3.4-C) projected that altered storage and release cycles from Bowman Dam would result in cooler water temperatures in late spring and early summer. However, temperatures would warm rapidly due to lower streamflows in August under the proposed action; temperatures would increase up to 2.8 °C above the no-action alternative in some years but warming would be less in most years. Increased temperatures during the later summer months could result in short-term degradation of other water quality parameters that are already impaired under the Clean Water Act Section 303(d) listing, including dissolved oxygen, pH, chlorophyll, total dissolved gas, and biological impairment.

While pesticides and nutrients are known to occur within return flows that enter the Crooked River (Oregon Water Quality Pesticide Management Team 2018; Noone 2020), the proposed action would not create additional pesticide or nutrient sources, pathways or otherwise alter the occurrence of pesticides or nutrients in the Crooked River. As described in HCP Chapter 3, *Scope of the DBHCP*, flow and diversion rate changes on the Crooked River are not expected to have noticeable changes in return flows at locations on the Crooked River. In addition, the proposed action would have no effect on discharges from the City of Prineville's wastewater treatment facility and associated contribution of water pollutants.

Ochoco Reservoir. Small changes in median and maximum water surface elevation in Ochoco Reservoir are expected to have little measurable impact on water quality and are therefore considered not adverse.

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 Reservoirs 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. Increased water temperatures in the lower Crooked River during late summer could intermittently and temporarily degrade water quality. Overall, effects of the proposed action on water quality in the Crooked River Subbasin would be not adverse

[9] See Appendix 3.1-C, *Analysis of RiverWare Model Version 18 Outputs and Implications for Final EIS*, for corrections due to modeling update.

compared to the no-action alternative, because warming effects on the Lower Crooked River would be intermittent and temporary and would not be expected to alter water quality parameters compared to the no-action alternative.

3.3.3.3 Alternative 3: Enhanced Variable Streamflows

WQ-1: Affect Water Quality in Deschutes River Subbasin

Effects on water quality from Alternative 3 compared to the no-action alternative would be the same or nearly the same for Crane Prairie and Crescent Lake Reservoir, the Middle and Lower Deschutes, Whychus and Tumalo Creeks, and Crescent Creek. Effects on water quality under Alternative 3 compared to the no-action alternative would be similar to those described for the proposed action in Wickiup Reservoir and the Upper Deschutes River, except that without the cap on maximum daily irrigation flows, adverse effects in Wickiup Reservoir would be of greater magnitude and would lead to potential adverse effects downstream in the Upper Deschutes River and beneficial effects in the Upper Deschutes River would be of lesser magnitude. Flows on the Little Deschutes River would be similar to the no-action alternative and, therefore, effects on water quality would be not adverse. In addition, these effects would occur earlier in the permit term (Table 3.1-1). Overall, effects on water quality in the Upper Deschutes Subbasin under Alternative 3 would be adverse because of adverse effects in Wickiup Reservoir due to further degradation of water quality in late summer and fall and associated downstream effects on Upper Deschutes River reaches downstream of the reservoir through Bend.

WQ-2: Affect Water Quality in Crooked River Subbasin

Changes in streamflows and surface water elevations 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 greater minimum flows in this reach compared to the 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 slightly improved or slightly reduced, depending on the water year type and stage in the permit term. Overall, effects of Alternative 3 on water quality in the Crooked River Subbasin compared to the no-action alternative would be not adverse for the reasons described for the proposed action.

3.3.3.4 Alternative 4: Enhanced and Accelerated Variable Streamflows

WQ-1: Affect Water Quality in Deschutes River Subbasin

Effects on water quality from Alternative 4 compared to the no-action alternative would be the same or nearly the same as described for the proposed action in Crane Prairie and Crescent Lake Reservoirs, the Middle and Lower Deschutes River, and Whychus and Tumalo Creeks. Winter flows in the Crescent Creek–Little Deschutes River system would not decline as much as under the proposed action, which would not greatly change the level of effects, which would not be adverse. Effects on Wickiup Reservoir and the Upper Deschutes River would be nearly the same as described for Alternative 3, except that effects would occur earlier in the permit term (Table 3.1-1). Overall, effects of Alternative 4 on water quality in the Deschutes River Subbasin compared to the no-action alternative would be adverse for the reasons described for Alternative 3.

WQ-2: Affect Water Quality in Crooked River Subbasin

Changes in streamflows and surface water elevations under Alternative 4, 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. Effects in this reach would be the same as described for Alternative 3, except that adverse effects described for the reach between the North Unit ID pumps and Smith Rock State Park would also occur in the reaches upstream to Bowman Dam. Overall, effects of Alternative 4 on water quality in the Crooked River Subbasin compared to the no-action alternative would be not adverse for the reasons described for the proposed action.

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

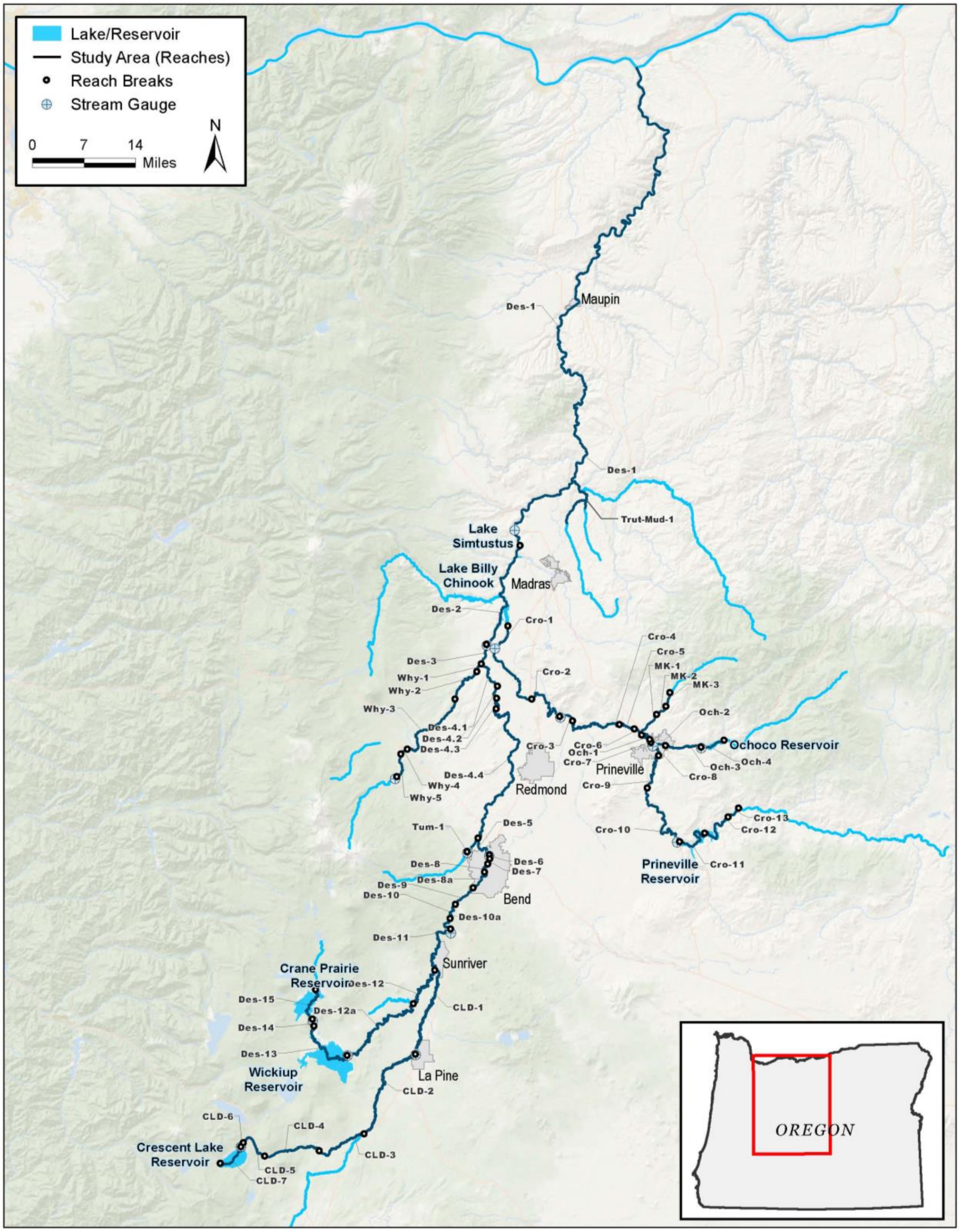
The study area for vegetation and wildlife consists of areas in or near the covered lands and waters and Prineville Reservoir and hydrologically associated lands where vegetation and wildlife could be affected under the proposed action and alternatives. The proposed action and alternatives would affect 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. However, these changes 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 (1 mile) 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.), FWS, and the National Marine Fisheries Service (NMFS). The 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 3.4-1 and described in Table 4 of Appendix 3.4-A.

The analysis of environmental consequences is based upon information presented in the Section 3.4.2, *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 (Section 3.4.3.3, *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.
- 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.

[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.

- 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

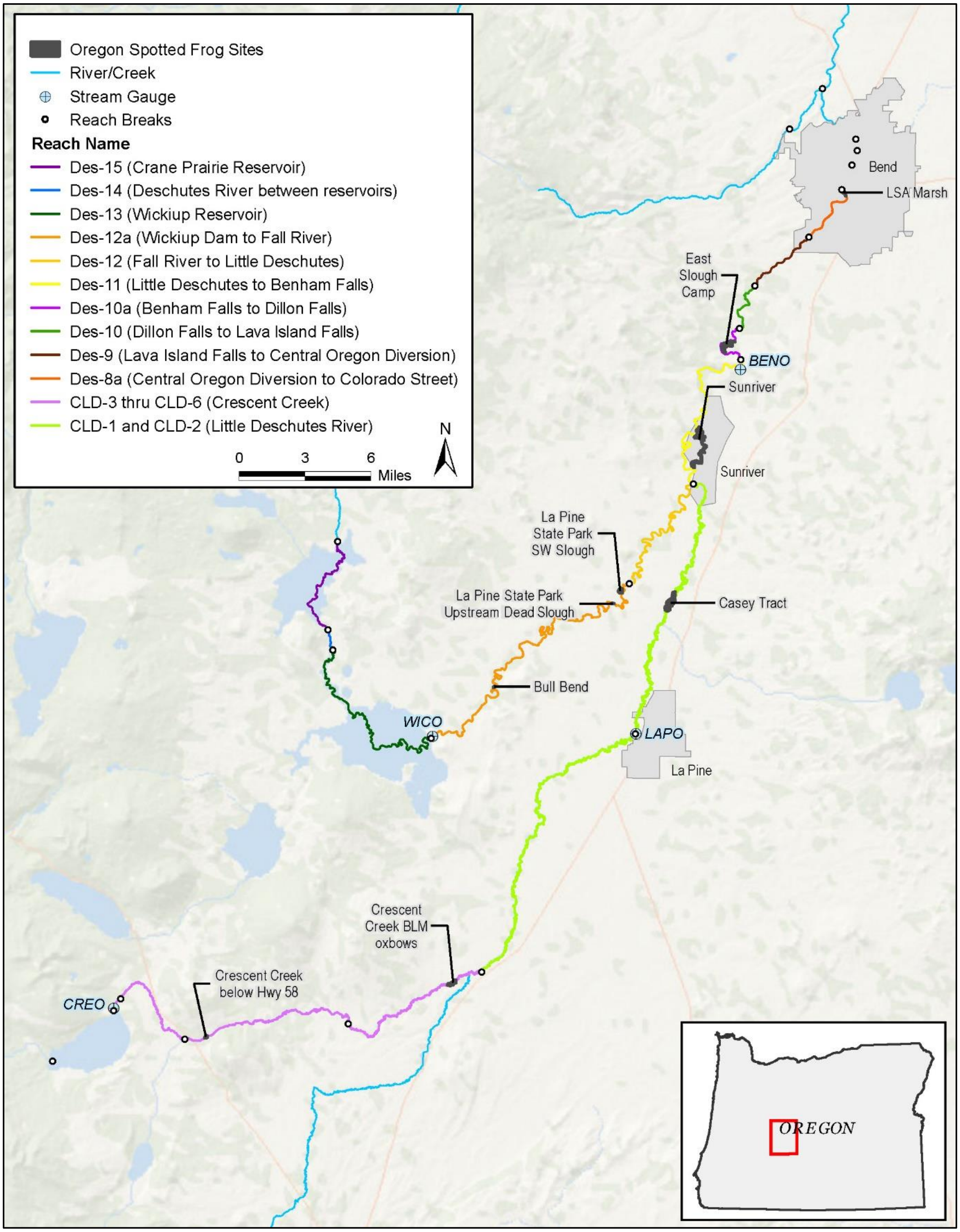
The study area for Oregon spotted frog includes the portion of the Deschutes Basin that is habitat for this species and could be affected by the proposed action and alternatives. The study area extends from Crane Prairie Reservoir down the Upper Deschutes River to the Old Mill District in Bend, Oregon (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) Section 6.0, *Effects of the Action* (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, data used to develop the 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 suitability at the level of the reach. The analysis focuses on a daily time scale during Oregon spotted frog pre-breeding (March 1–March 31), breeding (April 1–April 30), summer rearing (April 15–August 31), fall (pre-winter, September 1–October 15), and overwintering (October 16–March 1) 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***.

This analysis does not reach the site-specific depth of the analysis presented in the Deschutes Project BiOp (Sections 5.0, *Environmental Baseline*, and 6.0, *Effects of the Action*); rather, it provides a system-level comparison of environmental consequences of the alternatives on the Oregon spotted frog and its habitat in the study area. It is a reach-level assessment that relies primarily on the RiverWare model outputs of water flow volumes. These outputs are at a coarser spatial scale than required to assess impacts at individual sites. The assessment relied in part on known flow thresholds presented in the Deschutes Project BiOp as indicators of how sites in a particular reach may at least initially respond to the different flow regimes. Given the dynamic nature of this system and the expectation that habitat distribution and use by the frog will change over time, reach-level analysis was deemed appropriate for purposes of comparing conditions across the alternatives.

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

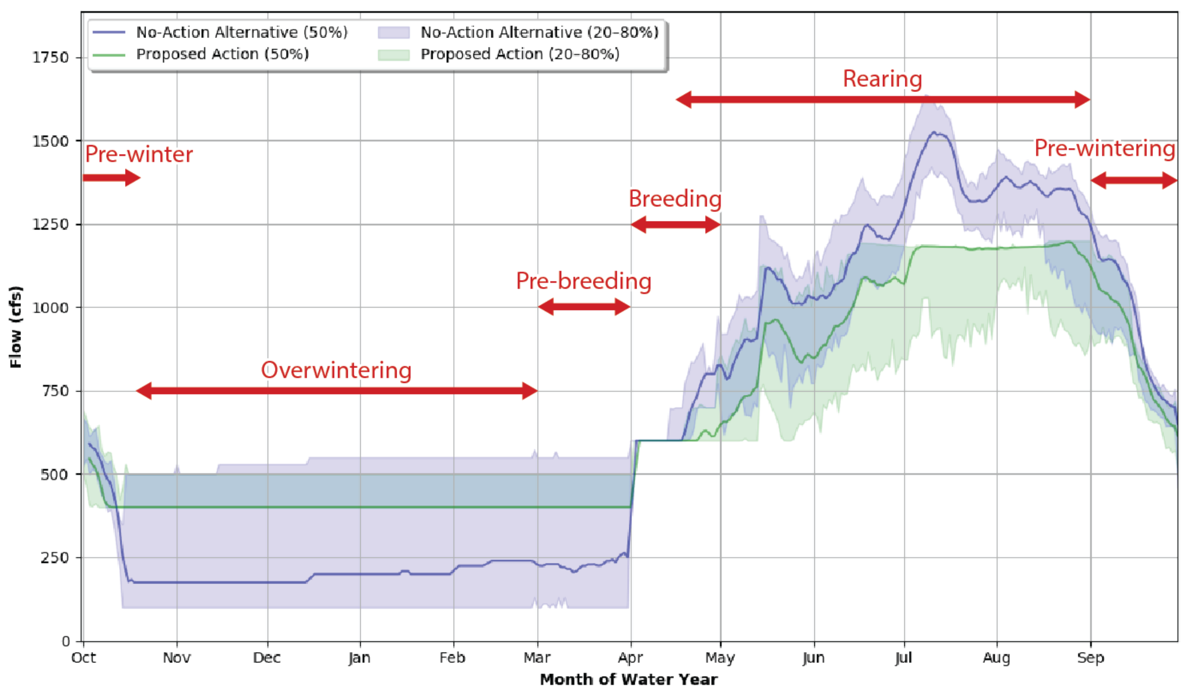


This analysis assesses the effects among the alternatives by comparing how the differing flow regimes might affect the following four key life history periods of Oregon spotted frog.

- Pre-breeding (March 1–March 31): During this period frogs emerge from overwintering sites and move to breeding locations if habitat conditions do not support these life history periods in the same location.
- Breeding (April 1–April 30): Frogs deposit egg masses in shallow wetland areas and during this period 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 15–August 31): Frog eggs hatch and tadpoles develop throughout the summer, finally metamorphosing into juvenile frogs.
- Pre-wintering (September 1–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–March 1): Frogs remain relatively inactive and are vulnerable to exposure and possible mortality via desiccation or 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.

- During pre-breeding, frogs move from their overwintering locations to breeding habitats.
- 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 from predators and thermal refugia from summer heat. This is the least sensitive life history period for the frog.
- 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 impact assessment herein relies 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, Section 6.0, *Effects of the Action,* Table 32 (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*).

The proposed action and Alternatives 3 and 4 include Conservation Measure UD-1: Upper Deschutes Basin Conservation Fund. This measure is not included in the no-action alternative. The fund would be used to improve or enhance habitat in the Upper Deschutes Basin for the Oregon spotted frog and other aquatic species that provide benefits to Oregon spotted frog (e.g., beaver), or otherwise address conditions in the Upper Deschutes Basin that affect the conservation and recovery of the Oregon spotted frog in the wild. Chapter 2, *Proposed Action and Alternatives*, and Appendix 2-C, *Implementation of UD-1: 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 UD-1 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 or transfer 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.

Conservation Measure CC-1 under the proposed action sets aside a portion of the water stored in Crescent Lake Reservoir (OSF storage) to be used specifically to benefit Oregon spotted frogs. This storage would be used to manage flows in Crescent Creek to maintain or increase winter minimum flow levels, increase instream flow levels in spring, or delay and draw out the ramp down of irrigation releases in the fall. Conservation Measure CC-1 in Alternatives 3 and 4 includes a higher minimum instream flow year-round but does not include the ability to use OSF storage to adaptively manage flows for the frog.

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.
- Rearing, when frogs rely on inundated vegetation to facilitate movement and provide cover from predators and thermal refugia from summer heat. This is the least sensitive life history period for the frog.
- Pre-winter, when frogs move to overwintering sites.
- Overwintering, when frogs are relatively inactive, comparing day counts of habitat inundation during rearing when frogs are most mobile.
- Pre-breeding, when frogs move from their overwintering locations to breeding habitats.

The analysis focuses on the implementation phases of each alternative as described in Section 3.1, Table 3.1-1. At the full implementation phase for each alternative, conditions affecting the Oregon spotted frog would be at their most beneficial or adverse level of effect. The proposed action and Alternatives 3 and 4 have different time frames (Table 3.1-1), 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.

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 modeled hydrographic patterns for each implementation phase of each alternative, including modeled flow changes, within-year, and then year-to-year variation among the alternatives, were also considered. The effect of adaptively managing flows for frogs in Crescent Creek (under Conservation Measure CC-1 of the proposed action) was also considered.

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, connectivity between habitats, abundance, 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 3.4-4, 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 3.4-4). 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 38-year period (1980–2018). 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.

Figure 3.4-4. Fish and Mollusks Study Area

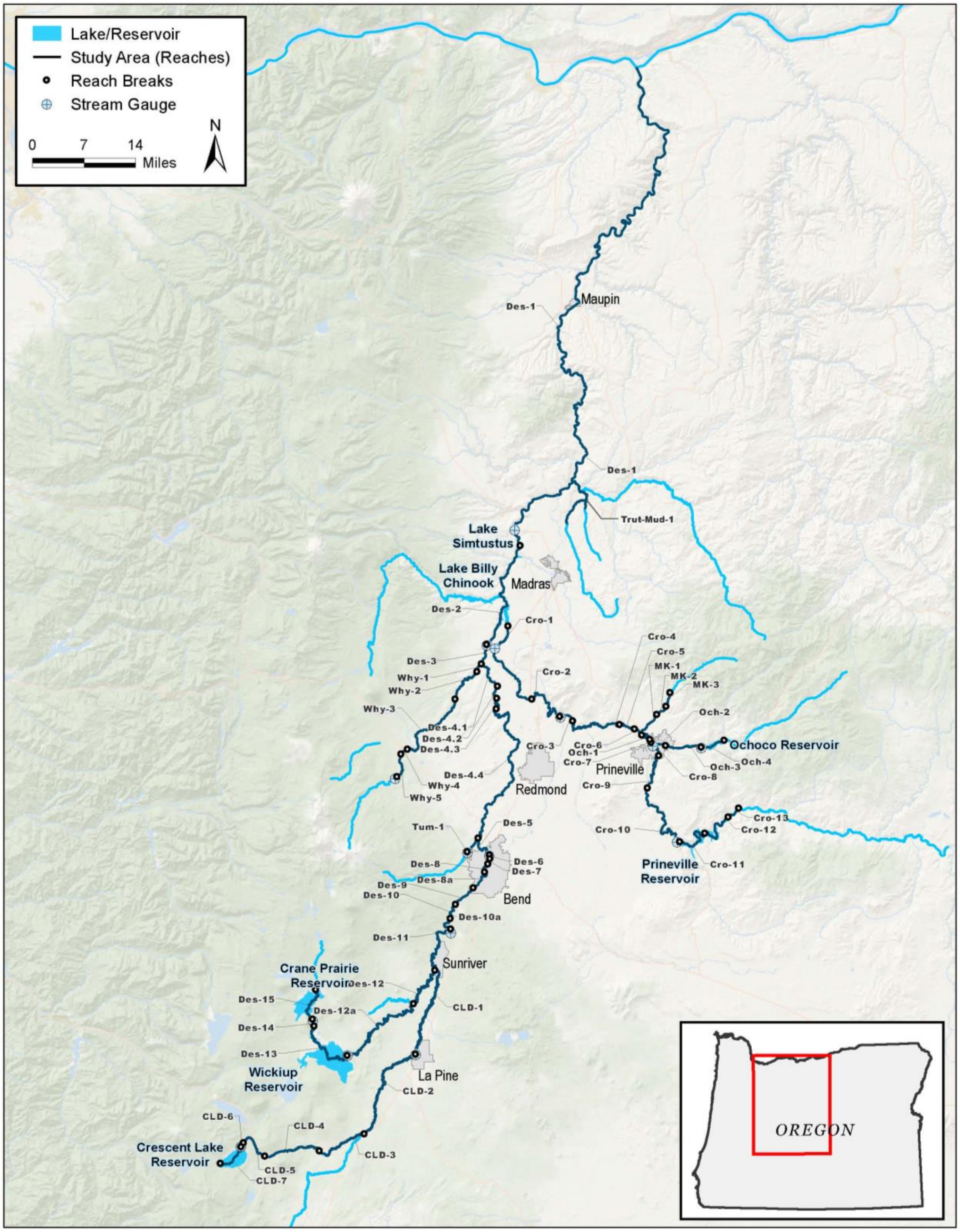


Table 3.4-1. Waterbodies Included in the Area of Potential Effects for Fish and Mollusks

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.
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.

Geographic Area	Waterbody	Description
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.
	Mud Springs and Trout Creek	Trout Creek is an eastside tributary to the Lower Deschutes River. Includes North Unit ID 58-11 and 61-111 irrigation returns.
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 70.5) to Lake Billy Chinook. The upper section (RM 70.5 to approximately RM 55.9) 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 7.3 receives significant groundwater inflow providing high-quality salmonid habitat in the Lower Crooked River.
	Ochoco Reservoir and Creek	Tributary to Crooked River at RM 43.9; Ochoco Reservoir is the upper extent of effects.
	McKay Creek	Tributary to Crooked River at RM 43.0.

RM = river mile; ID = Irrigation District.

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. The quantity and temperature of cooler water in Prineville Reservoir had a strong effect on predicted Crooked River water temperatures. The predicted temperature of outflow in the wet year type was 8 degrees Celsius (°C) warmer than the dry and normal water year types modeled. While this effect may seem counterintuitive, it was likely influenced by timing of water filling the reservoir and demonstrates the complexity of temperature issues in the Crooked River below Bowman Dam. Temperature thresholds described in R2 and Biota Pacific (2016) 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. Maximum weekly average temperature (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 ODFW, FWS, or NMFS.
- Substantially reduce the habitat, including ***critical 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.
- 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 2016a)
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 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 riverine, palustrine, and lacustrine wetland habitats that support Oregon spotted frogs.

Species Description

The Oregon spotted frog (*Rana pretiosa*) was listed as threatened under the Endangered Species Act (ESA) on August 29, 2014 (79 *Federal Register* [FR] 168:51657). 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 (79 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 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).

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 (oviposition habitat) 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.

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 to overwintering habitats between mid-September and late October. 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, which represents historically connected populations spanning east and west of the central Cascades in Oregon (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 (seasonal habitat). Breeding sites and other seasonal habitat within the study area are shown in Figure 3.4-2. All habitats are important for connectivity between populations and influencing survival and recovery of Oregon spotted frog. These areas are all within critical habitat that FWS considers occupied, where there is suitable habitat for Oregon spotted frogs.

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 currently and within the recent past. 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, Oregon spotted frog 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).

Current Habitat Condition

As described in the Deschutes Project BiOp, Sections 5.0, *Environmental Baseline* and 6.0, *Effects of the Action* (U.S. Fish and Wildlife Service 2017, 2019), historical and 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, Section 5.0, *Environmental Baseline*, 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, *Incidental Take Statement*, concluded that the current management of the Upper Deschutes River Basin for irrigation results in significantly degraded 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 listing rule (79 FR 168:51658–51710).

In the 2014 listing rule, 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).

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. A reintroduction program is underway for summer steelhead, spring Chinook, and sockeye above the Pelton-Round Butte Complex (Oregon Department of Fish and Wildlife and Confederated Tribes of the Warm Springs 2008).

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 Final 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	Sockeye salmon	*Oncorhynchus nerka*	NA	Indigenous, anadromous form

Taxonomic Group	Species Common Name	Species Scientific Name	Status	Origin
Non-covered species evaluated in the EIS				
Fish	Spring Chinook salmon	*Oncorhynchus tshawytscha*	SS	Indigenous
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
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 2016b); SS = A species listed as an Oregon Sensitive Species (Oregon Department of Fish and Wildlife 2016b); 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

Vegetation

Continuation of existing 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 during the period of instrumental records used in hydrologic modeling (1981–2018 water years). These historical 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 slightly reduced flow variation under the no-action alternative would allow a small improvement in the extent and functional value of riparian and wetland vegetation, by slightly and intermittently reducing the extremity of winter low flows that expose vegetation to subfreezing temperatures and drought stress that could contribute to dieback. 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 experience slightly less severe seasonal streamflow variation. This would occur because of ecological differences between weed and non-weed plant species. For growth and survival, all plants rely on resources, i.e., nutrients, water, and sunlight. Weeds tend to be inefficient in their use of these resources, but they are able to respond rapidly to changes in resource availability. This gives weeds a competitive advantage in areas where resource availability changes quickly, either seasonally or from year to year. Nonweedy species, however, tend to use resources more efficiently, which gives them a competitive advantage in areas where resource availability is relatively constant and predictable. The differences would be small, but still reduced hydrological variability would tend to reduce the prominence of weedy vegetation. 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 areas frequently exposed during drawdown. 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. Anticipated climate change effects vary across the study area, but include decreased snowpack, earlier snowmelt and runoff, lower summer streamflow, and more frequent high-magnitude storm and runoff events (Luce et al. 2019). 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 (Luce et al. 2019; Mote et al. 2019).

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 existing 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 existing 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 existing 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 (1981–2018) 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 existing water management operations would perpetuate degraded habitat conditions for the species over the analysis period, as described in Section 3.4.2.1, *Current Habitat Condition*, and in the Deschutes Project BiOp, Section 8.0, *Conclusion* (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, 2019) 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, and 60 to 80% by 2080. 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 existing 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. Extreme low winter streamflows have, under past water management, exposed bank vegetation to subfreezing temperatures and drought stress that can contribute to vegetation dieback and exposed streambanks. Slightly and intermittently reducing these extreme events could increase bank vegetation, which would contribute to reduced bank erosion, decreased water turbidity, and river channel sedimentation during high irrigation season flows. 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 for reintroduction above the Pelton-Round Butte project, and water conservation projects that increase streamflows, would affect fish and mollusks over the analysis period. Additional details are presented in Appendix 3.4-C*.*

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 Creek.[2] 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.

However, projected effects of climate change, described in Section 3.2, *Water Resources*, could result in adverse effects on the distribution and quality of fish habitat available in the study area. Changes in precipitation patterns and precipitation type (e.g., a shift from snowpack to rain) due to climate change could affect fish habitats, which would affect the abundance, productivity, and distribution of these fish and mollusk species.

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 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 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.

---

[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 was completed in 2019 and is providing access to this river for all fish species, supporting the reintroduction of steelhead and Chinook in this area, and recolonization by bull trout in the Crooked River.

3.4.3.2 Alternative 2: Proposed Action

This section describes effects on vegetation and wildlife under the proposed action compared to the no-action alternative.

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]

The proposed action would have no effect on vegetation communities on Tumalo Creek, the Upper Deschutes River between Crane Prairie and Wickiup Reservoirs (reach Des-14), the Lower Deschutes River including Lake Billy Chinook and Lake Simtustus (reaches Des-1 and Des-2), and Prineville and Ochoco Reservoirs because streamflows or reservoir elevations and variability would either be unchanged or changes would be negligible over the permit term compared to the no-action alternative.

Changes in Crane Prairie Reservoir (reach Des-15) would be beneficial. Water surface elevations during the growing season would be more stable, on a year-to-year basis (Table 3.4-6). This would allow a more complex and diverse riparian and wetland vegetation community to develop around the shores of the reservoir.

Changes in the Middle Deschutes River (reaches Des-3 to Des-6) would be small because riparian vegetation along the Middle Deschutes River depends primarily on groundwater inflow for moisture, so it is not particularly responsive to changes in streamflows. Nonetheless, the moderate increases in October to March flows would have a small beneficial effect by diminishing seasonal flow variability. Changes in the Crooked River would also be small because they would occur outside of the growing season, or occur in areas with little or no vegetation, or in reaches primarily supported by groundwater inflows. Some of the changes would be slightly beneficial or slightly adverse, but because of their small magnitude there is low confidence that the changes would be detectable; accordingly, their net effect is not adverse.

Increased minimum flows on Ochoco and McKay Creeks under the proposed action (Conservation Measures CR-2 and CR-3) would have beneficial effects on riparian and wetland vegetation on these creeks compared to the no-action alternative. On Whychus Creek, implementation of Conservation Measures WC-2 and WC-6 would provide for restoration actions beneficial to riparian vegetation. These changes would tend to increase the extent, diversity, and resilience of riparian and wetland vegetation along the creek.

Crescent Lake Reservoir would experience increased average water depths and reduced year-to-year variability, both of which would benefit the extent and stability of the few patches of wetland and riparian vegetation found around the reservoir. On the lower three reaches of the Crescent Creek–Little Deschutes River system, there would similarly be some increases in flow accompanied by reduced year-to-year flow variability during the growing season, which would benefit the extent and stability of wetland and riparian vegetation in these reaches.[5]

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

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

[5] See Appendix 3.1-C, *Analysis of RiverWare Model Version 18 Outputs and Implications for Final EIS*, for corrections due to modeling update.

increase and irrigation season flows decrease in stages over the permit term (Table 3.1-1), with minor changes associated with implementation of Conservation Measure WR-1 in the first 7 years, larger changes beginning in permit year 8, and all changes implemented by year 13. 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 (reach Des-13). The reservoir would immediately begin to experience increased variability in the mean monthly reservoir level. Beginning in year 8, variability in pool elevations would increase by more than 100% in all months from December to June, with smaller increases of 4 to 66% in the other months. 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 would be tempered by the fact that riparian and wetland vegetation currently found at the reservoir adapted to the existing high year-to-year variability in reservoir elevations both throughout the year and on a year-to-year basis. In summary, the proposed action would achieve improved riparian conditions at Crane Prairie Reservoir and throughout the Upper Deschutes River but at the cost of a potential decline in riparian and wetland vegetation 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, at locations other than Wickiup Reservoir, streamflow variation and variability in reservoir levels would either be consistent with or decrease relative to the no-action alternative, except in the case of Wickiup Reservoir. 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, Wickiup Reservoir would immediately begin to experience greater year-to-year variability in mean monthly reservoir levels; those increases would become much larger beginning in year 8 of the permit term, and would further increase beginning in year 13 of the permit term. The large areas of unvegetated soil exposed around Wickiup Reservoir 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 Wickiup Reservoir elevations. Therefore, increases in invasive weed cover in the vicinity of Wickiup Reservoir would likely be temporary.

Effect Conclusion: The proposed action would have no effect on riparian and wetland vegetation in Tumalo Creek, the Deschutes River between Wickiup and Crane Prairie Reservoirs (reach Des-14), the Lower Deschutes River including Lake Billy Chinook and Lake Simtustus (reaches Des-1 and Des-2), and Prineville and Ochoco Reservoirs. Effects in Crane Prairie Reservoir, Crescent Lake Reservoir, the Upper Deschutes River, Ochoco Creek, McKay Creek, Whychus Creek, and the Crescent Creek–Little Deschutes River system would be beneficial. Effects in the Middle Deschutes River (reaches Des-3 to Des-6), and the Crooked River would be not adverse. Effects in Wickiup Reservoir would be adverse. Overall, the effect of the proposed action would be beneficial compared to the no-action alternative because beneficial effects would improve habitat conditions over a large portion of the study area, while adverse localized vegetation impairments would be limited to Wickiup Reservoir.[6]

Table 3.4-6. Effects on Vegetation Communities by Reach under the Proposed Action Compared to the No-Action Alternative based on Modeled Changes in Seasonal Flows and Elevations[a,b]

Reach	Effects on Vegetation
Des-15 (Crane Prairie Reservoir)	There would be 14–43% monthly increases in the mean monthly reservoir level of Crane Prairie Reservoir, amounting to a reservoir level change of 0.5–1.5 feet. Variability in reservoir levels would diminish from February to July, and would increase from October to January. Water surface elevations during the growing season would be more stable 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 (Crane Prairie Reservoir to Wickiup Reservoir)	Flows would change in a complex manner, with substantial decreases in September, November, and December and substantial increases in January, February, and May. Flow variability would generally show small increases, except for substantial decreases in November and December. 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 some inconsistent reservoir level changes in the first 12 years of the permit term, including moderate pool increases from August to September in years 1 through 7 of the permit term and moderate decreases from June to July in years 8–12 of the permit term. Thereafter, pool levels would be reduced in all months, with reductions of 16–26% from December to July, and small reductions in the other months. These changes are substantial: a 20% change is approximately 10 feet. From November to July, there would also be extreme increases in year-to-year variability; from February to June variability would increase by more than 200%. The increased variability would result in occasional runs of multiple years with exceptionally high or, especially, 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 would be somewhat moderated to the extent that the changes occurred prior to the growing season.

[6] See Appendix 3.1-C, *Analysis of RiverWare Model Version 18 Outputs and Implications for Final EIS*, for corrections due to modeling update.

Reach	Effects on Vegetation
Des-12a (Wickiup Reservoir to Fall River confluence)	Changes would be minor through year 7 of the permit term, but thereafter, flows would increase substantially (by 16–54%) from October through March, the lowest flow months. Flow variability in those months would diminish by about 17–52%. Flows would diminish by 4–22% from April through September, the highest flow months, with small changes in 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 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 (Fall River confluence to Little Deschutes River confluence)	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 (Little Deschutes River confluence to Benham Falls)	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 Des-10 (Benham Falls to Arnold Canal diversion)	Flow changes would be minor in the first 12 years of the permit term, but by year 13 would increase by 14–20% from October through March, the lowest flow months. Flows would diminish (by 4–14%) from April through August, the highest flow months. Flow variability would decrease (by 15–37%) from October through March and would increase substantially (81–109%) in June and July, 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 Des-8a Des-8 Des-7 (Arnold Canal diversion to North Unit ID diversions)	Through year 12 there would be small (up to 11%) increases in October-to-March flows, and small (up to 11%) decreases in April-to-August flows. Starting in year 13, these changes have the same timing but increase in magnitude, with both increases and decreases of up to 21%. November through March flow variability would decrease by 18–35%, while June and July flow variability would increase by 63–93%. The reduced summer 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.

Reach	Effects on Vegetation
Des-6 Des-5 (North Unit ID diversions to Tumalo Creek confluence)	Initially, flow changes would be minor, but by year 13 of the permit term, October to March flows would increase by 17–29%, with minor changes from April to September. Year-to-year flow variability would generally show minor changes except in July to September, when increases of 33–262% would occur. 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 (Tumalo Creek confluence to Whychus Creek confluence)	Changes would be essentially the same as on Des-5, which has similar hydrology (with the addition of Tumalo Creek flows).
Des-3 (Whychus Creek confluence to CULO gauge)	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 (CULO gauge to Pelton Dam)	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 (Pelton Dam to Columbia River)	Flow changes would be negligible (maximum change 3%) and flow variability would not change substantially. Therefore, no effects on vegetation are expected.
CLD-7 (Crescent Lake Reservoir)	For the entire permit term, the reservoir would operate throughout the year at a substantially greater depth (about a 5-foot increase, corresponding to 33–41% in all months). There would be reduced year-to-year variability of about 20% in all months. Most of the reservoir perimeter abuts upland forest, but there are several areas of wetland and riparian vegetation that would likely increase in area and otherwise benefit from the higher water levels and reduced pool elevation variability.
CLD-6 CLD-5 CLD-4 (Upper Crescent Creek)[b]	In the first 7 years of the permit term there would be some moderate winter flow reductions. Thereafter, changes in flows and flow variability in these reaches would be minor (maximum changes of -8 to +13% in any month, with a general pattern of small winter increases and small summer decreases). Flow variability would increase substantially, rising 27–131% from October to April, but with some decreased variability from July to September. These changes are primarily outside of the growing season and have little potential to affect vegetation. No effects on vegetation are expected.
CLD-3 CLD-2 CLD-1 (Sunriver to above Walker Basin)[b]	These reaches have moderate (15–32%) July-to-October flow increases in the first 7 years of the permit term. Thereafter, those changes cease on CLD-2 and CLD-3, but persist on CLD-1. In all reaches, flow variability drops moderately from July to September, but is otherwise unchanged. These changes would increase the depth and duration of summer inundation of riparian and wetland vegetation, while also decreasing year-to-year variability; these changes would tend to increase the extent and resilience of that vegetation.
Tum-1 (Tumalo Creek)	Flows in Tumalo Creek would be unchanged. Therefore, there would be no effect on vegetation.

Reach	Effects on Vegetation
Why-5 Why-4 Why-3 Why-2 Why-1 (Whychus Creek)	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 Cro-12 Cro-11 (Prineville Reservoir)	Changes in mean monthly reservoir level would be negligible, but there would be moderate increases (19–28%) from January through August in year-to-year variability in the mean monthly pool elevation. Because there is little riparian and wetland vegetation at the reservoir, these changes have little potential to affect vegetation.
Cro-10 (Prineville Reservoir to Rice-Baldwin diversion)	Flow changes would be small over the permit term, with increases of up to 17% in June and July, decreases of up to 12% in September and October, and negligible changes the rest of the year. Flow variability likewise shows negligible change, except for large increases (up to 175%) in July. Given that conditions remain largely unchanged in the growing season, with slight flow increases but also some variability increases, there is unlikely to be any detectable change in riparian or wetland vegetation.
Cro-9 (Rice-Baldwin diversion to Peoples Canal diversion)	The first 12 years of the permit term produce some inconsistent changes in average monthly flow, such as June and July flow decreases that later turn into increases. By year 13 there is a clear increase of 34–68% in June and July flows, a 7–32% decrease in August to November flows, and little change otherwise. Flow variability increases substantially (175%) in July, but otherwise remains fairly stable. 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 are not large enough to substantially affect riparian or wetland vegetation.
Cro-8 (City of Prineville)	Flow changes would be very similar to those on Cro-9, but of lower magnitude. 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 Cro-6 (City of Prineville to Central Canal diversion)	Changes would be essentially the same as on Cro-9.
Cro-5 Cro-4 (Central Canal diversion to Lone Pine Road crossing)	There would be little change in the first 12 years of the permit term. Thereafter, flows would increase by 16–23% in June and July, decrease by 6–18% from August to November, and little change otherwise. Flow variability would increase in July, decrease in September, and little change otherwise. 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 (Lone Pine Road crossing to North Unit ID pump station)	Flow changes would be negligible in years 1–7 of the permit term, starting to develop from years 8–12. By years 13–30, there would be small to moderate (11–39%) reductions in May-to-September flows, with a moderate (21–49%) decrease in year-to-year variability, with negligible changes the rest of the year. 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.

Reach	Effects on Vegetation
Cro-2 Cro-1 (North Unit ID pump station to Lake Billy Chinook)	Changes would be essentially the same as Cro-3.
MK-3 MK-2 MK-1 (McKay Creek)	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 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 Och-2 Och-1 (Ochoco Creek)	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; ID = Irrigation District

[a] Timing and magnitude of stated changes are based on RiverWare model outputs, as detailed in Appendix 3.4-A, Table 6.

[b] See Appendix 3.1-C, *Analysis of RiverWare Model Version 18 Outputs and Implications for Final EIS*, for corrections due to modeling update.

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 Tumalo Creek, the Upper Deschutes River between Crane Prairie and Wickiup Reservoirs (reach Des-14), the Lower Deschutes River including Lake Billy Chinook and Lake Simtustus (Des-1, Des-2), and Prineville and Ochoco Reservoirs. 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 Middle Deschutes River (reaches Des-3 to Des-6) and Crooked River reaches Cro-1 to Cro-10.

- In the Middle Deschutes River (reaches Des-3 to Des-6), flow changes would initially be minor, but by year 13 of the permit term, October to March flows would increase by 17 to 29%, with minor changes from April to September. Year-to-year flow variability would generally show minor changes except in July to September, when increases of 33 to 262% would occur. The winter flow increases would provide slightly increased water surface area for wildlife to forage, but would occur at a time of year when the increases would not make an appreciable contribution to the food supply of these species, particularly the insect-eater guild. Increased summer flow variability would reduce foraging opportunities in years with reduced flow, while increasing opportunities in higher flow years. Foraging opportunities for all affected guilds would show little change, and the increased summer flow variability would slightly impair habitat suitability. Overall, effects on wildlife use in the Middle Deschutes River would be not adverse.

- The Crooked River from its confluence with the Deschutes River upstream to the North Unit Irrigation District (ID) pumps (reaches Cro-1 to Cro-3) flows as a narrow stream at the bottom of a deep canyon. The moderate May-to-September flow reductions under the proposed action would be compensated by moderate decreases in year-to-year variability, producing slightly reduced but slightly more resilient habitat conditions. Overall, these changes would produce only small changes in 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 moderate flow increases (16 to 23% in June and July) over the permit term and would continue to have high year-to-year variability. Moreover, the June flow increases would tend to be offset by small August-to-November flow decreases. Therefore, no substantial changes in the utility of these reaches for wildlife would occur. 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 moderate flow increases for June and July are offset by small but persistent August-to-November flow decreases, such that substantial changes in the utility of these reaches for wildlife are unlikely. Overall, effects on the Crooked River would be not adverse.

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); Crescent Creek (reaches CLD-4 to CLD-6); and Whychus, Ochoco and McKay Creeks. 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. Also, Conservation Measure UD-1 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 such as reed canarygrass and bullfrogs to Oregon spotted frogs along the Upper Deschutes River that would persist despite improvements in hydrology 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. Overall, effects on wildlife use in the Upper Deschutes River between Wickiup and Bend would be beneficial.
- In Wickiup Reservoir (reach Des-13), the adverse effects on vegetation described in BIO-1 would mean that wildlife use of the reservoir is volatile on a year-to-year and month-to-month basis. Reduced water levels particularly may impair use of the reservoir by waterfowl, but also may increase the area available for foraging by elk and deer.
- 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 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 Crescent Creek reaches CLD-1 to CLD-3, the beneficial impacts (which begin in permit year 1, but become more persistent and stable in year 13) on riparian and wetland vegetation described in BIO-1 would increase habitat suitability for all guilds.
- In Crescent Creek reaches CLD-4 to CLD-6, there would be some moderate winter flow reductions in the first 7 years of the permit term. These flow reductions would likely lead to some reduction in winter 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 7 of the permit term. Flow variability would increase in the winter months, but would decrease in summer, when the affected guilds are most active; this would tend to increase habitat suitability slightly.
- In Ochoco, McKay, and Whychus Creeks, the beneficial effects on riparian and wetland vegetation described in BIO-1 would improve habitat suitability for the elk-deer, generalist, fish-eater, shallow-water, and insect-eater guilds.

Effect Conclusion: The proposed action would have no effect on wildlife in Tumalo Creek, Upper Deschutes River between Crane Prairie and Wickiup Reservoirs (reach Des-14), the Lower Deschutes River including Lake Billy Chinook and Lake Simtustus, and Prineville and Ochoco Reservoirs. Effects in Crane Prairie and Crescent Lake Reservoirs; the Upper Deschutes River; Ochoco, McKay, and Whychus Creeks; and the Crescent Creek–Little Deschutes River system would be beneficial. Effects in the Middle Deschutes River (reaches Des-3 to Des-6), and the Crooked River would be not adverse. Effects in Wickiup Reservoir would be adverse. Overall, the effects of the proposed action would be beneficial compared to the no-action alternative because beneficial effects would improve habitat conditions over a large portion of the study area, while adverse localized vegetation impairments would be limited to Wickiup Reservoir.[7]

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.

The proposed action is likely to improve conditions for Oregon spotted frog and its habitat compared to the no-action alternative as follows.

- 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 incidence of abrupt stranding of frogs as they move to overwintering locations.
- Managing the upper Deschutes River below Wickiup dam to increase winter flows such that overwintering habitats are inundated with water and travel distances between the overwintering sites and breeding sites are decreased.
- Tumalo ID managing flows, with input from and in coordination with FWS, in Crescent Creek and, to some extent, the Little Deschutes River, using the OSF storage provided by Conservation Measure CC-1 to improve habitat conditions.

[7] See Appendix 3.1-C, *Analysis of RiverWare Model Version 18 Outputs and Implications for Final EIS*, for corrections due to modeling update.

- Providing Conservation Measure UD-1, which could be used to fund efforts to enhance Oregon spotted frog habitat and address threats, such as controlling invasive species.

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 13 years to reach its full implementation. Until then, a highly modified hydrograph would persist, and especially during phase 1, the first 7 years of implementation. During this time, flows as modeled 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. These negative effects on habitat conditions could be somewhat reduced by operation of Wickiup Reservoir (WR-1(A–E)) and strategic release of water following Conservation Measure CP-1 (H). In Crescent Creek and the Little Deschutes River, Conservation Measure CC-1 provides a share of stored water that can be used to react to local conditions to improve Oregon spotted frog habitat conditions. 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. Conservation Measure UD-1 would provide funds that could be used to offset some of these detrimental effects by improving or enhancing habitat in the Upper Deschutes Basin for the Oregon spotted frog and other aquatic species, or otherwise addressing conditions in the Upper Deschutes Basin that affect the conservation and recovery of the Oregon spotted frog.

The proposed action also includes effectiveness monitoring and adaptive management plans, detailed in Final Deschutes Basin HCP, Chapter 7, *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., weather affects the timing of breeding), there are operational management actions prescribed to modify flow or reservoir storage and water elevation in response to those changes.

Effect Conclusion: During most life history periods and in all reaches except Wickiup Reservoir (Des-13 and Upper Deschutes River between Crane Prairie and Wickiup Reservoirs (Des-14) considered in this analysis, the proposed action at full implementation (years 13–30) 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 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). During the first phase of implementation (years 1–7), and to a lesser extent during phase 2 (years 8–12), the proposed action would perpetuate degraded habitat conditions for Oregon spotted frog in the basin, although Conservation Measures CP-1, WR-1, CC-1, and UD-1 could be deployed to actively improve degraded conditions and offset some of those effects. Starting in phase 2 (year 8), the proposed action would have an adverse effect in Wickiup Reservoir compared to the no-action alternative during all life history periods of the Oregon spotted frog, due to highly variable water levels caused by irrigation water management activities associated with water storage and drawdown of reservoir levels. The effects of the proposed action during rearing in other reaches would not be adverse. 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 on the species in Wickiup Reservoir.

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)	**Overwintering, pre-breeding, breeding[a]:** Modeling indicates little difference in flow during the pre-breeding and breeding seasons. OSF storage could be applied to positively affect water inundation patterns at Oregon spotted frog breeding sites that are associated with the Little Deschutes River below the confluence with Crescent Creek during low water years. Supplemental water could inundate breeding sites earlier in season and aid movement of frogs from overwintering locations to breeding sites. OSF storage could be used in winter during low water years to offset the effects of late or no arrival of winter precipitation. **Rearing[a]:** OSF storage could be applied to enhance rearing habitat prior to release of irrigation flows from Crescent Dam, especially during low water years. **Pre-winter[a]:** OSF storage could be applied to lengthen the time of the ramp down from irrigation flows to the overwinter minimum flow. The less abrupt change in flows may prevent abrupt stranding of frogs as they migrate to overwintering sites. **Emergent vegetation:** Inundation levels during the growing season and therefore conditions for Oregon spotted frog would be relatively unchanged. Conservation Measure UD-1 could be used to fund efforts to enhance riparian and wetland vegetation. **Invasive species:** Conditions for invasive species and therefore threats to Oregon spotted frog would be relatively unchanged. Conservation Measure UD-1 could support control of invasive species.
CLD-3 CLD-4 CLD-5 CLD-6 (Crescent Creek)	**Pre-breeding and breeding:** There is little difference in flow during the breeding season. OSF storage could be applied to increase flows from winter minimum earlier in the season, prior to onset of irrigation. Supplemental water could inundate breeding sites earlier in season and aid movement of frogs from overwintering locations to breeding sites. **Rearing:** Reaches would consistently experience slightly more water in the system early in the rearing period as modeled; 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. OSF storage could be applied to enhance rearing habitat prior to release of irrigation flows from Crescent Dam. **Pre-winter:** Reaches would experience a slightly greater decrease in flows during pre-winter, which means water elevations would drop more. OSF storage could be applied to lengthen the time of ramp down from irrigation flows to the overwinter minimum flow. The less abrupt change in flows may prevent abrupt stranding of frogs as they migrate to overwintering sites. **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. Based on annual conditions, OSF storage could be applied to increase minimum winter flows to offset the effects of late or no arrival of fall or winter precipitation. **Emergent vegetation:** Inundation levels during the growing season would be higher, as modeled. Conservation Measure UD-1 could be used to fund efforts to enhance riparian and wetland vegetation **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

Reach	Effects
	Oregon spotted frogs. Conservation Measure UD-1 could support control of invasive species.
Des-8a (Central Oregon Diversion to Colorado Street)	**Pre-breeding and breeding:** Reach would experience slightly more days of inundation. Reach 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. **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. Conservation Measure WR-1 (E) stabilizes flows around 1,100 cfs (median flow) until early September. **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 could prevent abrupt stranding of frogs as they migrate to overwintering sites. **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. **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. Conservation Measure UD-1 could be used to fund efforts to enhance riparian and wetland vegetation. **Invasive species:** Reed canarygrass would continue to persist in this reach. Year-round inundation of wetlands and a more stable river hydrograph beginning in year 8 are likely to improve conditions for bullfrogs and nonnative fish species known to prey on Oregon spotted frogs. Conservation Measure UD-1 could be used to fund bullfrog control measures or address nonnative fish species.
Des-9 (Lava Island Falls to Central Oregon Diversion)	**Pre-breeding and breeding:** During phases 2 and 3, reach would experience a slightly smaller 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. **Rearing:** Conservation Measure WR-1 (E) regulates a minimum flow of at least 1,300 cfs at BENO from July 1 through at least September 15, the latter part of the rearing period, and early part of pre-winter periods assessed here. Although flows in this reach do not directly correspond to the BENO gauge, flow regulation as measured at BENO also affects this downstream reach. Although no wetland vegetation inundation threshold is identified for this reach, the minimum flow control under Conservation Measure WR-1 (E) combined with the greater stability during later phases of the permit term would result in conditions similar to the no-action alternative during this portion of rearing. Inundated vegetation provides cover for developing tadpoles and juvenile or adult frogs. **Pre-winter:** Maintenance of a minimum flow under Conservation Measure WR-1 (E) measured at the BENO gauge also affects this reach. Conservation Measure WR-1 (J) limits the speed of the fall ramp down to result in a more gradual step down of flow at the BENO gauge, which also affects flow patterns in this reach. Maintenance of inundation and then a slow ramp down to overwintering flows could prevent abrupt stranding and would facilitate frog movement to overwintering sites. **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. **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,

Reach	Effects
	and dependence on the river as a water source. Conservation Measure UD-1 could be used to fund efforts to enhance riparian and wetland vegetation. **Invasive species:** Reed canarygrass would continue to persist in this reach. Year-round inundation of wetlands and more stable river hydrograph beginning in year 8 are likely to improve conditions for bullfrogs and nonnative fish species known to prey on Oregon spotted frogs. Conservation Measure UD-1 could be used to fund bullfrog control measures or address nonnative fish species.
Des-10 Des-10a (Lava Island Falls to Benham Falls)	**Pre-breeding:** Reaches would experience progressively more days of inundation at 1,200 cfs through implementation phases. Near the end of the pre-breeding time period, frogs would begin to experience the ramp up in flows from winter minimums to the beginning of the breeding season. The first phase is similar to the no-action alternative, but phases 2 and 3 result in a smaller overall increase in flow during this ramp up. The decreased overall flow variation would reduce the likelihood of mortality of early-laid egg masses through displacement during changes in flow. **Breeding:** Sites within the reach would experience more stable flows that also exceed the 1,300-cfs threshold for wetland inundation across the month of April under all phases. The reach would experience smaller changes in flow at the onset of the irrigation season, improving conditions for frogs because there is less chance of stranding. Within-year flow variation would be much lower during the breeding period in later implementation phases, which would reduce the likelihood of mortality of egg masses through desiccation if stranded by low flows. **Rearing:** Reaches would experience fewer days of wetland vegetation inundation during this period; however, Conservation Measure WR-1 (E) sets minimum flows at BENO at 1,300 cfs from July 1 through at least September 15, the latter part of the rearing period, and early part of pre-winter periods assessed here, which would result in conditions similar to the no-action alternative. Inundated vegetation provides cover and heat refugia for developing tadpoles and juvenile or adult frogs. **Pre-winter:** Conservation Measure WR-1 (E) maintains inundating flows until at least September 15. Reaches would progressively experience a smaller amount of change as flows decrease at the end of the irrigation season, which could prevent abrupt stranding of frogs as they migrate to overwintering sites. Conservation Measure WR-1 (J) also limits the speed of the fall ramp down to result in a more gradual step down of flow. Maintenance of inundation and then a slow ramp down to overwintering flows would facilitate frog movement to overwintering sites during the pre-wintering period most effectively. **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. **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. **Invasive species:** Reed canarygrass would continue to persist in these reaches. Year-round inundation of wetlands and more stable river hydrograph beginning in year 8 are likely to improve conditions for bullfrogs and nonnative fish species known to prey on Oregon spotted frogs. Conservation Measure UD-1 could be used to fund control measures for bullfrogs and nonnative fish species.
Des-12a Des-12 Des-11 (Wickiup Dam to	**Pre-breeding:** Later implementation phases result in a smaller overall increase in flow during this ramp-up due to the larger baseline overwinter flows. This would facilitate frog movement to breeding locations and reduce likelihood of mortality of early egg masses from displacement.

Reach	Effects
Benham Falls)	**Breeding:** Days of flows exceeding 900 cfs (current vegetation inundation threshold that increases suitability of habitat for Oregon spotted frog) would remain rare. Within-year flow variation would be much lower during the breeding period at full implementation, and Conservation Measures WR-1 (B) and (C) 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. **Rearing:** Reaches would experience increasingly fewer days of wetland vegetation inundation through the successive implementation phases. During full implementation Conservation Measure WR-1 (H) sets the maximum flow at 1,200 cfs. The effect of fewer days of wetland vegetation inundation at the 900–cfs threshold could lessen over time as vegetation responds to lower flows. Hence, lower volumes of water are likely to inundate emergent vegetation at full implementation. During rearing, tadpoles and metamorphic frogs are mobile, but need the cover offered by vegetation, so flows that maintain vegetation inundation remain important. **Pre-winter:** Reaches would experience fewer days of wetland vegetation inundation. Through the phases of implementation, reaches would progressively experience a smaller amount of change as flows decrease at the end of the irrigation season to reach the winter minimum flows under Conservation Measures WR-1 (F, G, and H). The less drastic change in inundation water elevation means that frogs may be less likely to experience abrupt standing as they move to overwintering locations. **Overwintering:** Sustained higher winter flows would improve conditions for overwintering by inundating larger areas of habitat within the Deschutes River and associated sloughs and maintaining a shorter travel distance between overwintering locations in the river and breeding sites in the adjacent wetlands. **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. **Invasive species:** Reed canarygrass would continue to persist in this reach. Year-round inundation of wetlands and more stable river hydrograph beginning at full implementation are likely to improve conditions for bullfrogs and nonnative fish species known to prey on Oregon spotted frogs. Conservation Measure UD-1 could be used to fund control measures for bullfrogs and nonnative fish species.
Des-13 (Wickiup Reservoir)	Habitat conditions in Wickiup Reservoir would decline based on the following changes: • During a normal year, water volume and elevation would be lower during all key life history periods except during pre-winter. • During a dry year, less water volume and lower elevations would be available during all life history periods, especially in the later phases of implementation. • During a wet year, water volume and elevation would be higher during all life history periods except overwintering, especially during later phases of implementation. • Higher variability in water volume and elevation would be detrimental to emergent vegetation but it would also worsen conditions for invasive bullfrogs and fish species.

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. Furthermore, the CRAO gauge modeled outputs represent adjustments in the model intended to meet and sustain desired conditions for Oregon spotted frogs in Crane Prairie Reservoir. **Pre-breeding and breeding:** Flows would fluctuate more throughout this period, which can result in increased egg mass mortality. **Rearing:** Flow would continue to display erratic swings but to a lesser degree. **Pre-winter:** Reach would experience more stable conditions, which could increase the use of this reach at least for dispersal during pre-winter. **Overwintering:** Reach would experience more stable flow conditions, which could result in an increased use of the reach for overwintering, but conditions are not ideal.
Des-15 (Crane Prairie Reservoir)	Habitat conditions in Crane Prairie Reservoir would improve based on the following changes: • During all water year types (wet, normal, dry), the volume of water would be relatively unchanged during rearing and pre-winter, would increase during pre-breeding and breeding, and would increase greatly during overwintering. • Water elevations would increase during rearing in all types of years, and during pre-wintering in normal and wet years. • During breeding season, pool elevation and storage volume stability and vegetation inundation would be relatively unchanged. • 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. • Volume would be prevented from decreasing below 37,870 acre-feet during the winter compared to 35,000 acre-feet under the no-action. Smaller volume fluctuation would be expected to support frogs by increasing stability of a key abiotic component (water) that supports the vegetation community. • 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, improving habitat conditions for the frog.

cfs = cubic feet per second

[a] Overwintering = October 16–March 1 (137 days), Pre-breeding = March 1–March 31 (31 days), Breeding = April 1–April 30 (30 days), Rearing = April 15–August 31 (139 days), Pre-winter = September 1–October 15 (45 days).

Table 3.4-8. Effects of 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	**PB**	**B**	**R**	**P**	**O**	**PB**	**B**	**R**	**P**	**O**	**PB**	**B**	**R**	**P**	**O**
CLD-1 and CLD-2 (Little Deschutes River)	BE	BE	NE	BE	BE	AE	NE	NE	NE	NE	AE	NE	NE	NE	NE
CLD-3 through CLD-6 (Crescent Creek)	BE	BE	BE	NE	NE	AE	BE	BE	AE	AE	AE	NE	BE	AE	AE
Des-8a (Central Oregon Diversion to Colorado Street)	BE	BE	BE	BE	BE	BE	BE	AE	BE	BE	BE	BE+	AE+	BE	BE+
Des-9 (Lava Island Falls to Central Oregon Diversion)	BE	BE	NE	BE+	BE	BE	BE	AE	BE	BE	BE	BE+	AE+	BE	BE+
Des-10 (Dillon Falls to Lava Island Falls)	BE	BE	NE	BE+	BE	BE+	BE	AE	BE	BE+	BE+	BE+	AE+	BE	BE+
Des-10a (Benham Falls to Dillon Falls)	BE	BE	NE	BE+	BE	BE+	BE	AE	BE	BE+	BE+	BE+	AE+	BE	BE+
Des-11 (Little Deschutes to Benham Falls)	BE+	BE	BE	BE	BE	BE	BE	AE	BE	BE+	BE+	BE	AE+	BE+	BE+
Des-12 (Fall River to Little Deschutes)	BE+	BE	BE	BE	BE	BE	BE	AE	BE	BE+	BE+	BE	AE+	BE+	BE+
Des-12a (Wickiup Dam to Fall River)	BE+	BE	BE	BE	BE	BE	BE	AE	BE	BE+	BE+	BE	AE+	BE+	BE+
Des-13 (Wickiup Reservoir)	AE	AE	AE	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	NE	NE	NE
Des-15 (Crane Prairie Reservoir)	BE	BE	BE	BE	BE	BE	BE	BE	BE	BE	BE	BE	BE	BE	BE

PB=Pre-breeding, 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 in 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 beneficial effects on bull trout habitat in Whychus Creek from Conservation Measures WC-2, WC-4, WC-5, and WC-7,[8] and small beneficial effects 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 below.

Bull trout critical habitat was designated in the study area in September 2005 (70 FR 185; 56212) and revised on September 30, 2010 (U.S. Fish and Wildlife Service 2010; FR 75(200) 63898). Appendix 3.4-C summarizes temperature thresholds and predicted temperatures for juvenile and subadult bull trout rearing in all months (Figure 31). These temperatures support the potential use of the Crooked River by foraging bull trout during the winter in all modeled reaches. During the summer months, predicted temperatures were favorable to bull trout in bull trout critical habitat on the Crooked River extending from Osborne Canyon (river mile [RM] 7.3) downstream to Lake Billy Chinook (Reaches Cro-1.2 and 1.1; RMs 7.3 to 0) (Torgerson et al. 2007).

More detailed data, analysis, and graphics related to effects on bull trout, other fish species, and mollusks are provided in Appendix 3.4-C. Table 3.4-9 shows the direction of effects for each species or species group under the proposed action and action alternatives.

Table 3.4-9. Fish and Mollusks Overall Effects Summary for Proposed Action, Alternative 3, and Alternative 4

Affected Species or Habitat Type	Proposed Action	Alternative 3	Alternative 4
BIO-4: Affect Bull Trout Habitat	NA	NA	NA
BIO-5: Affect Bull Trout Migratory Life Stages	BE	BE	BE
BIO-6: Affect Steelhead Trout Habitat	NA	NA	NA
BIO-7: Affect Steelhead Trout Migratory Life Stages	NE	NE	NE
BIO-8: Affect Spring Chinook Salmon Habitat	NA	NA	NA
BIO-9: Affect Spring Chinook Salmon Migratory Life Stages	NA	NA	NA
BIO-10: Affect Sockeye Salmon Habitat	NE	NE	NE
BIO-11: Affect Sockeye Salmon Migratory Life Stages	NE	NE	NE
BIO-12: Affect Redband Trout Habitat	BE	NA	NA
BIO-13: Affect Nonnative Resident Trout Habitat	NA	NA	NA
BIO-14: Affect Summer/Fall Chinook Salmon Habitat	NE	NE	NE
BIO-15: Affect Kokanee Salmon Habitat and Migratory Life Stages	NA	NA	NA
BIO-16: Affect Native Non-Trout and Non-Game Species Fish Habitat	NA	NA	NA
BIO-17: Affect Freshwater Mollusk Habitat	V	V	V

BE – Beneficial Effect; NE – No Effect; NA – Not Adverse; AE – Adverse Effect; V – Variable

[8] Minimum instream flows below the Three Sisters diversion on Whychus Creek under Conservation Measure WC-1are assumed under the no-action alternative.

Middle Deschutes. Increased fall and winter streamflows under Conservation Measures DR-1 and WR-1 would result in median streamflows in the Middle Deschutes River increasing by approximately 30 to 80%, depending on the month from October to March. This would have a beneficial effect on the quantity and connectivity of bull trout habitat for foraging, migrating, and overwinter (FMO) subadults and adults (increasing wetted channel area and adding more depth to pool habitat) over the permit term in the portion of the reach accessible to the species.

Crooked River. Bull trout moving upstream from Lake Billy Chinook have been captured in the Opal Springs Dam temporary fish trap RM 0.8). With completion of a fish passage structure at Opal Springs Diversion Dam in November 2019, subadult and adult bull trout are observed to migrate upstream of Opal Springs Dam. Preliminary fish counts at Opal Springs Dam as of August 1, 2020, reported 238 bull trout have moved upstream through the fish ladder, ranging in length from 190 millimeters (mm) to 390 mm with an average length of 247 mm (Lickwar pers. comm. [a]). The extent of distribution of these fish is unknown; they may occupy habitats throughout the river up to Bowman Dam during the winter when temperatures are favorable. Summer daily maximum temperatures exceed the temperature thresholds for subadult and adult bull trout under the no-action alternative in much of the Crooked River, with the exception of the reach immediately downstream of Bowman Dam (Reach Cro-10; RMs 55.9 to 70.5) and lower Crooked River from the Crooked River confluence with Lake Billy Chinook to Osborne Canyon at RM 7.3.

Under Conservation Measure CR-4, funds would be available to support Crooked River habitat restoration measures or temporary purchases of instream water rights 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 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 protecting streamflow and avoiding periods of very low streamflow 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 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 Cro-2 through 1.3; RMs 22.4 to 7.3) from May through September in years 13 through 30 of the permit term. The effect of lower streamflows during this period may also decrease water quality in this reach (temperature, pH and dissolved oxygen) adversely affecting bull trout habitat.

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[9] in years 13 through 30 of the permit term (Figure 30, 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. In the 13-mile-long reach immediately downstream of Bowman Dam (Reach

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

Cro-10), the number of days that water 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 increasing very warm days in most of the downstream reaches.

The fewer days meeting the water temperature preference threshold and an increase in warm days would be an adverse effect on bull trout remaining in the river from June to September. The likelihood of bull trout moving into the Crooked River up to Bowman Dam and the shift in water temperatures indicate an adverse effect on bull trout habitat in the Crooked River downstream of Bowman Dam from RM 70.5 to Osborne Canyon at RM 7.3.

While pesticides and nutrients are known to occur within return flows that enter the Crooked River (Oregon Water Quality Pesticide Management Team 2018; Noone 2020), the proposed action would not create additional pesticide sources, nutrient sources, or pathways. Nor would the proposed action otherwise alter the occurrence of pesticides or nutrients in the Crooked River affecting bull trout habitat. As described in Final Deschutes Basin HCP Chapter 3, *Scope of the DBHCP*, flow and diversion rate changes on the Crooked River are not expected to have noticeable changes in return flows at locations on the Crooked River. In addition, the proposed action would have no effect on discharges from the City of Prineville's wastewater treatment facility and associated contribution of water pollutants.

Effect Conclusion: In the Crooked River, Conservation Measures CR-4, CR-5, and CR-6 would result in partial beneficial effects on bull trout habitat. Water management under the proposed action at full implementation (years 13–30) 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 may increase with increased North Unit ID reliance on Crooked River storage 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 13 through 30 and lower streamflows below the North Unit ID pumps to Osborne Canyon.

However, overall effects on bull trout habitat would be not adverse because adverse effects on the Crooked River would be limited to the Crooked River upstream of Osborne Canyon (RM 7.3) to Bowman Dam (RM 70.5). These effects would occur only in summer months when existing conditions are not favorable to bull trout because of water temperatures, and effects would be limited to dry and normal water year types in years 13 through 30 of the permit term. Conditions would improve on the Middle Deschutes River and Whychus, Ochoco and McKay Creeks, and would be unchanged relative to the no-action alternative in other areas occupied by bull trout (the Lower Deschutes River, Lake Billy Chinook, Lake Simtustus, and the 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 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 beneficial effects on bull trout migratory life stages in Whychus Creek by providing access to additional habitat (Conservation

Measure WC-7)[10] and small beneficial effects 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 below.

Middle Deschutes. Increased median streamflows by 30 to 80% 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 or minor beneficial effects on bull trout migratory life stages in the Crooked River because temperatures would not be affected during primary migration windows for subadult and adult bull trout entering and moving upstream in the fall and leaving the Crooked River in the spring. Beneficial effects would occur as a result of minimum streamflows identified under Conservation Measure CR-1. Lower streamflows under the proposed action downstream of the North Unit ID pump diversion would occur during periods with warm temperatures and not conducive to migrating bull trout and, thus, would not have an adverse effect.

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 fall and winter subadult and adult migration periods. In Whychus Creek, access to additional habitat would provide beneficial effects. In Ochoco and McKay Creeks, increased streamflows 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, but negligible beneficial effects or no effects elsewhere.

BIO-6: Affect Steelhead Trout Habitat

The proposed action would have no effect on steelhead trout habitat in 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 beneficial effects on steelhead trout habitat in Whychus Creek and small beneficial effects in Ochoco Creek and McKay Creek for the reasons described for bull trout habitat in Impact BIO-4. Effects in the remaining reaches relevant to the species are described below.

Middle Deschutes. Increased median streamflows by 30 to 80%, depending on month, in the Middle Deschutes River from October to March (Conservation Measures 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 and riffle habitats used by steelhead trout.

Crooked River. Conservation Measures CR-1, CR-4, and CR-6 would benefit steelhead trout habitat as described for bull trout (Impact BIO-4).

[10] Conservation Measures WC-1 is assumed under the no-action alternative.

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.

Decreased streamflows downstream of the North Unit ID pumps to Osborne Canyon from May through September would have an adverse effect on steelhead trout habitat 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 (Figure 34, Appendix 3.4-C) and inconclusive effects on winter rearing habitat, although higher streamflows are predicted to increase habitat capacity independent of summer water temperatures (Figures 35 and 36, 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 13 through 30 of the permit term (Figure 39, Appendix 3.4-C).

As discussed in Section 3.4.1, *Methods*, and in Berger et al. (2019), outflow water temperatures in the modeled wet year type were warmer than in the dry and normal year types because the reservoir did not fill until March. Outflow temperatures in June were approximately 13 °C compared to 6 °C in the dry and normal year types. The warmer outflow temperatures affected conditions for juvenile steelhead in that year type. In the reach immediately downstream of Bowman Dam (Reach Cro-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 Cro-9; RMs 55.9 to 49.4), 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.

As described for bull trout (Impact BIO-4), the proposed action would not create additional pesticide or nutrient sources, pathways or otherwise alter the occurrence of pesticides or nutrients in the Crooked River affecting steelhead trout habitat.

Effect Conclusion: In the Crooked River, Conservation Measures CR-1, CR-4, and CR-6 would result in beneficial effects on steelhead habitat. However, water management under the proposed action (Conservation Measure WR-1) would result in an adverse effect on water temperatures and juvenile habitat in all water year types in years 13 through 30 of the permit term depending on annual water management practices. Water supply modeling demonstrates years when early irrigation season diversions from the Crooked River could occur as water supply availability on the Deschutes River declines. The frequency of this adverse outcome would depend on specific, annual water supply management decisions and water supply availability that are not captured fully by modeling results. However, across the study area, overall effects of the proposed action on steelhead trout habitat compared to the no-action alternative would be not adverse. Adverse effects would be limited to the Crooked River during summer months in reaches where existing conditions are less favorable to steelhead trout because of water temperatures; conditions across the rest of the study area occupied by steelhead trout would either improve (Whychus Creek, the Middle Deschutes River and Ochoco and McKay Creeks), or remain unchanged (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 the Lower Deschutes, because the increase in winter streamflows over the permit term would be minor. The proposed action would have beneficial effects on bull trout migratory life stages in Whychus Creek and small beneficial effects in Ochoco Creek and McKay Creek for the reasons described for bull trout in Impact BIO-5. Effects in the remaining reaches relevant to the species are described below.

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 at 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 outside of the irrigation season, under the proposed action during years 13 through 30 of the permit term, suggest slightly 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. Conservation Measure CR-7 would protect pulse streamflows downstream of the Ochoco ID diversion and North Unit ID pumps when pulse streamflows are implemented by Reclamation, in consultation with NMFS and FWS. Protection of pulse streamflows would be beneficial to move fish through the Crooked River. However, there is the potential for streamflows to be lower downstream of the North Unit ID pumps in May and June during juvenile steelhead migration, depending on water year type and water management, which would be an adverse effect absent pulse streamflows. There was no evidence that the proposed action streamflows 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 adult and smolt 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 in some years and reaches. (Figures 40 and 41, Appendix 3.4-C). Overall, because of a combination of beneficial effects (higher winter streamflows, potentially more favorable temperatures, and protection of pulse flows) and adverse effects (lower streamflows downstream of the North Unit ID pumps in May and June) 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 a beneficial effect or 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 a small beneficial effect on steelhead migration. In Whychus Creek, access to additional habitat would provide beneficial effects. In Ochoco and McKay Creeks, increased streamflows would have small beneficial effects. 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. Protection of pulse streamflows on the Crooked River would have a beneficial effect on steelhead migration.

Overall, the proposed action would have no effect on steelhead trout migratory life stages compared to the no-action alternative. Increases in streamflows, where they would occur, would not change enough to suggest an overall effect during steelhead migration life stages.

BIO-8: Affect Spring Chinook Salmon Habitat

The proposed action would have no effect on spring Chinook habitat in 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 beneficial effects on spring Chinook salmon habitat in Whychus Creek and small beneficial effects in Ochoco Creek for the reasons described for bull trout habitat in Impact BIO-4. Effects in the remaining reaches relevant to the species are described below.

Middle Deschutes. The proposed action would have no effect on spring Chinook salmon habitat during the irrigation season because streamflows in the Middle Deschutes during this period would be unchanged over the permit term. Small to moderate increases in winter streamflows, under the proposed action, would have no effect on spring Chinook salmon habitat. The portion of the reach accessible to the species over the permit term is heavily influenced by groundwater inputs and would not change substantially.

Crooked River. Conservation Measures CR-1, CR-4, and CR-6 would benefit spring Chinook salmon habitat as described for bull trout in 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 Measure 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 adversely affect spring Chinook salmon habitat on the Crooked River downstream of the North Unit ID pumps to Osborne Canyon (Reaches Cro-2 through 1.3; RMs 22.4 to 7.3) from May through September.

Analysis of temperature thresholds for spring Chinook salmon spawning, egg incubation and juvenile rearing suggest an effect of water management operations on water temperatures under the modeled streamflows for the proposed action (Figures 43, 44, and 45, Appendix 3.4-C). Water management operations and associated modeled water temperatures in wet water years result in a substantial increase in number of lethal days (days that the 7-day average of daily maximum temperatures [7-DADM] was greater than 19 °C]) at the end of the permit term. This was a slight increase (~1 °C) in predicted water temperatures resulting in more days slightly above 19 °C under the proposed action versus a number of days between 18 and 19 °C under the no-action alternative. This difference is functionally minor as the no-action alternative and proposed action both have no days in the preference category (<14 °C) during presumed spawning in August and September in most of the Crooked River reaches (Figure 42, Appendix 3.4-C). The proposed action has minimal effect on juvenile Chinook salmon habitat in the modeled wet year as change in streamflows and water temperatures relative to juvenile rearing thresholds were minor compared to the no-action alternative.

However, water management and water temperatures for the dry and normal water years toward the end of the permit term indicate a potential for adverse effects on Chinook salmon habitat in the approximately 63 miles between Bowman Dam and Osborne Canyon (Figure 45, Appendix 3.4-C). For example, in the modeled normal water year in the reach immediately downstream of Bowman Dam (Reach Cro-10), the number of days that water temperatures meeting 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 Cro-9) and in the reach just upstream of the city of Prineville (Reach Cro-8; RMs 49.4 to 46.7) 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 the city 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.

As described for bull trout (Impact BIO-4), the proposed action would not create additional pesticide or nutrient sources, pathways or otherwise alter the occurrence of pesticides or nutrients in the Crooked River affecting spring Chinook habitat.

Effect Conclusion: In the Crooked River, Conservation Measures CR-1, CR-4, and CR-6 would result in beneficial effects on spring Chinook salmon habitat. However, water management under the proposed action related to 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 toward the end of the permit term depending on annual water management practices. Water supply modeling assumes early irrigation season diversions from the Crooked River could occur 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 70.5) and Osborne Canyon (RM 7.3) in years 13 through 30 of the permit term. Furthermore, increased North Unit ID reliance on the Crooked River under Conservation Measure WR-1 would decrease streamflows and adversely affect spring Chinook salmon habitat on the Crooked River downstream of the North Unit ID pumps.

However, across the study area, overall effects of the proposed action on spring Chinook salmon habitat would be not adverse compared to the no-action alternative. This is because adverse effects would be limited to the Crooked River during summer months in reaches where existing conditions are less favorable to spring Chinook because of water temperatures; conditions across the rest of the study area waters occupied by spring Chinook salmon would either improve (Whychus Creek and Ochoco Creek) or remain unchanged (the Middle Deschutes River, 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 migratory life stages in Whychus Creek,[11] 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 spring Chinook migratory life stages in Ochoco Creek and McKay Creek for the reasons described for bull trout in Impact BIO-5. Effects in the remaining reaches relevant to the species are described below.

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 a

[11] Beneficial effects described for bull trout in Impact BIO-4 and steelhead Impact BIO-6, are not expected to benefit spring Chinook because habitat made accessible under Conservation Measure WC-7 is steeper gradient and less favorable to spring Chinook.

small beneficial effect on spring Chinook salmon adult migration in late winter prior to the irrigation season because of higher streamflows (Conservation Measures WR-1 and DR-1).

Crooked River. Conservation Measures CR-1 and CR-7 would benefit spring Chinook salmon migratory habitat as described for steelhead trout (Impact BIO-7).

Conservation Measure CR-7 would benefit downstream migrating juvenile spring Chinook and upstream migrating adult spring Chinook for the reasons described for steelhead in Impact BIO-7. However, there is the potential for streamflows to be lower downstream of the North Unit ID pumps in May and June absent pulse streamflows, depending on water year type and water management, which would be an adverse effect when juvenile and adult spring Chinook would be migrating.

Analysis of temperature thresholds for spring Chinook salmon upstream migrating adults from March through June suggest a slight adverse effect of the proposed action on adult migrating spring Chinook (Figure 46, Appendix 3.4-C). Spring Chinook have been observed moving later in the season. 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). Another spring Chinook adult was observed moving upstream in the Crooked River during summer 2020 (Lickwar pers. comm. [b]). In addition, 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. [c]). These results suggest that spring Chinook salmon may attempt to migrate upstream during the summer 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.

Analysis of temperature thresholds for seaward migrating smolts from February through May suggest no effect of the proposed action (Figure 47, Appendix 3.4-C).

Average depth of riffles in the Crooked River indicate low streamflows may impede adult migration, under the no-action alternative (Deschutes Basin Board of Control and City of Prineville 2019: Chapter 8, Section 8.3.3). Water supply modeling suggests 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 22.4. However, adult migration may be adversely affected downstream of the North Unit ID diversion to approximately Osborne Canyon (RM 7.3) 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 and migrating spring Chinook salmon smolts from March to April, but may result in an adverse effect on habitat for adult spring Chinook salmon migrating in May, June, 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 at the end of the typical migration period between Bowman Dam and Osborne Canyon, and increases in streamflows in other portions of the study area would not change enough to suggest an overall effect during spring Chinook salmon migration life stages.

BIO-10: Affect Sockeye Salmon Habitat

Effects of measures in Whychus Creek are likely upstream of sockeye salmon spawning and egg incubation habitat and the proposed action would have no effect. Differences in reservoir volume and elevations in Lake Billy Chinook and Lake Simtustus would be minor under the proposed action and would have no effect on sockeye salmon habitat. Changes in streamflows in the Lower Deschutes River would be minor over the permit term. Effects in the remaining reaches relevant to the species are described below.

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 in locations used by sockeye salmon for spawning and egg incubation would have no effect on sockeye salmon habitat (differences are minor suggesting no effect on streambed scour or channel erosion rates).

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 Cro-1.2 and Cro-1.1; RMs 7.3 to 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 in locations used by sockeye salmon 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 small. 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 below.

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.

BIO-12: Affect Redband Trout Habitat

The proposed action would have no effect on redband trout habitat in Tumalo Creek, the Lower Deschutes River, Lake Billy Chinook, Lake Simtustus, and Prineville Reservoir 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 beneficial effects on redband trout habitat in Whychus Creek for the reasons described for bull trout habitat (Impact BIO-4) and in Ochoco Creek from increased flows described for bull trout (Impact BIO-4). Effects in the remaining reaches relevant to the species are described below.

Crescent Lake Reservoir. Crescent Lake Reservoir elevations would be approximately 5 feet higher during most of the year and moderately less variable between years under the proposed action. Higher and less variable reservoir elevations in the spring would occur when redband trout are accessing lake tributaries for spawning. Higher and less variable lake elevations would also improve connectivity to wetlands located on the south side of the lake over more of the year, likely lake ecology for redband trout prey items. However, higher lake elevations may inundate some wetlands leading to impaired conditions. Overall, the proposed action would have a beneficial 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 improvements in streamflow related to releases of storage under Conservation Measure CC-1 to benefit Oregon spotted frog during critical life stages. Additional beneficial effects on redband trout habitat would be from 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. Median streamflows would be lower during the winter, which may negatively affect over-winter rearing habitat for redband trout. Managed higher spring streamflows may have mixed effects on spawning and incubation habitat. Higher streamflows may cause some areas to be unsuitable for redband trout spawning based on stream velocity and depth, while other areas may be improved with higher spring streamflows. Therefore, the proposed action would have a not adverse effect on redband trout habitat in Crescent Creek.

Little Deschutes River. There would be beneficial changes in streamflows in the Little Deschutes River with higher summer streamflows under the proposed action. Therefore, the proposed action would have a beneficial effect on redband trout habitat in the Little Deschutes River.[12]

Crane Prairie Reservoir. Reservoir elevations would be slightly less variable from April through October, and reservoir elevation would be slightly higher from October through May. Reservoir

[12] See Appendix 3.1-C, *Analysis of RiverWare Model Version 18 Outputs and Implications for Final EIS*, for corrections due to modeling update.

elevations would be slightly more variable across years from November through March. However, the differences in reservoir management under the proposed action were considered minor and would have no effect on water quality and on redband trout in the reservoir. The proposed action would have no effect on redband trout habitat in Crane Prairie Reservoir because differences are minor.

Upper Deschutes between Crane Prairie and Wickiup Reservoirs. Streamflows in the Upper Deschutes River between Crane Prairie Reservoir and Wickiup Reservoir would be less variable over 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. Streamflows would be lower in the fall and early winter, and there would be an abrupt transition to lower streamflows in November under the proposed action. The transition to lower streamflows also occurs under the no-action alternative but would be in January compared to November under the proposed action. This transition may be less adverse when it occurs in November compared to January when water temperatures are colder and redband trout may be more closely associated with the substrate during that time.

Therefore, the proposed action would have a mix of no effect and beneficial effects on redband trout habitat in the Upper Deschutes River between Crane Prairie and Wickiup Reservoirs.

Wickiup Reservoir. The 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) and water quality, as described in Section 3.3, *Water Quality*. Reservoir management would increase the severity of existing low concentrations of dissolved oxygen in the bottom waters, eventually leading to a complete loss of oxygen in these waters and warming of surface waters. In addition, effects on dissolved oxygen in the bottom waters would increase the release of phosphorus from the sediments, which could increase the intensity and duration of existing cyanobacteria blooms in the reservoir during the summer and into early fall. Furthermore, the extreme drawdown in some years during the summer would increase the chance of 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). The 1,200 cfs maximum flow under the proposed action (Conservation Measure WR–1) in years 13 through 30 of the permit term would have a further beneficial effect on redband habitat. Reduced summer streamflows would be expected to result in higher emergent vegetation recruitment into the river channel, thereby improving riparian conditions and channel complexity 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 48, Appendix 3.4-C).

Spring and early summer streamflows at the start of the irrigation season would be lower under the proposed action in response to lower storage in Wickiup Reservoir at the beginning of the irrigation season. Managed releases from Wickiup Reservoir would stabilize spring and early summer streamflows and avoid extreme variation during critical redband spawning and egg incubation life stages. The proposed action would result in less within-year variation in spring and summer streamflows in years when storage is unable to meet irrigation demand (Figure 48, Appendix 3.4-C).

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. Variation in streamflows in the spring determined by the CV was lower under the proposed action at the end of the permit term. This lower variation may benefit redband spawning, egg incubation, and juvenile rearing survival, by preventing dewatering in locations where adult redband trout are attempting to spawn. This beneficial effect would be less downstream of Benham Falls because of additional inflow from the Little Deschutes and elsewhere, offsetting the effects of irrigation releases on daily streamflow.

As described in Section 3.3, changes in water temperature, pH, dissolved oxygen, nitrate, or phytoplankton in the Upper Deschutes from Wickiup Reservoir would be minor and would have a minor effect on redband trout habitat.

A potential 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 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.

Implementation of Conservation Measure UD-1 under the proposed action, 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.

Overall, the improved conditions with higher winter streamflows, lower summer streamflows, improved riparian conditions in the Deschutes River, and Conservation Measure UD-1 indicate a beneficial effect of the proposed action on redband trout habitat in the Upper Deschutes River between Wickiup Reservoir and the city of Bend.

Middle Deschutes. Increased median streamflows in the Middle Deschutes River from October to March (Conservation Measures 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.). However, down ramping of streamflows at the start of the irrigation season is not predicted to change under the proposed action. The ramp down of streamflows follows a typical pattern starting in early April and ending by the second week of April. Any adverse effect of down ramping during this period on redband trout would be the same under the proposed action as under the no-action alternative. Therefore, the proposed action would have an overall beneficial effect on redband trout habitat in the Middle Deschutes River from Conservation Measures DR-1 and WR-1.

Crooked River. In the Crooked River, redband trout are abundant in the reach immediately downstream of Bowman Dam (Reach Cro-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 Cro-1.2 and Cro-1.1) because of a consistent input of cool groundwater.

Conservation Measures CR-1, CR-4, and CR-6 would benefit redband trout habitat as described for bull trout (Impact BIO-4).

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 trout (Impact BIO-6). These effects include differences in streamflow across the year, which would affect the amount of habitat available and water temperatures during critical life stages. 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 years 13 through 30 of the permit term, as described for steelhead trout (Impact BIO-6). The Crooked River downstream of the canyon reach (Reach Cro-9) and in the reach just upstream of the city of Prineville (Reach Cro-8; RMs 49.4 to 46.7) 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 Cro-10) would be less severe. Therefore, the proposed action would have a moderately adverse effect on redband trout habitat in the Crooked River in the canyon reach downstream of Bowman Dam (Reach Cro-10) and a more severe adverse effect in reaches downstream of the canyon reach (Reaches Cro-8 and Cro-9) during the irrigation season and below the North Unit ID pumps at RM 22.4 to Osborne Canyon at RM 7.3.

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 (Figure 36, Appendix 3.4-C). Higher winter streamflows would increase habitat quality and capacity for juvenile steelhead when removing effects of summer water temperatures. The same conclusion is applicable to juvenile redband trout.

During the irrigation season, streamflows would be lower downstream of the North Unit ID pumps to Osborne Canyon (Reaches Cro-2 through Cro-1.3; RMs 22.4 to 7.3) from May through September due to increased North Unit ID reliance on the Crooked River under the proposed action.

As described for bull trout (Impact BIO-4), the proposed action would not create additional pesticide or nutrient sources, pathways or otherwise alter the occurrence of pesticides or nutrients in the Crooked River affecting redband trout habitat.

Effect Conclusion: The proposed action would have no effect on redband trout habitat in Tumalo Creek, the Lower Deschutes River, Lake Billy Chinook, Lake Simtustus, and Prineville Reservoir. Overall, there would be no effect on redband trout in Crane Prairie Reservoir and the Upper Deschutes River between Crane Prairie Reservoir and Wickiup Reservoir, and a not adverse effect in Crescent Creek. There would be a beneficial effect in the Upper and Middle Deschutes River, Little Deschutes River,[13] Crescent Lake Reservoir, and Whychus, Ochoco, and McKay Creeks. There would be adverse effects on redband trout habitat in Wickiup Reservoir and the Crooked River. Adverse effects in the Crooked River would be limited to summer months when existing conditions were less favorable to redband trout because of water temperatures. Overall, across the entire study area the proposed action would have a beneficial effect on redband trout habitat compared to the no-action alternative because of the extent of area where beneficial effects would occur.

[13] See Appendix 3.1-C, *Analysis of RiverWare Model Version 18 Outputs and Implications for Final EIS*, for corrections due to modeling update.

BIO-13: Affect Nonnative Resident Trout Habitat

The proposed action would have mixed effects on nonnative trout habitat as described for bull trout and steelhead trout (Impact BIO-4 and Impact BIO-6).

Increased winter streamflows in the Upper Deschutes River between Wickiup Reservoir and Bend and Middle Deschutes River downstream of Bend 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 in years 13 through 30 of the permit term.

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 beneficial effects in the Upper Deschutes River; Middle Deschutes River; Little Deschutes River;[14] and Whychus, Ochoco, and McKay Creeks. There would be an adverse effect in Wickiup Reservoir as described for redband trout (Impact BIO-12). 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 Lake Billy Chinook and Lake Simtustus, because changes in the volumes and elevations of the reservoirs would be minor. Kokanee spawning and egg incubation habitat in Whychus Creek occurs above likely effects of the conservation measures. Effects in the remaining reservoirs relevant to the species are described below.

Crescent Lake Reservoir. The proposed action would have a beneficial effect on kokanee salmon habitat and migratory life stages in Crescent Lake Reservoir because lake conditions would improve with higher lake elevations and volume (Figure 19, Appendix 3.4-C).

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 a beneficial effect on kokanee salmon habitat and migratory life stages in Crane Prairie Reservoir.

Wickiup Reservoir. The predicted variation in reservoir elevations and lower volume over the permit term would affect kokanee habitat in the reservoir. Effects would be minor in years 1

---

[14] See Appendix 3.1-C, *Analysis of RiverWare Model Version 18 Outputs and Implications for Final EIS*, for corrections due to modeling update.

through 7 of the permit term. Near the end of the permit term (years 13–30), effects low water years during the winter would have an adverse effect on kokanee habitat in the reservoir.

As described in Section 3.3, changes in water quality in Wickiup Reservoir under the proposed action would have an adverse effect on Kokanee salmon habitat.

Effect Conclusion: There would be no effect on kokanee salmon habitat in Lake Billy Chinook, Lake Simtustus, or Whychus Creek. Effects would be adverse in Wickiup Reservoir due to low reservoir elevations and volumes, greater seasonal differences, and water quality. Beneficial effects would occur in Crescent Lake and Crane Prairie Reservoirs due to higher lake elevations and volume. Overall, the proposed action would have a not adverse effect on kokanee salmon habitat and migratory life stages because adverse effects would be limited to Wickiup Reservoir, beneficial effects would occur in Crescent Lake and Crane Prairie Reservoirs, and there would be no effect in other reaches, including Lake Billy Chinook.

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 variation in reservoir elevation and volume as described for redband trout (Impact BIO-12). 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 13–30) 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. Overall, effects in this reach on non-game species habitats would be not adverse because of the beneficial effect during winter to all 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 the variation in reservoir elevation and volume, seasonal differences, and water quality effects as described for redband trout (Impact BIO-12) and the Crooked River due to more days with warmer temperature as described for steelhead trout (Impact BIO-6). Effects in the Upper Deschutes River downstream of Wickiup Reservoir would be not adverse because of the beneficial effect during winter to all species. There would be beneficial effects in the Middle Deschutes River during storage season, beneficial effects in the Little Deschutes River,[15] 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 be 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. Crescent Lake Reservoir elevations would be higher during most of the year and less variable over the year under the proposed action. There would be greater across-year variability in the fall. Overall, the effect on Crater Lake tightcoil and evening field slug tightcoil habitat would be not adverse.

Crescent Creek. Increased spring streamflows would provide additional moist habitat for Crater Lake tightcoil. Streamflow differences during winter months would have little to no effect on this species because tightcoil often burrow 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 winter streamflows could lessen habitat for the field slug, increased spring 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 the winter could adversely interfere with western pearlshell mussel juvenile development and adult maturation; however, increased spring streamflows could be beneficial for maturing western pearlshell mussels and for their glochidia traveling on host salmonids. 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 during the winter could cause additional mussel stranding. Increased streamflows in April through June would provide additional habitat and better streamflow conditions during the time period of larval pearlshell attachment and maturation on host fish.

Little Deschutes River. Changes in streamflows would be beneficial across an annual cycle, resulting in improved habitat (perennially moist areas) for Crater Lake tightcoil and evening field slug. Therefore, effects on these species would be beneficial.[16]

Changes in streamflow would be minimal in May and June, the critical period of reproduction and juvenile establishment for western pearlshell mussel. Therefore, there would be no effect on western pearlshell mussel habitat.

---

[15] See Appendix 3.1-C, *Analysis of RiverWare Model Version 18 Outputs and Implications for Final EIS*, for corrections due to modeling update.

[16] See Appendix 3.1-C, *Analysis of RiverWare Model Version 18 Outputs and Implications for Final EIS*, for corrections due to modeling update.

Upper Deschutes. In the Upper Deschutes between Crane Prairie Reservoir and Wickiup Reservoir (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 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 streamflow during fall and winter months in most of the Upper Deschutes would provide additional habitat during this time, and while summer months experience lower streamflows, the 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 streamflows 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. Down ramping of streamflows at the start of the irrigation season is not predicted to change based on RiverWare model results at the DEBO node. Any adverse effect of down ramping during this period on Crater Lake tightcoil and evening field slug would be the same as under the no-action alternative. Therefore, effects on western pearlshell mussel would be not adverse.

Higher winter streamflows would be beneficial to western ridged mussels, where they are present in this reach up to Big Falls. Change in streamflows from June through August, the most critical period reproduction and juvenile settlement, would be very minimal and not adverse. Overall, the effect would be not adverse.

Crooked River. In the Upper and Middle Crooked River, decreased streamflows during the summer could cause drying of potential habitat for Crater Lake tightcoil. In the reach downstream of the North Unit ID pumps to Osborne Canyon. This could adversely affect tightcoil habitat.

The increased frequency of decreased median monthly streamflows 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.

Ochoco and McKay Creeks. The proposed action would have small beneficial effects on freshwater mollusk habitat in Ochoco and McKay Creeks from increased flows described for steelhead trout (Impact BIO-6). Overall, the effect on western pearlshell mussels would be not adverse.

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. Effects would be adverse in the Crooked River. Overall, across the entire study area effects of the proposed action on mollusk habitat compared to the no-action alternative would be a mixture of beneficial, not adverse, and adverse depending on the species.

3.4.3.3 Alternative 3: Enhanced Variable Streamflows

This section describes effects on vegetation and wildlife 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 is referenced for brevity.

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 but the following reaches.

- There would be negligible differences in Crane Prairie Reservoir (reach Des-15) apart from small elevation raises in November and December that would be unlikely to affect vegetation.
- Crescent Lake Reservoir depths would increase only slightly, and variability would not change, resulting in beneficial but minor effects on vegetation.
- Crescent Creek below the reservoir would see minor April and October-November flow decreases, and the Little Deschutes River would have only negligible changes in flow and flow variability that would be unlikely to affect vegetation.
- The whole Crooked River system below Prineville Reservoir would experience minor to moderate June-July flow increases and November decreases, with July increases in flow variability. As with Alternative 2, the net effect on vegetation would be small and likely neutral, with any benefits of increased growing season flows offset by increased flow variability.

Since the differences listed above have little effect on vegetation, effects on vegetation under Alternative 3 would be the same as described for the proposed action. However, adverse effects on Wickiup Reservoir and beneficial effects along the Upper Deschutes River would occur approximately 7 years earlier in the permit term than under the proposed action.

Effect Conclusion: Effects on vegetation communities under Alternative 3 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 (Table 3.1-1). Overall, the effects of Alternative 3 on vegetation communities would be beneficial compared to the no-action alternative because the beneficial effects on riparian and wetland vegetation in Crane Prairie Reservoir, the Upper Deschutes River, Crescent Lake Reservoir, the Crescent Creek–Little Deschutes River system, Ochoco Creek, McKay Creek, and Whychus Creek would be more widespread and 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 Crane Prairie Reservoir, the Crescent Creek–Little Deschutes River system, and the Crooked River. Therefore, effects on wildlife would be the same as described for the proposed action, except that the altered hydrologic changes in Crane Prairie Reservoir, the Crescent Creek–Little Deschutes River system, and the Crooked River would not produce any substantial changes in vegetation, relative to the no-action alternative. Thus, there is minimal potential for changes on these reaches to affect wildlife.

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. Under Alternative 3, those changes begin approximately 7 years earlier than under the proposed action. Therefore, effects on wildlife in these reaches would be the same as described for the proposed action but would also begin earlier in the permit term.

Effect Conclusion: Effects of Alternative 3 on wildlife and its habitat compared to the no-action alternative would be of the same magnitude as described for the proposed action, but would differ in timing. 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, Crescent Lake Reservoir, the Upper Deschutes River, Ochoco Creek, McKay Creek, Whychus Creek, and the Crescent Creek–Little Deschutes River system would be more widespread and more extensive than habitat impairments, which are limited to Wickiup Reservoir.

BIO-3: Affect Oregon Spotted Frog Habitat

Modeled changes in flows in the Upper Deschutes River reaches under Alternative 3 compared to the no-action alternative would be similar to those described for the proposed action in years 8 through 30. In general, summer flows would diminish and winter flows would increase compared to the no-action alternative. Accordingly, effects of hydrological changes in these reaches on Oregon spotted frog and its habitat would be the same as described in Table 3.4-1 with the following modifications.

- Des-8a through Des-12a (Deschutes River downstream from Wickiup Reservoir):
    - Pre-breeding: The increase in flow as the system shifts from winter storage to the irrigation season would be smaller and would reduce more quickly over the phases of implementation, increasing beneficial effects.
    - Breeding: Reaches would experience more days of flows that meet current inundation thresholds or flow toward off-channel sites, increasing beneficial effects.
    - Rearing: Less stable flows, especially during late rearing season, could hinder emergent vegetation colonization of areas that are inundated at lower topographical levels (e.g., slough habitat), and lower flows late in the season would be more common and could further dry wetlands and expose juvenile frogs to predation, increasing adverse effects.
    - Pre-winter: Frogs would experience a smaller change in flow to reach the winter minimum, possibly preventing abrupt stranding of frogs as they migrate to overwintering sites, increasing beneficial effects.

- Overwintering: Higher sustained flow levels and less year-to-year variation would result in more consistently wetted overwintering sites and shorter distances between breeding and overwintering locations, increasing beneficial effects.

- Des-13 (Wickiup Reservoir):
  - A further decline in all habitat conditions in Wickiup Reservoir, increasing adverse effects; refer to Appendix 3.4-B for details.

In Crescent Creek and Little Deschutes River, winter minimum flows under Alternative 3 would be less, resulting in neutral to slightly adverse conditions without the ability to adjust flows using the OSF storage component of Conservation Measure CC-1 provided under the proposed action. Overall, beneficial effects would be reduced.

Effects in Crane Prairie (Des-15) would be the same as described for the proposed action.

The acceleration of flow improvements in most reaches and during most life history periods during phases 1 and 2 of this alternative 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 more quickly than they would under the proposed action. Table 3.4-2 shows the direction of hydrology-related effects for each life history stage by reach. Refer to Appendix 3.4-B for the full analysis.

Effect Conclusion: Beneficial and adverse effects under Alternative 3 compared to the no-action alternative would be similar to those described for the proposed action, except that both the beneficial effects in the Upper Deschutes River reaches below Wickiup Reservoir and adverse effects in Wickiup Reservoir and the reach above it would be amplified and would occur earlier in the permit term (starting in year 1 and reaching full implementation starting in year 13) and would, therefore, have a longer duration. Also, effects in Crescent Creek would be mixed: beneficial during breeding and rearing to slightly adverse during other life history periods. Effects in Crane Prairie (Des-15) would be the same as described for the proposed action. Overall, effects on Oregon spotted frog and its habitat under Alternative 3 would be beneficial compared to the no-action alternative.

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 shifts in irrigation diversions at full implementation would be of slightly lesser magnitude due to instream protection of uncontracted releases under this alternative (Conservation Measure CR-1). Figures 51 through 53 in Appendix 3.4-C present detailed model results of temperature modeling and bull trout life stage temperature thresholds. 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 56 and 57 in Appendix 3.4-C present habitat model results for steelhead trout. Figures 58 through 60 in Appendix 3.4-C present detailed model results of temperature modeling and steelhead trout life stage temperature thresholds. In addition, effects in the Middle Deschutes River and Crooked River would occur slightly 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. Figures 61 and 62 in Appendix 3.4-C present detailed model results of temperature modeling and steelhead trout migratory life stage temperature thresholds for the Crooked River. 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 63 in Appendix 3.4-C presents habitat model results for spring Chinook. Figures 64 through 66 in Appendix 3.4-C present results of temperature modeling and spring Chinook life stage temperature thresholds. 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). Figures 67 and 68 in Appendix 3.4-C present results of temperature modeling and spring Chinook migratory life stage temperature thresholds for the Crooked River. 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, Wickiup Reservoir, Crescent Lake Reservoir, Crescent Creek, Little Deschutes River, and the Crooked River between North Unit ID pumps and Osborne Canyon. Effects on redband trout on the Upper Deschutes River would be beneficial compared to the no-action alternative for the reasons described for the proposed action. However, as described in the introduction to this alternative, recovery of riparian conditions and channel complexity for juvenile redband trout could be reduced, compared to the proposed action, without the summer flow cap. Conditions in Wickiup Reservoir would be more adverse under Alternative 3 compared to the proposed action because of lower and greater variability in reservoir elevations and volume in years 11 to 30 of the permit term. Slightly higher elevations in Crescent Lake Reservoir throughout the year and in the spring when redband trout are accessing tributaries for spawning would likely have no discernable effect on redband trout connectivity to tributary spawning habitat compared to the no-action alternative. Lower fall and early spring streamflows, slightly higher late spring and early summer streamflows, and slightly greater late spring and early summer streamflow variability in Crescent Creek would be too minor to have a discernable effect on redband trout habitat in Crescent Creek compared to the no-action alternative. In the Little Deschutes River, higher summer streamflows described for the proposed action would not occur and there would be no discernible effect on redband trout habitat compared to the no-action alternative. In the Crooked River between North Unit ID pumps and Osborne Canyon, effects would be adverse compared to the no-action alternative for the reasons described for the proposed action, but they 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, would be of longer duration under Alternative 3 than the proposed action (Table 3.1-1). The combination of effects on Wickiup Reservoir and the Upper Deschutes River below Wickiup Reservoir would occur earlier in the permit term and could lead to adverse effects of higher magnitude than the proposed action. Overall, effects on redband trout habitat under Alternative 3 would be not adverse compared to the no-action alternative.

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, Crescent Lake Reservoir, Crescent Creek, Little Deschutes River, and the Crooked River between North Unit ID pumps and Osborne Canyon, as described for redband trout (Impact BIO-12). 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, except for Crescent Lake Reservoir, as described for redband trout (Impact BIO-12). 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 not 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 for Crescent Lake Reservoir, Crescent Creek, and Little Deschutes River, as described for redband trout (Impact BIO-12). 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 in the Little Deschutes River and floater species mussels and western pearlshell mussels in the Crooked River where there would be a not adverse effect. There would be no effect on freshwater mollusk habitat in the Little Deschutes River. 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 vegetation and wildlife 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 is referenced for brevity.

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 Alternative 3. Therefore, effects on vegetation would be the same as described for Alternative 3, with the exception that, since Alternative 4 achieves flow targets more quickly, the changes described for Alternative 3 would occur several years earlier. Also, 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.

Effect Conclusion: Effects on vegetation communities under Alternative 4 compared to the no-action alternative would be the same as described for Alternative 3, except that effects would occur several years earlier but accrue over a shorter permit term. Overall, the effects of Alternative 4 on aquatic and riparian vegetation would be beneficial compared to the no-action alternative because the beneficial effects on riparian and wetland vegetation in Crane Prairie Reservoir, the Upper Deschutes River, Crescent Lake Reservoir, the Crescent Creek–Little Deschutes River system, Ochoco Creek, McKay Creek, and Whychus Creek 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 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 Alternative 3. The exception would be that, since Alternative 4 achieves flow targets more quickly, the changes described for Alternative 3 would occur several years earlier, and since the permit term is shorter, those changes could end earlier as well.

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 Alternative 3, but would begin to accrue several years earlier and would occur over a shorter permit term. Overall, effects of Alternative 4 on habitat for wildlife would be beneficial compared to the no-action alternative because habitat improvements due to hydrologic modifications and vegetation improvements in Crane Prairie Reservoir, Crescent Lake Reservoir, the Upper Deschutes River, Ochoco Creek, McKay Creek, Whychus Creek, and the Crescent Creek–Little Deschutes River system 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 in the Upper Deschutes River reaches under Alternative 4 compared to the no-action alternative would be similar to those described for the proposed action in years 8 through 30; in general summer flows would diminish and winter flows would increase compared to the no-action alternative. Accordingly, effects of hydrological changes in these reaches on Oregon spotted frog and its habitat would be the same as described in Table 3.4-1 with the modifications presented for Alternative 3. Under Alternative 4 these modifications would be of greater magnitude and would further increase beneficial effects in in the Upper Deschutes River reaches below Wickiup Reservoir and adverse effects in Wickiup Reservoir and the reach feeding into it.

Although Alternative 4 would reach full implementation flows by year 6, faster than either the proposed action (which would take 12 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 17 years under the proposed action and 20 years under Alternative 3 (Table 3.1-1).

Effects in Crescent Creek and Little Deschutes River would be similar to those described for Alternative 3. Effects in Crane Prairie would be the same as described for the proposed action. Table

3.4-2 shows the direction of hydrology-related effects for each life history stage by reach. Refer to Appendix 3.4-B for the full analysis.

Effect Conclusion: Beneficial and adverse effects under Alternative 4 compared to the no-action alternative would be similar to those described for the proposed action and Alternative 3. The exceptions would be that both beneficial effects in the Upper Deschutes River reaches below Wickiup Reservoir and the adverse effects in Wickiup Reservoir and the reach above it would be amplified and would occur earlier in the permit term than under the proposed action or Alternative 3, but full implementation would occur for a shorter duration. Beneficial effects in Crane Prairie (Des-15) would be the same as described for the proposed action. Mixed effects in Crescent Creek would be similar to Alternative 3. 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. Figures 72 through 74 in Appendix 3.4-C present results of temperature modeling and bull trout life stage temperature thresholds.

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 would be of shorter overall duration than under the proposed action or 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; these beneficial effects would occur earlier in the permit term but would be of shorter overall duration than under the proposed action or Alternative 3 (Table 3.1-1). 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 79 and 81in Appendix 3.4-C present habitat model results for steelhead trout. Figures 85 through 89 in Appendix 3.4-C present results of temperature modeling and steelhead trout life stage temperature thresholds. These beneficial and adverse effects would occur earlier in the permit term but would be of shorter overall duration than under the proposed action or Alternative 3 (Table 3.1-1). 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. 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 84 in Appendix 3.4-C presents detailed habitat model results for spring Chinook. Figures 85 through 87 in Appendix 3.4-C present results of temperature modeling and spring Chinook life stage temperature thresholds. These beneficial and adverse effects would occur earlier in the permit term but would be of shorter overall duration than under the proposed action or Alternative 3 (Table 3.1-1). 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. 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 Crescent Lake Reservoir, Crescent Creek, Little Deschutes River, Wickiup Reservoir, the Upper and Middle Deschutes River, and the Crooked River. Changes in Crescent Creek and Little Deschutes River streamflows and Crescent Lake 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 Alternative 3. Increased storage season streamflows 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 streamflow and decreased summer streamflow 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 fall and winter releases from Wickiup Reservoir in above-normal and wet years under this alternative (Conservation Measure WR-1).

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. These beneficial and adverse effects would occur earlier in the permit term but would be of shorter overall duration than under the proposed action or Alternative 3 (Table 3.1-1). Overall, effects on redband trout habitat under Alternative 4 would be not adverse compared to the no-action alternative for the reasons described for the proposed action and Alternative 3.

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 except Crescent Lake Reservoir, Crescent Creek, Little Deschutes River, and Wickiup Reservoir, where effects would be the same as described for Alternative 3. Effects in Wickiup Reservoir, the Upper and Middle Deschutes River, and the Crooked River would occur earlier in the permit term but would be of shorter overall duration than under the proposed action or Alternative 3 (Table 3.1-1). Overall, effects on nonnative resident trout habitat under Alternative 4 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 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 Crescent Lake Reservoir, where effects would be the same as described for Alternative 3, and 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. These effects would occur earlier in the permit term but would be of shorter overall duration than under the proposed action or Alternative 3 (Table 3.1-1). 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 Crescent Lake Reservoir and Crescent Creek, and Little Deschutes River, where effects would be the same as described for Alternative 3 and the Upper Deschutes River, Wickiup Reservoir, and the Crooked River as described below. 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. These effects would occur earlier in the permit term but would be of shorter overall duration than under the proposed action or Alternative 3 (Table 3.1-1). 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 the Little Deschutes River and floater species mussels and western pearlshell mussels in the Crooked River. There would be no effect in the Little Deschutes River. There would be no adverse effect in the Crooked River 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. Effects in Wickiup Reservoir, the Upper and Middle Deschutes River, and the Crooked River would occur earlier in the permit term but would be of shorter overall duration than under the proposed action or Alternative 3 (Table 3.1-1). 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.

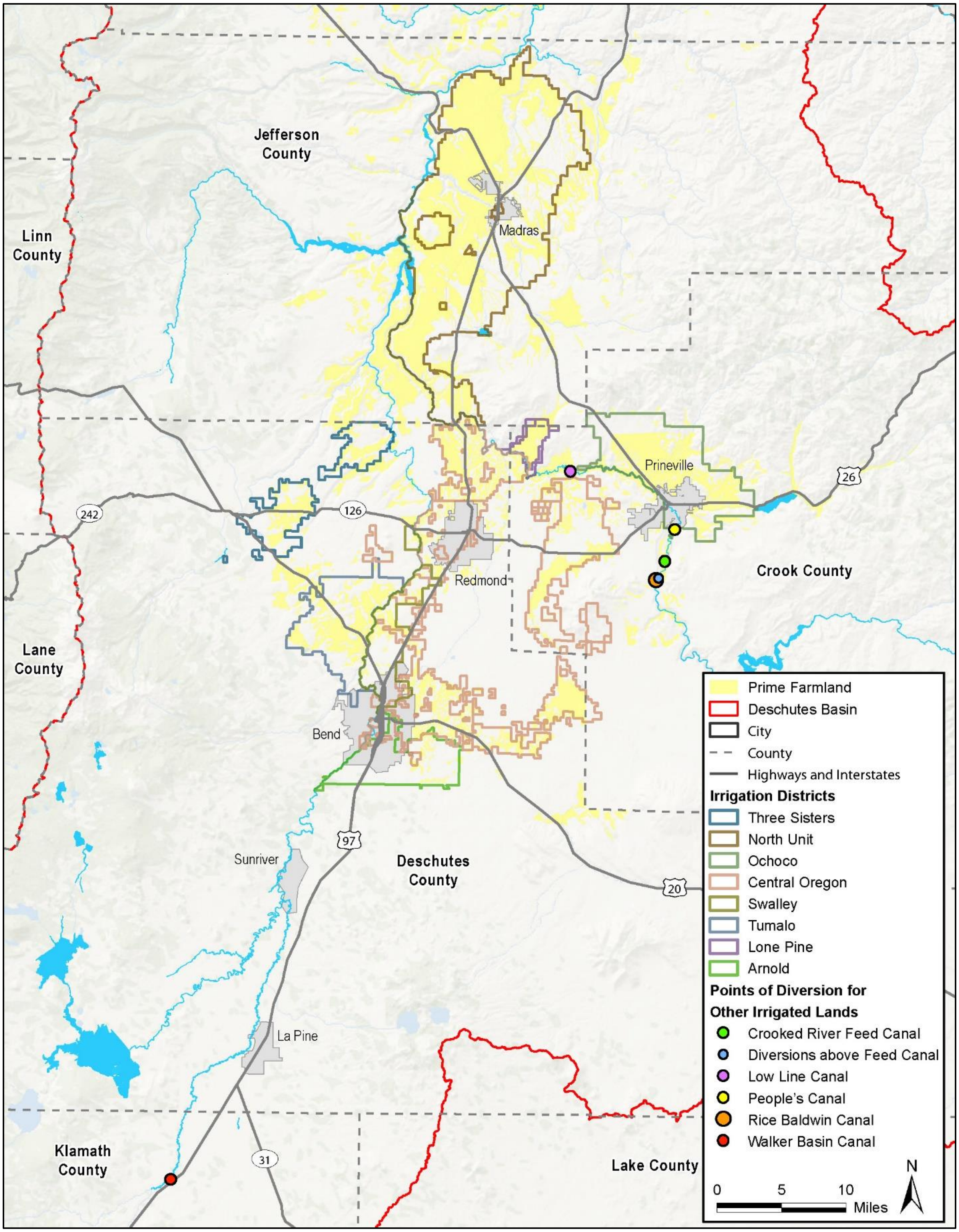
As highlighted in Section 3.2, *Water Resources*, there is significant annual variability in hydrology in both the Upper Deschutes River and Crooked River Basins. Dry water years result in much lower flows—and therefore reduced water supplies available for diversion—compared to wet water years. To assess effects of the proposed action and alternatives on irrigation water supplies, this analysis focuses on three water year types: wet (80th percentile of water available for diversions), median[1] (50th percentile of water available for diversions), and dry water years (20th percentile of water available for diversions).[2] The intent for analyzing effects using these three water year types is to

---

[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.

[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.

Figure 3.5-1. Agricultural Lands in the Study Area



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.
- 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.

3.5.2 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.

[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.

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 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 Ochoco Creek McKay Creek 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 Deschutes River Crescent Creek

Sources: Deschutes Basin Board of Control 2019

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			
County	Total Irrigated Land (acres)	Harvested Cropland (acres)	Pastureland and Other Land (acres)	% of Total Irrigated Land that is Harvested Cropland
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).

Harvested cropland acreage fluctuates through time; however, based on U.S. Census of Agriculture data for 1997 to 2017 (U.S. Department of Agriculture, National Agricultural Statistics Service 2019c), harvested cropland acreage has generally declined across the study area by approximately 12%, with smaller declines in Deschutes (8%) and Jefferson (9%) Counties and a larger decline in Crook County (18%). Harvested cropland acreage is related to water availability, but also to changes in land use in the region in response to population change.

When harvested cropland is considered in the context of total number of farms and proportion of smaller farms (fewer than 100 acres) consolidation and fragmentation of farms in the study area can be better understood. In Crook County, the number of farms has remained fairly stable, but the share of smaller farms has grown from 53 to 64% between 1997 and 2017. In Deschutes County, the number of farms has also remained relatively stable over the same period and the high proportion of smaller farms has also remained fairly constant. In Jefferson County, the number of farm operations overall is falling, but there is no clear trend in the number of smaller farms; this indicates that larger farms are likely consolidating into fewer operations in Jefferson County.

While farm economics and lifestyle preferences affect the consolidation and fragmentation of farmland into larger or smaller farms, population growth is the factor that most affects land use conversion. As highlighted in Section 3.9 (Table 3.9-1), the study area's population grew by 17% from 2010 to 2018; with Bend, Redmond, and Sisters all growing at an even faster rate. However, Oregon's unique statewide planning statutes strictly limit agricultural conversions. In accordance with Oregon's land use planning law, the conversion of farmland is strictly limited outside of urban growth boundaries (UGBs). Under Oregon law, cities in the study area establish UGBs for lands that are anticipated to urbanize in the future as part of their mandated comprehensive plans; the cities also review and expand these UGBs to accommodate growth (Oregon Department of Land Conservation and Development 2020). Outside of the UGBs, Oregon's Statewide Planning Goal 3 (OAR 660-015-0000(3)) otherwise protects farmland by prohibiting urban development and allowing non-farm land uses only under limited circumstances where such uses are "minimized to allow for maximum agricultural productivity" (Oregon Department of Land Conservation and Development 2020). Oregon's planning law is overseen by the state's Land Conservation and Development Commission, which reviews all city and county comprehensive plans for consistency with the statewide planning program.

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 in dry water years (due both to historical hydrology and changes in water management associated with the Biological Opinion) include North Unit ID and Three Sisters ID in particular, with existing dry year

[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.

water shortages also experienced in, Lone Pine ID, Ochoco ID, and Central Oregon ID (Table 2 in Appendix 3.5-A). The Central Oregon ID 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 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).

[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 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.

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

Continuation of existing water management operations under the no-action alternative, described in Chapter 2, *Proposed Action and Alternatives*, would result in no change to the amount of water available for diversion under the no-action alternative compared to existing conditions. However, in many districts, district-wide and on-farm water conservation achieved through the piping of canals and increased irrigation efficiency anticipated to occur over the 30-year analysis period would increase the water available to crops under the no-action alternative compared to existing conditions for dry years.[7] Recognizing that conservation is most likely to occur in response to shortages, water supply to crops in median and dry water years under the no-action alternative, proposed action, and action alternatives is capped at the no-action median water year supply. As such, future median year crop acreage does not increase relative to existing median year crop acreage under the no-action alternative (or any other alternative). Therefore, the average acreage irrigated by each irrigation district is expected to be very similar to existing acreage (Table 3.5-4, and Table 1 in Appendix 3.5-A) in median years but to increase over time in dry years compared to existing conditions. In particular, water use efficiency is expected to benefit (i.e., provide water savings) North Unit ID, with benefits also to Arnold ID, Lone Pine ID, Ochoco ID, and Three Sisters ID.[8] Table 3.5-5 shows the potential increase in the proportion of existing acreage that would receive full irrigation under the no-action alternative compared to existing conditions in dry water years over the analysis period. 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, for the no-action alternative. The section titled *Agricultural Water Use Efficiency* in Appendix 3.5-A provides additional information on water use efficiencies related to the piping of irrigation district canals and on-farm irrigation and conveyance of water.

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. Table 3.5-5 captures the benefit associated with conservation through time; apart from conservation, the no-action alternative is assumed to be the same as the existing conditions.

[7] Recognizing that conservation is most likely to occur in response to shortages, water supply to crops in median and dry water years under the no-action alternative, proposed action, and action alternatives is capped at the no-action median water year supply. As such, future average crop acreage does not increase relative to existing average crop acreage under the no-action alternative (or any other alternative).

[8] 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.

Table 3.5-5. Potential Increase in Acres Equivalent Irrigated under the No-Action Alternative Compared to Existing Conditions, Dry Water Year (Acres Equivalent)

Year	Arnold ID	Lone Pine ID	North Unit ID	Ochoco ID	Three Sisters ID	All Other Districts and Irrigated Lands	Total All Irrigated Lands
Existing Conditions	3,900	2,300	45,600	18,600	6,600	55,700	132,800
2020	100	100	800–1,900	0–100	0–600	0	1,300–3,100
2025	100	100	2,300–6,800	0–100	0–600	0	4,300–6,900
2030	100	100	3,900–11,400	0–100	0–600	0	6,700–6,900
2040	100	100	6,400–14,300	0–100	0–600	0	6,700–6,900
2049	100	100	8,700–16,000	0–100	0–600	0	6,700–6,900
% Change	3%	4%	3–14%	0–1%	0–9%	0%	1–5%

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, and earlier and lower summer runoff. For irrigators, these changes may result in more reliance on stored water, and may also result in lower total water supply in the future as stored water supplies and runoff may be exhausted earlier in the season.

As highlighted in Section 3.9 (Table 3.9-1), the study area's population is projected to grow 68% by 2050; with Bend, Redmond, Sisters, and Prineville all projected to grow at an even faster rate. This population growth may result in conversion of farmland to urban uses, if the farmland is within the UGB,[9] or potential fragmentation of larger farms into smaller, lifestyle farms.

Effect Conclusion: Under the no-action alternative, the water available to crops in dry water years is anticipated to decrease over time due to climate change, but increase over time compared to existing conditions because of on-farm and district water conservation achieved through the piping of canals and increased irrigation efficiency. The aggregate effect of conservation and climate change may result in possible beneficial or adverse effects on total irrigated acreage, depending on the overall effect on the total amount of water available for irrigation compared to existing conditions. Population growth in the region may have an adverse effect on agricultural lands through increased urbanization and associated conversion of agricultural land to urban uses within established UGBs. Additionally, population growth in the region may result in increased fragmentation of agricultural land into smaller lifestyle or hobby farms. Therefore, effects on agricultural land use under the no-action alternative in terms of total irrigated lands and total land in agricultural use may be beneficial or adverse, depending primarily on future water availability and population growth patterns.

[9] If it is within the UGB now, or if it is in the UGB in the future due to an extension of the UGB in response to population growth in accordance with state law.

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. 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 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 presented 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).

Table 3.5-6. Estimated Maximum Affected Acres Equivalent Irrigated under the Proposed Action Compared to the No-Action Alternative, Median and Dry Water Years (Acres Equivalent)

	Lone Pine ID		North Unit ID		All Other Districts/Other Irrigated Lands		Total All Irrigated Lands	
Year	Median	Dry	Median	Dry	Median	Dry	Median	Dry
2020	0	-100 to -300	0	3,700 to 5,500	0	0	0	3,600 to 5,200
2025	0	0	0	2,400 to 0	0	0	0	0 to 2,400
2030	0	0	0	-11,600 to 0	0	0	0	0 to -11,600
2040	0	0	0	-4,100 to 0	0	0	0	0 to -4,100
2049	0	0	0	-800 to 0	0	0	0	0 to -800
% Change	0%	0 to -13%	0%	12 to -22%	0%	0%	0%	4% to -8%

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 24 in Appendix 3.5-A provides additional dry year detail.

Under the proposed action, across all irrigated lands over the 30-year permit term in a median water year, there would be no change in the acres equivalent that could be fully irrigated throughout the season under either conservation scenario. During a dry water year, affected acres equivalent fully irrigated all season could range from an increase of 5,200 acres (high conservation scenario) to a decrease of 11,600 acres (low conservation scenario). As shown in Table 3.5-6, Lone Pine ID and North Unit ID are the only districts projected to be affected by water shortage during dry years under the proposed action. Impacts in Lone Pine ID are projected to be limited to a reduction of 100 to 300 acres equivalent during dry years in the first few years of the permit term. North Unit ID, under the high conservation scenario, would have an increase of up to 3,700 acres equivalent irrigated during at least one subseason in the initial years of the permit term; under the low conservation scenario, irrigated acres equivalent would increase in the first 10 years of the permit term then decrease by up to 11,600 acres (22%) after year 10 (Table 24 of Appendix 3.5-A). Decreases in irrigated acres equivalent would result in fallowing or deficit irrigation. However, increased fallowing or deficit irrigation of agricultural lands under the proposed action is not expected to result in these lands being converted to non-agricultural uses because of the restrictions on conversion mandated by Oregon land use planning law. The proposed action would not affect the application of current statewide and county land use laws and zoning for agricultural lands, which protect agriculturally zoned lands as described in Section 3.5.2.2, *Agricultural Resources*. Therefore, the proposed action is not expected to result in conversion of 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 dry years in Lone Pine ID and North Unit ID. These changes in the acreage of land irrigated are not expected to result in a conversion of agricultural lands to other land uses because of protection of agricultural lands under existing land use laws and zoning. Therefore, effects on agricultural land use under the proposed action would be not adverse. Section 3.9 addresses how increased fallowing or deficit irrigation of irrigated lands could affect the local economy.

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.

Table 3.5-7 summarizes the estimated maximum change in acres equivalent under Alternative 3 compared to the no-action alternative for median and dry water years. In a median water year, fallowing/deficit irrigation effects across all irrigated lands over the permit term would be limited to 600 acres in North Unit ID under the low conservation scenario for a few years in the middle of the permit term (around year 2030). During a dry water year, the affected acres equivalent across all districts would range from a reduction of 0 to 9,900 acres under the high conservation scenario to a reduction of 7,400 to 16,500 acres under the low conservation scenario.

Most dry year acreage effects are in North Unit ID. Under the high conservation scenario, North Unit ID is projected to experience a reduction of up to 20% in irrigated acres equivalent in dry years during the first 10 to 20 years of the permit term (compared to 8% under the proposed action). Under the low conservation scenario, North Unit ID may experience a reduction in irrigated acres equivalent in dry years across the permit period of up to 31% (compared to 22% under the proposed action). (See Tables 28 and 29 of Appendix 3.5-A).

Lone Pine ID and Arnold ID would also experience effects in a dry year: a reduction of 100 to 400 acres equivalent in Lone Pine ID and 300 to 500 acres equivalent in Arnold ID. In Lone Pine ID, effects would be limited the first few years of the permit term under both high and low conservation scenarios, but affect acres equivalent would be slightly greater (up to 21%) than under the proposed action (13%). In Arnold ID, effects (a 3 to 10% reduction in irrigated acres equivalent) would be limited to the low conservation scenario but are would occur throughout the permit term. Increased fallowing or deficit irrigation of agricultural lands under Alternative 3 is not expected to result in these lands being converted to non-agricultural uses, as described for the proposed action.

Table 3.5-7. Estimated Maximum Affected Acres Equivalent Irrigated under Alternative 3 Compared to the No-Action Alternative, Median and Dry Water Years (Acres)

	Arnold ID		Lone Pine ID		North Unit ID		All Other Districts / Other Irrigated Lands		Total All Irrigated Lands	
Year	**Median**	**Dry**	**Median**	**Dry**	**Median**	**Dry**	**Median**	**Dry**	**Median**	**Dry**
2020	0	0 to -100	0	-300 to -500	0	-9,600	0	0	0	-9,900 to -10,200
2025	0	0 to -400	0	0	0	-8,700 to -13,900	0	0	0	-8,700 to -14,300
2030	0	0 to -100	0	0	0 to -600	-4,400 to -16,400	0	0	0 to -600	-4,400 to -16,500
2040	0	0 to -100	0	0	0	0 to -10,600	0	0	0	0 to -10,700
2049	0	0 to -100	0	0	0	0 to -7,300	0	0	0	0 to -7,400
% Change	0%	0 to -10%	0%	0 to -21%	0 to -1%	0% to -31%	0%	0%	0%	0% 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.

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 North Unit ID, Arnold ID, and Lone Pine ID. Increased fallowing or deficit irrigation would be similar to but greater than that described for the proposed action. These changes in the acreage of land irrigated are not expected to result in a conversion of agricultural lands to other land uses because of protection of agricultural lands under existing land use laws and zoning. Therefore, effects on agricultural land use under Alternative 3 would be not adverse. Section 3.9 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.

Table 3.5-8 summarizes the estimated maximum change in acres equivalent under Alternative 4 compared to the no-action alternative for median and dry water years. Under Alternative 4, the affected acres equivalent across all irrigated lands over the 20-year permit term would range from 0 to 5,800 acres in a median year to 600 to 18,500 acres in a dry year.

Most effects are experienced in North Unit ID, with some dry year effects in Lone Pine ID and Arnold ID. Effects vary over time and in some cases are 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 scenario) assumptions.

In median water years, impacts are limited to North Unit ID with a small (1%) acreage equivalent reduction under the high conservation scenario in the initial years of the permit term and an 11% reduction under the low conservation scenario until near the end of the permit term. (Table 31 of Appendix 3.5-A). In dry water years, North Unit ID would experience a reduction of up 29% acreage equivalent under the high conservation scenario (compared to up to 8% under the proposed action and 20% under Alternative 3) and a reduction of up to 36% under a low conservation scenario (compared to up to 22% under the proposed action and 31% under Alternative 3) throughout the permit term.

Arnold ID effects would be limited to the dry water year, with a reduction in irrigated acres equivalent of up to 13% in a dry water year under the low conservation scenario (compared to no effects under the proposed action and up to a 10% reduction under Alternative 3) and a reduction of 8% in the initial years of the permit term in a dry water under the high conservation scenario (compared to no effects under the proposed action and Alternative 3).

As under the proposed action and Alternative 3, Lone Pine ID effects would be limited to the dry water year during the initial few years of the permit term (Tables 31 and 32 of Appendix 3.5-A) with a reduction in acres equivalent of 17% under the high conservation scenario (compared to 4% under the proposed action and up to 13% under Alternative 3) and a reduction of 21% under the low conservation scenario (compared to 13% under the proposed action and the same under Alternative 3).

Table 3.5-8. Estimated Maximum Affected Acres Equivalent Irrigated under Alternative 4 Compared to the No-Action Alternative, Median and Dry Water Years (Acres)

	Arnold ID		Lone Pine ID		North Unit ID		All Other Districts / Other Irrigated Lands		Total All Irrigated Lands	
Year	Median	Dry	Median	Dry	Median	Dry	Median	Dry	Median	Dry
2020	0	-300 to -500	0	-400 to -500	-400 to -2,200	-13,900	0	0	-400 to -2,200	-14,600 to -14,900
2025	0	0 to -500	0	0	0 to -5,800	-12,800 to -18,000	0	0	0 to -5,800	-12,800 to -18,500
2030	0	0 to -400	0	0	0 to -2,400	-5,000 to -16,900	0	0	0 to -2,400	-5,000 to -17,300
2039	0	0 to -400	0	0	0	-600 to -11,800	0	0	0	-600 to -12,200
% Change	0%	0 to -13%	0%	0 to -21%	0 to -11%	-1 to -36%	0%	0%	0 to -4%	0 to -13%

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.

Increased fallowing or deficit irrigation of agricultural lands under Alternative 3 is not expected to result in these lands being converted to non-agricultural uses, as described for the proposed action.

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 North Unit ID, Arnold ID, and Lone Pine ID. Increased fallowing or deficit irrigation would be similar to but greater than that described under the proposed action and Alternative 3. These changes in acreage of land irrigated are not expected to result in a conversion of agricultural lands to other land uses because of protection of agricultural lands under existing land use laws and zoning. Therefore, effects on agricultural land use under Alternative 4 would be not adverse. Section 3.9 addresses how increased fallowing or deficit irrigation of irrigated lands could affect the local economy.

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 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).

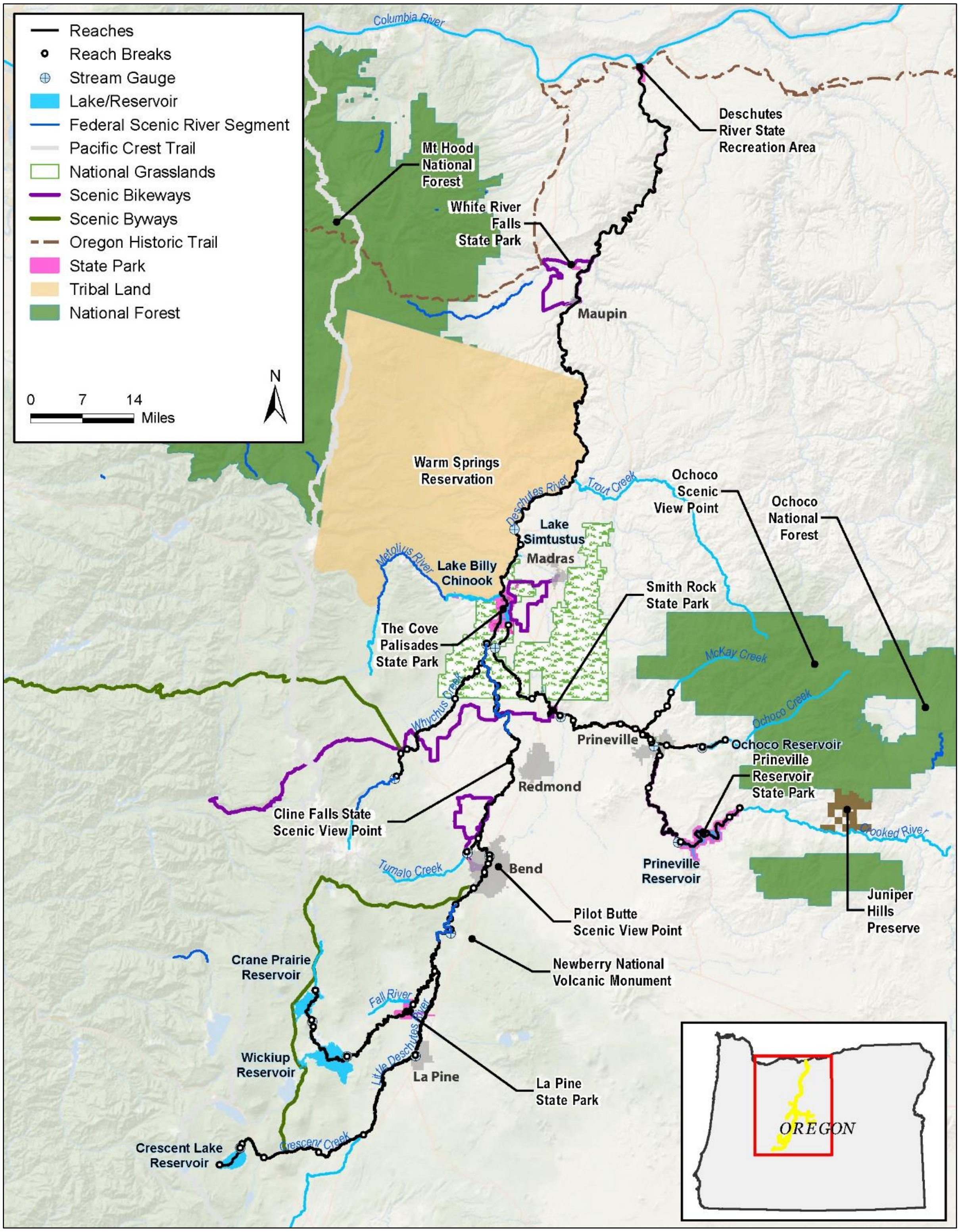
Federal and state scenic byways include the Cascade Lakes, McKenzie Pass-Santiam Pass, and Oregon Outback National Scenic Byways. Designated state bikeways in the study area are Sherars Falls, Madras Mountain Views, Sisters to Smith Rock, McKenzie Pass, Twin Bridges, and Crooked River Canyon. Federal 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.

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.

Figure 3.6-1. Major Visual Resources in the Deschutes Basin



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 existing 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 (Impacts WR-2 and WR-4), are the primary mechanism for altering the visual character and quality of lands and waters in the direct effects study area. 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 (Impact BIO-1), 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, including along reaches of federal and state scenic river segments. These changes would also be evident at Crescent Lake Reservoir and on the lower three reaches of the Crescent Creek–Little Deschutes River system where the changes would benefit the extent and stability of wetland and riparian vegetation. 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 (Impact WR-4), would not be sufficient in magnitude to affect visual access in the following areas: the Lower Deschutes River downstream of Lake Billy Chinook, the Crooked River, Whychus Creek, McKay Creek, Ochoco Creek, and the Crescent Creek–Little Deschutes River system. 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. As further described in Section 3.7 (Impact REC-1), whitewater rafting often occurs in reaches where changes in flow would be minimal, including the popular lower reaches of the Deschutes River downstream of Lake Billy Chinook. These changes in flow would not significantly reduce whitewater opportunities or enjoyment of experiences. However, there would be a noticeable change in visual access to the Deschutes River and reservoirs upstream of Bend, where lower water surface elevations in the summer would prevent access to fast-flowing waters for rafting and reduce the number of days many popular whitewater runs in the Upper Deschutes are optimal or even suitable for whitewater sports. Lower flows would expose rocks and make boating more difficult and hazardous in some reaches of the Deschutes River, upstream of Bend, such as the popular Meadowcamp and Big Eddy runs. However, most areas would still be conducive for paddling and floating on the river and swimming in the river so that recreational uses—and visual access, including access to designated scenic river segments—on this stretch of river would be maintained. In addition, as described in Section 3.7, more stable river levels provided under the proposed action would result in an increase in natural shoreline vegetation and an increase in aesthetic values, which would in turn generate a greater interest to visit these areas. Therefore, visual access, including access to designated scenic river segments, would increase from recreational viewers seeking out these improved areas for recreational experiences such as hiking, backpacking, camping, fishing, wildlife watching, and picnicking.

Wild and Scenic River Recommended Flows

As identified in Section 3.6.2.1, *Affected Environment*, *Visual Character*, and shown in Figure 3.6-1, segments of the Deschutes and Metolius Rivers and Whychus Creek are designated Federal Wild and Scenic Rivers classified as scenic and portions of the Metolius River and Upper and Lower Deschutes Rivers are Oregon State Scenic Waterways. Changes in seasonal river and creek flows under the proposed action have the potential to affect visual access to scenic rivers and vegetation that contributes to the scenic quality of rivers. These effects are described under *Changes to Visual Access* and *Large-Scale Changes to Vegetation Patterns.* The Oregon Water Resources Department has established recommended flow requirements for new water rights to prevent the impairment of recreation, fish, and wildlife uses in scenic waterways (Oregon Water Resources Department 1991). Because the proposed action falls under existing water rights, it would not conflict with the recommended flows for new water rights.

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, Crescent Lake Reservoir, and the lower three reaches of the Crescent Creek–Little Deschutes River system 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. In addition, changes in flows would reduce the number of days that many popular whitewater runs in the Upper Deschutes could be used, but changes would not greatly affect popular lower reaches of the Deschutes River that are downstream of Lake Billy Chinook. Most areas along the Upper Deschutes would still be accessible for paddling, floating, and swimming. Improvements to natural shoreline vegetation produced by more stable flows would also improve aesthetic quality and generate a greater interest to visit these areas, increasing visual access. 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 dry water years only 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. The dry year effects under the proposed action would be limited to Lone Pine ID and North Unit ID: up to an approximate 13% increase in affected acreage in Lone Pine ID and up to an approximate 22% increase in North Unit ID compared to the no-action alternative.[1] As described in Section 3.5, the proposed action is not expected to result in the conversion of agricultural lands to other land use types.

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 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, *Socioeconomics and Environmental Justice*) 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 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.

[1] All estimates of affected agricultural acreage are based on the low water conservation scenario described in Section 3.5.

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 or nearly the same as described for the proposed action, except that both beneficial and adverse effects related to changes in hydrology under Alternative 3 would occur earlier in the permit term than under the proposed action (Table 3.1-1), so they would be of greater duration.

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 similar to those described for the proposed action. Reduced irrigation of agricultural lands would affect a greater acreage under Alternative 3 than the proposed action. In a dry year, affected acreage under Alternative 3 would increase up to 21% in Lone Pine ID (compared to 13% under the proposed action), 31% in North Unit ID (compared to 22% under the proposed action), and 31% in Arnold ID (compared to no effect). There would also be a small increase in affected acreage in North Unit ID in normal water years near the middle of the permit term. In addition, these changes would occur earlier in the permit term (Table 3.1-1) and would have an overall longer duration under Alternative 3 than the proposed action. However, as described for the proposed action, the reduced irrigation would not result in notable changes in the visual character and quality of irrigated lands and would, therefore, 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 Alternative 3, but the changes would occur several years earlier but over a shorter permit term (Table 3.1-1).

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 the visual character and quality of irrigated lands under Alternative 4 compared to the no-action alternative would be similar to those described for the proposed action and Alternative 3. Reduced irrigation of agricultural lands would affect slightly greater acreage under Alternative 4 than the proposed action or Alternative 3 in Lone Pine ID and North Unit ID in dry years. Affected acreage in North Unit ID in normal water years identified for Alternative 3 would also increase under Alternative 4. In addition, these changes would occur earlier but over a shorter permit term than the proposed action or Alternative 3 (Table 3.1-1). As described for the proposed action, the reduced irrigation would not result in notable changes in visual character and the quality of irrigated lands and would, therefore, 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. In addition, lower levels can affect boating safety by exposing stumps and rocks, restrict access (particularly for boat launches), and increase recreational crowding (Bureau of Reclamation 2000). 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 or eliminate 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 River 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 the most popular runs located in the Lower Deschutes River (Oregon State Parks 2018a). However, several runs in the Upper Deschutes River are also popular due to their closeness to Bend, including the Meadowcamp run (3 miles) located within the city of Bend. The Crooked River is also a well-known for whitewater sports (rafting, kayaking, canoeing) 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 River 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 River from the northern boundary of Sunriver to Lava Island Camp, classified as Scenic River Area (administered by USFS).
- 3 miles of the Upper Deschutes River from Lava Island Camp to the Bend Urban Growth boundary, classified as Recreational River Area (administered by USFS).
- 20 miles of the Middle Deschutes River, 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 River 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 River include cultural, fish, geologic, historic, recreational, scenic, wildlife, and botanical. ORVs of the Middle Deschutes River include cultural, fish, geologic, recreational, scenic, wildlife, hydrologic, botanical, ecological, and wilderness. ORVs of the Lower Deschutes River 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/Lower Crooked Wild and Scenic Rivers' 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

Continuation of existing water management operations under the no-action alternative 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

This section describes effects on recreation under the proposed action compared to the no-action alternative.

REC-1: Change Recreational Opportunities or Quality of Experiences in and Along Rivers, Creeks, and Reservoirs

Reservoir Levels

As detailed in Section 3.2 (Impact WR-3), changes in reservoir levels under the proposed action are projected to be most pronounced at Wickiup Reservoir. Median water surface elevations would become more variable as less water is stored year-round compared to the no-action alternative. Variability in Wickiup Reservoir levels would begin in year 1. Beginning in year 8, variability would more than double in all months from December to June, with smaller increases in other months. Variability in surface elevations may include exceptionally high or exceptionally low water at Wickiup Reservoir.

Increased low water events projected to occur under the proposed action 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. 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, recreationally important fish—including kokanee, coho salmon, redband trout, brook trout, brown trout, and mountain whitefish—would be adversely affected by the increased frequency, severity, and duration of low water events. Reduced fish populations and shoreline access would combine to create an adverse effect on recreational fishing, camping, and boating at Wickiup Reservoir. 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 (Impact WR-3), the relatively minor changes in reservoir levels at Crane Prairie, Crescent Lake, Prineville, Ochoco, and Lake Billy Chinook Reservoirs projected to occur under the proposed action are not expected to reduce recreational opportunities or experiences.

Seasonal River and Creek Flows

Changes in flows, as described in Section 3.2 (Impact WR-4), would not be sufficient in magnitude to adversely affect recreational opportunities and experiences in the following areas: the Lower Deschutes River (downstream of Lake Billy Chinook), the Crescent Creek–Little Deschutes River system, the Crooked River, and 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 irrigation seasonal flows (which correspond to the highest recreational demand and use) is projected to decrease 15% in a normal year and 23% in a dry year (Table 13 in Appendix 3.2-A, *Water Resources Technical Supplement*) compared to the no-action alternative. This would reduce the number of days many popular whitewater runs in the Upper Deschutes River that are optimal or even suitable for whitewater sports. In some reaches, including the popular Meadowcamp and Big Eddy runs, lower flows would expose rocks and make boating more difficult and potentially hazardous. In addition, in years 13 through 30, irrigation period maximum flows are capped at 1,200 cfs. This would eliminate the summer high flows that have become popular for whitewater sports in the Upper Deschutes River, including the Meadowcamp and Big Eddy sections.

Whitewater sports in the popular lower reaches of the Deschutes River downstream of Lake Billy Chinook would not be adversely affected, as changes in flow would not be sufficient to significantly reduce whitewater opportunities or enjoyment of experiences (see Section 3.2, Impact WR-4).

Overall, reduced flows during the irrigation season in the Upper Deschutes River would result in an adverse impact on popular whitewater sections in this area. However, the proposed action would also create more stable and predictable 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, including hiking, backpacking, camping, fishing, wildlife watching, and picnicking.

As described in Section 3.4 (Impact BIO-12), changes in the timing and extent of flows and water temperatures could adversely affect redband trout and other recreationally important fish in the Crooked River, particularly from years 13 through 30 of the permit term. Effects would be not adverse in the 8 miles of the Crooked River downstream of Osborne Canyon and habitat would be improved in other areas (Impact BIO-12). Overall, the proposed action would have a beneficial effect on redband trout habitat compared to the no-action alternative because of the extent of area where beneficial effects would occur.

Effect Conclusion: The proposed action would result in adverse effects on whitewater sports in the Upper Deschutes River due to reduced flows and associated whitewater opportunities. The proposed action would also result in more natural and consistent flows and improved shoreline vegetation, fish and wildlife habitat, and aesthetics. In the Upper Deschutes River Basin, recreational opportunities and experiences other than whitewater rafting 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 and with more severity; this would result in adverse effects related to additional days of poor or eliminated access to boat ramps and shoreline campgrounds and reduced aesthetic values and shore-based and water-based opportunities and experiences, including fishing, boating, camping, and hiking. Some adverse effects would occur on the recreationally popular redband trout in Wickiup Reservoir and in portions of the Crooked River. Overall, effects on recreation in rivers and streams would be not adverse because of the general improvement of most recreation opportunities and experiences in the study area.

REC-2: Conflict with Existing and Future Wild and Scenic River and State Scenic Waterway Designations

The proposed action would reduce recreational values specific to whitewater sports in the Upper Deschutes River. This would adversely affect the whitewater component of recreational values in this area, as specified and protected by the Wild and Scenic River and State Scenic Waterway designations. However, more natural flow regimes in the Upper Deschutes River are expected to result in improved conditions for native vegetation, fish and wildlife habitat, and shoreline/bank conditions over time. These ecologically beneficial effects, in turn, would increase scenic values and associated recreational opportunities and enjoyment of experiences, including fishing, hiking, and wildlife viewing. Effects on flow regimes on other designated Wild and Scenic Rivers and the lower reaches of the Deschutes State Scenic Waterway are not expected to be sufficient to alter ORVs. Based on conclusions presented in other resource sections of this EIS, the proposed action would have a net benefit to 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 or State Scenic Waterways because more natural and consistent flows and enhanced ecological function would be provided.

Effect Conclusion: While returning the Upper Deschutes River to more natural flow regimes under the proposed action would reduce whitewater opportunities, it would improve vegetation, shorelines, and other recreational opportunities. Therefore, the overall effect of the proposed action on designated Wild and Scenic River and State Scenic Waterways reaches would be not adverse compared to the no-action alternative.

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 similar to those described for the proposed action, with reduced summer flows, more natural and stable overall flow levels and associated improvement in shoreline vegetation, fish and wildlife habitat, and aesthetics. The primary difference between Alternative 3 and proposed action effects is whitewater rafting in the Upper Deschutes River between Wickiup Dam through Bend. Although irrigation season flows and associated whitewater rafting opportunities would still be reduced in this reach of the river, under Alternative 3, without the summer flow cap included under proposed action Conservation Measure WR-1, some occasional high summer flows and associated whitewater recreational uses would be available. Eliminating the flow cap would also reduce beneficial effects on shoreline vegetation, although improvements would still occur due to overall less extreme flow levels. In addition, under Alternative 3, the duration of both beneficial and adverse effects related to reduced flows would be greater than under the proposed action because they would begin earlier in the permit term (Table 3.1-1). In summary, Alternative 3 would reduce opportunities for whitewater recreation in the Upper Deschutes River, although to a lower extent than under the proposed action due to no summer flow maximum. Overall, effects on recreation under Alternative 3 compared to the no-action alternative 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 similar to those described for the proposed action, with the exception that adverse effects on whitewater rafting in the Upper Deschutes River would be lower without the cap on irrigation season flows. As with the proposed action, Alternative 3 would result in more natural and consistent flows and enhanced ecological function on the Upper Deschutes River. Both beneficial and adverse effects would involve a longer duration because the effect would start earlier in the permit term (Table 3.1-1). Overall, effects on designated Wild and Scenic River reaches under Alternative 3 would be not adverse compared to the no-action alternative for the reasons described for the proposed action.

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

Effects on recreational opportunities and experiences related to reservoir levels and streamflows under Alternative 4 compared to the no-action alternative would be the same as described for Alternative 3, except that beneficial and adverse effects would start earlier and would have an overall shorter duration (Table 3.1-1). Overall, effects on recreation under Alternative 4 compared to the no-action alternative would be not adverse for the reasons described for the proposed action.

REC-2: Conflict with Existing and Future Wild and Scenic River Designations

Effects on the values and uses of Wild and Scenic Rivers associated with changes to streamflows under Alternative 4 compared to the no-action alternative would be the same as described for Alternative 3, except that beneficial and adverse effects would start earlier and have an overall shorter duration (Table 3.1-1). Overall, effects on designated Wild and Scenic River reaches under Alternative 3 would be not adverse compared to the no-action alternative for the reasons described for the proposed action.

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 analysis period was 30 years to correspond with the length of the permit term. The affected tribes, however, may frame decisions on water resources by weighing the effects for seven generations into the future. Although the analysis period was 30 years, resource impacts consider longer goals, e.g., reestablishing harvestable salmon and steelhead populations upstream of the Pelton-Round Butte Complex.

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*, water resources described in Section 3.2, *Water Resources*, and water quality described in Section 3.3, *Water Quality*.

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 currently and in the future 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 middle of 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).

The off-reservation Sherars Falls and Bridge fishing site on the Deschutes River at river mile (RM) 44 is of significant cultural, historic, and economic significance to the Warm Springs Tribes (Confederated Tribes of Warm Springs 2020). Tribal members fish with dip nets and set nets from wood scaffolding at the falls. In 1979, the Warm Springs Tribes purchased land adjoining the site, and title to the land was transferred to the United States Government in trust for the Warm Springs Tribes. A management scheme was developed by the Warm Springs Tribes to protect the interests of the tribes, preserve the natural beauty of the site, manage the area for the benefit of both Indians and non-Indians, and aid in the implementation of the Lower Deschutes River Wild and Scenic River Plan.

The 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 off-reservation waters bordering the reservation. The 1997 settlement did not specifically address the Warm Springs Tribes claim to any off-reservation water rights in the Deschutes Basin within the study area. These claims have not been adjudicated or otherwise quantified in the Deschutes Basin and, thus, no effects on these claims are analyzed. However, effects on the treaty resources that any such water right claims would seek to protect—fish, wildlife, and vegetation—are analyzed in Section 3.4, *Biological Resources*. Effects on treaty-reserved rights to harvest fish, hunt wildlife, and collect roots and berries are described in this section.

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 Modocs, 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 sockeye salmon, steelhead trout, and bull trout. Descriptions of the affected environment for these species are presented in Section 3.4.

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 returning to habitats upstream of the Pelton-Round Butte Complex.

3.8.2.5 Non-Covered Fish and Mollusk Species

Non-covered fish species include spring Chinook salmon, 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

3.8.2.6 Alternative 1: No Action

Fish, Fish Habitat, and Fishing Sites

Although 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 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 was completed and became operational in November 2019. Fish passage at this structure removed a barrier to resident and anadromous fish species to the Crooked River that has been in place since 1982. This is a significant step toward the reintroduction of steelhead trout and Chinook salmon into the Crooked River.
- 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 (Appendix 2-B).

However, projected effects of climate change, described in Section 3.2, could result in adverse effects on the distribution and quality of habitat available in the study area. 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 would 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 resources. It is likely the no-action alternative would not adversely affect spring Chinook salmon, fall Chinook salmon, and steelhead trout resources originating from the Lower Deschutes River study area because 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 to the Columbia River). The no-action alternative may adversely affect steelhead trout utilizing Trout Creek, depending on the extent of impacts on irrigation returns to tributaries of Trout Creek. 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 existing 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 (water years 1981–2018) that established the existing environmental conditions. These historical 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 by slightly and intermittently reducing the extremity of winter low flows that expose vegetation to subfreezing temperatures and drought stress that could contribute to vegetation dieback. 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. Improvements in vegetation providing wildlife habitat would be minor for the reasons discussed for vegetation. 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 existing 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.

3.8.2.7 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 currently 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 in the Crooked River, but would have adverse irrigation season effects in some reaches at full implementation (years 13–30) depending on annual water management practices. The adverse effects would be due to shifts in release of water from Prineville Reservoir affecting water temperatures in the Crooked River downstream of Bowman Dam.

The change in Wickiup Reservoir elevation and volume at full implementation and water quality effects would result in adverse effects on kokanee and trout habitat and populations in Wickiup Reservoir.

In the Upper Deschutes River downstream of Wickiup Reservoir to Bend, habitat conditions for redband trout would improve over the permit term.

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. 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 Upper and 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. Changes in Wickiup Reservoir elevation and volume and water quality 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 mixture of effects (mostly beneficial or no effect) includes a large portion of the study area, while adverse localized effects would be limited to Wickiup Reservoir and the Crooked 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 in the Crooked River. 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 63-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 13–30). These effects are described in more detail in Section 3.4 under Impacts BIO-6 through BIO-9.[1] The adverse temperature effects on habitat in some years would result in higher mortality of fish released into the Crooked River for reintroduction and progeny of 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 in the Crooked River.

The proposed action would have small beneficial effects on steelhead and spring Chinook habitat in the Middle Deschutes River, Whychus Creek, Ochoco Creek, and McKay Creek for the reasons described in Section 3.4 (Impacts BIO-6 through BIO-9).

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 on the Crooked River that could delay or prevent 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 into the Crooked River compared to the no-action alternative and beneficial effects elsewhere. Overall, the effects would be adverse considering the importance of the Crooked River to reintroduction over the permit term, despite small beneficial effects in the Middle Deschutes River, Whychus Creek, Ochoco Creek, and McKay Creek.

---

[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.

The effect conclusion for Impact TR-2 should not be directly compared to the effect conclusions for Impacts BIO-6 through BIO-9 in Section 3.4, *Biological Resources*. Impact TR-2 evaluates effects of the proposed action and action alternatives on habitat requirements for reintroduced fish species and effects on reintroduction. The adverse effects of water management in some reaches of the Crooked River in some years, as discussed in Impacts BIO-6 through BIO-9, are considered an adverse effect on Impact TR-2 because of the importance of the Crooked River watershed for reintroduction (Oregon Department of Fish and Wildlife and Confederated Tribes of the Warm Springs 2008). Impacts BIO-6 through BIO-9 evaluate effects on steelhead and spring Chinook salmon habitat and migratory life stages across the entire study area (i.e., Crooked River habitats upstream of Pelton-Round Butte and Lower Deschutes River habitats); therefore, adverse effects on habitat in some Crooked River reaches in some years along with a mixture of not adverse, no effect, and beneficial effects in other water bodies occupied by the species resulted in an overall conclusion of not adverse.

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; Whychus 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 (Impact BIO-1), 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 increased variability in reservoir elevation and volume, described in more detail in Section 3.4 (Impact BIO-1), would result in prolonged episodes of drying or inundation of riparian vegetation. This change would reduce the long-term quality and function of riparian vegetation around the reservoir, and wildlife use of riparian areas around 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. 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 because of the larger portion of the study area that would experience a mixture of beneficial effect or no effect compared to adverse effects limited to Wickiup Reservoir.

TR-4: Affect Warm Springs Tribes' 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. There is a low potential for water quality in Lake Billy Chinook, Lake Simtustus, and the Lower Deschutes River to be affected by changes in Deschutes River and Crooked River water quality associated with the proposed action as described in Section 3.3*y* (Impact WQ-1). Effects of the proposed action on water quality in the Deschutes River are expected to be minor because the Middle Deschutes River experiences considerable groundwater inputs that would reduce water quality effects in the Upper Deschutes River. Effects of the proposed action on water quality in the Crooked River would be minor and limited to certain water year types.

Effect Conclusion: The proposed action would have no effect on the Warm Springs Tribes' ability to exercise their reserved water right compared to no-action alternative.

3.8.2.8 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 in the Upper and Middle Deschutes River, Wickiup Reservoir, and Crooked River.

Beneficial effects in the Upper Deschutes River would be not as great without the summer cap on streamflow included in Conservation Measure WR-1 under the proposed action in years 13 through 30.

Streamflows during the irrigation season in the Crooked River would be higher than described for the proposed action during release of uncontracted fish and wildlife storage from Prineville Reservoir, because these flows would be protected from diversion under Alternative 3. Adverse effects in Wickiup Reservoir would be more severe under Alternative 3 than described for the proposed action because reservoir elevation and volume would be lower and would vary more under Alternative 3.

In addition, 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 because the mixture of effects (mostly beneficial or no effect) includes a large portion of the study area, while adverse localized effects would be limited to Wickiup Reservoir and the Crooked 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 described for the proposed action would be of slightly lesser magnitude due to instream protection of uncontracted fish and wildlife releases under this alternative. 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. Adverse effects in Wickiup Reservoir would be more severe under Alternative 3 than described for the proposed action because reservoir elevation, and volume would be lower and would vary more than it would under Alternative 3. 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 for the reasons described for the proposed action.

TR-4: Affect Warm Springs Tribes' Reservation Reserved Water Right

Alternative 3 would have no effect on Warm Springs Tribes' reservation reserved water right compared to the no-action alternative for the reasons described for the proposed action.

3.8.2.9 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, the Upper and Middle Deschutes River, and the Crooked River where both beneficial and adverse effects would be of greater magnitude. These effects would occur earlier in the permit term than under the proposed action or Alternative 3, but effects of full implementation would be of a shorter duration (Table 3.1-1).

Streamflows during the storage season in the Crooked River would be higher than described for the proposed action and Alternative 3. Crooked River storage season streamflows would be managed to exceed 80 cfs, with Ochoco ID responsible for 50 cfs. Streamflows during the irrigation season in the Crooked River would be the same as described for 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 for the reasons described for the proposed action.

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 3.4.3.4 (Impacts BIO-6 through BIO-9) for the reasons described for Alternative 4. Effects would occur earlier in the permit term under Alternative 4, but effects of full implementation would be of a shorter duration (Table 3.1-1). 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 and would occur earlier in the permit term, but would be of a shorter duration at full implementation (Table 3.1-1). Overall, effects of Alternative 4 on wildlife and plant species potentially harvested by tribal members would be not adverse compared to no-action alternative for the reasons described for the proposed action.

TR-4: Affect Warm Springs Tribes' 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.

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.

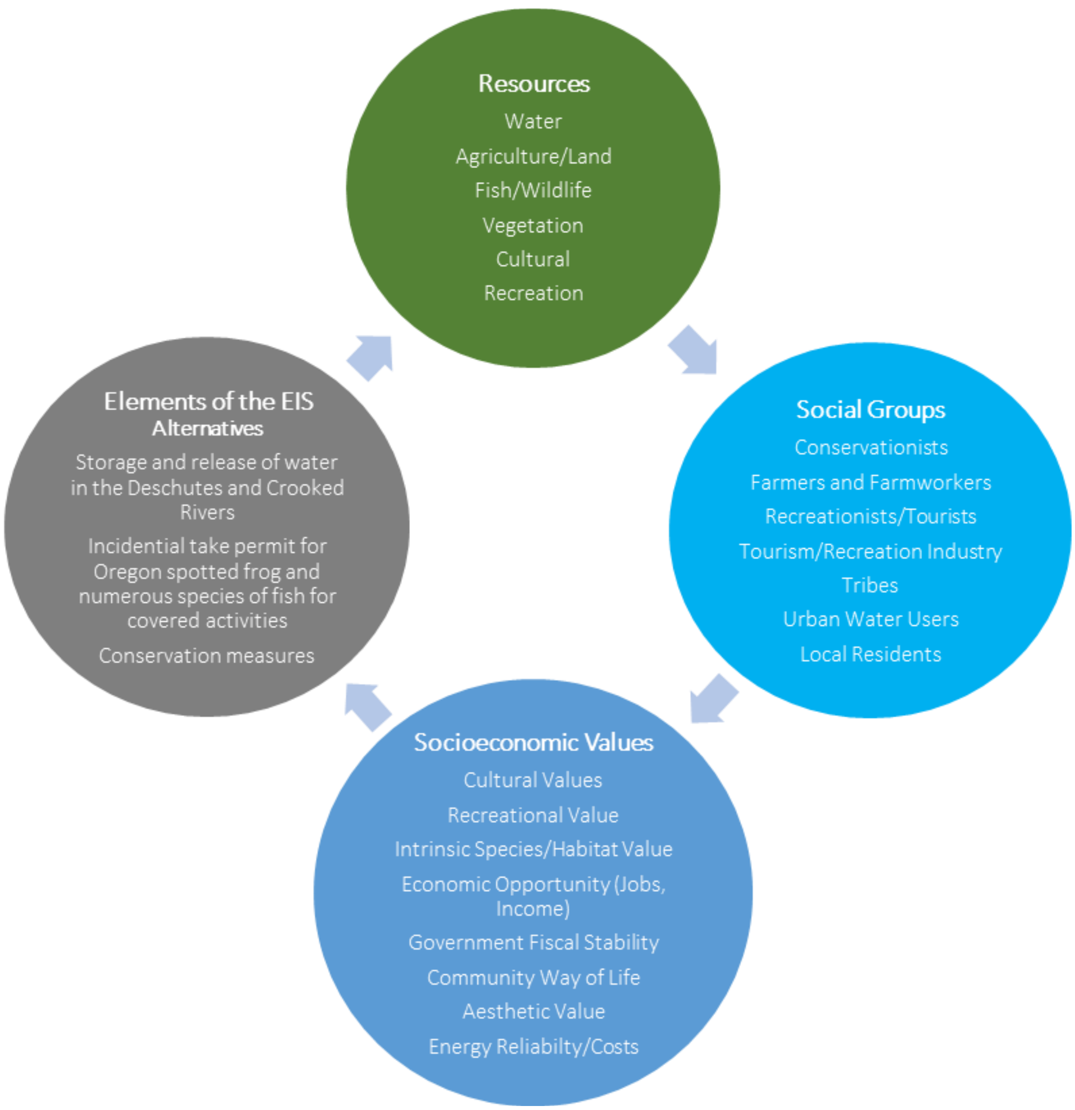
1. Identify changes to natural resource management and natural resource availability and quality that may affect socioeconomic values and environmental justice populations.
2. Identify potentially affected socioeconomic values.
3. Qualitatively and quantitatively describe the change in socioeconomic 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

[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,

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.

Figure 3.9.1. Socioeconomic Values and the Habitat Conservation Plan



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.

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.

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 County	20,978	22,710	32,277	8%	42%
Prineville	*9,253*	*10,010*	*18,377*	*8%*	*84%*
Deschutes County	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 County	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.

Socioeconomic Value (Social Groups)	Key Resources	Description
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 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 Hydroelectric Project and the Opal Springs Dam. The Pelton–Round Butte Hydroelectric 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 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; they are also a potentially affected environmental justice group. The tribes 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 all 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 all farmworkers in study area counties are migrant workers. In summary, farmworkers are both disproportionately low-income and minority, and are another potentially affected environmental justice group.

Table 3.9-4. Race/Ethnicity of Farm Operators by County in the Study Area

Race/Ethnicity of Farm Operators	Crook County	Deschutes County	Jefferson County	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. Selected Farmworker Socioeconomic Characteristics (Earnings, Days Hired, and Proportion Migrant) in the Study Area

Socioeconomic Characteristic	Crook County	Deschutes County	Jefferson County	Study Area
Average Annual Hired Farmworker Earnings/ Job	$11,166	$9,845	$13,563	$11,729
Percent of All Farmworkers, Hired for Less than 150 Days	62%	65%	48%	57%
Migrant Farmworkers as a % of All Study Area Farmworkers	13%	7%	3%	7%

Source: 2017 Census of Agriculture (National Agricultural Statistics Service 2019).

In sum, there are two potentially affected environmental justice populations of concern: tribal members and farmworkers.

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

[2] As discussed in the Section 3.2, *Water Resources*, municipal water supplies are not expected to be affected.

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.

Table 3.9-6. Agriculture, Recreation/Tourism, and Total Economic Activity in Study Area, 2017

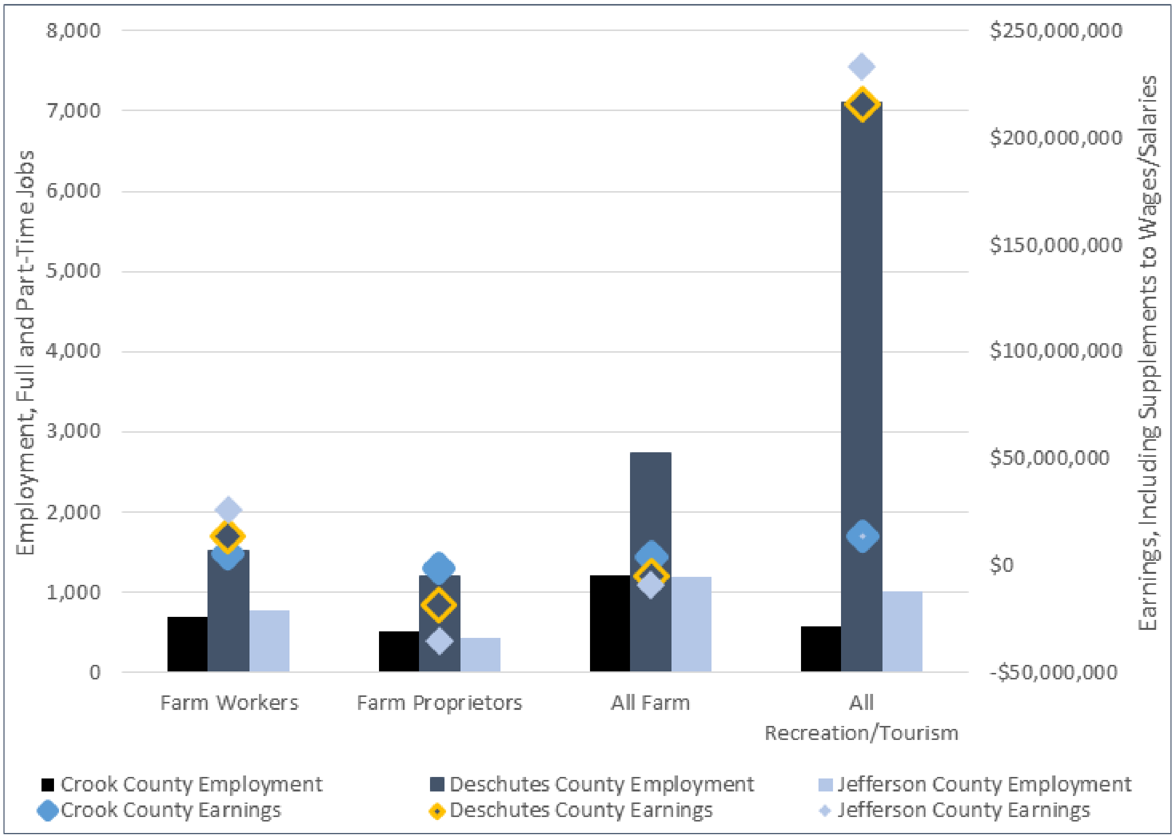
County/Sector	Employment (full- and part-time jobs)	Earnings
Crook		
Farm Workers/Proprietors[a]	1,219	$4,098,000
Recreation/Tourism Sectors[b]	580	$13,800,000
Other Sectors	8,027	$438,806,000
Total	9,826	$456,704,000
% Farm-Related[a]	12%	1%
% Recreation Tourism-Related[b]	6%	3%
Deschutes		
Farm Workers/Proprietors[a]	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.

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). A 2015 Oregon State University Extension Service study of the statewide economic contribution of agriculture in the State of Oregon estimated that when including food and fiber processing, agricultural support services, wholesale trade, and transportation and warehousing associated with all Oregon agricultural production, total employment and income supported by agriculture at the state level may be approximately 2.5 times the direct agricultural employment and income (Sorte and Rahe 2015). Data specific to the study area indicate that the total county-level employment and income in the study area may be in the range of 1.1 to 2.1 times the direct agricultural employment and income (IMPLAN 2017).

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 account for approximately 6% of employment and 3% of income in the study area. Further, the natural resources that support the recreation industry also support the general quality of life and retention/attraction of residents to the region that also contributes to the local economy.

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 for the last several years have been 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. The settlement agreement particularly affected water supplies for Tumalo Irrigation District (ID),, but other affected districts 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] 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.

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.

3.9.3.1 Alternative 1: No Action

Based on analyses in other resource sections, there would be little to no effect on aesthetics (Section 3.6, *Aesthetics and Visual Resources*), recreation (Section 3.7, *Recreation*), urban/municipal water supplies (Section 3.2, *Water Resources*), or cultural resources (Section 3.10, *Cultural Resources*) 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, *Biological Resources*) and agricultural resources (Section 3.5, *Land Use and Agricultural Resources*), there may be potential impacts on the following socioeconomic resources and values: economic opportunity, community way of life, fiscal government stability, tribal resource values, intrinsic species/habitat conservation values, and environmental justice populations. These are described below.

As described in Section 3.2, 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 up to 1% over the 30-year analysis period and across water conservation scenarios. As a proportion of total economic activity in the study area, this is a 0% change in study area employment or income, even in Jefferson County, where potential impacts of water conservation under the no-action alternative are the greatest.

Table 3.9-8. Annual Total Employment and Income from Forage/Grain Production under No-Action Alternative Compared to Existing Conditions, Dry Water Year

Type of Economic Impact	County			Study Area
	Crook	Deschutes	Jefferson	
Employment (Full and Part-Time Jobs)				
Jobs	330	740	490 to 500	1,560 to 1,570
Change from existing conditions	0	0 to 5	5 to 15	5 to 20
% Change[a]	0	0 to 1%	1 to 3%	0 to 1%
Income (Employee Compensation and Proprietor Income)				
Income (Millions $)	$15.4	$18.4	$12.3 to $12.7	$46.0 to $46.4
Change from existing conditions (Millions $)	$0	$0	$0.1 to $0.5	$0.1 to $0.5
% Change[a]	0%	0%	1 to 4%	0 to 1%

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.
[a] 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 water conservation, 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 Plan (Black Rock Consulting 2016),

[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.

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. However, to the extent that individual farms are not able to financially sustain these increased costs, this may result in the proprietor having to cease farming, with associated socioeconomic hardship on affected farm owners.

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, there is a not adverse effect on recreation resources, and thus a not adverse effect on recreation value.

As described in Section 3.4, 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 Oregon spotted frog 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 Warm Springs 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, 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) and socioeconomic values associated with habitat/species conservation related to climate change.

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.

Regarding environmental justice effects, there are no expected environmental hazards that would result from the no-action alternative; therefore, no environmental hazard effects on environmental justice populations. However, environmental justice effects may result from changes in economic opportunity and changes in species and habitat.

Farm employment and income may increase or decrease, and any decreased farm employment and income (such as due to climate change) would likely adversely affect minority and low-income farm workers (an environmental justice population) appreciably more than the general population. Conversely, any increased farm employment and income (such as due to increased water use efficiency) would likely beneficially affect the environmental justice farmworker population appreciably more than the general population. The magnitude of beneficial effects on the environmental justice farmworker population under the no-action alternative are expected to be small throughout the permit period (with a change in farmworker employment and income of less than 1% across all water year types and throughout the permit time period), while the timing and magnitude of potential adverse effects (possibly related to climate change, changing market conditions, and urban growth) are not known.

Potential adverse effects on cultural and economic values associated with species and habitat conservation due to climate change would likely be experienced by the tribal members (an AIAN environmental justice population) of the Confederated Tribes of Warm Springs (and other tribes outside the study area) in a way that appreciably exceeds the effects on the general population. As noted in Section 3.4*,* restoration and protection strategies under the no-action alternative could result in improvements to fish and wildlife habitat. Climate change, however, could adversely affect the distribution and quality of habitat in the study area (particularly in the Crooked River) that is valued by tribal members and others (although the timing and magnitude of these effects cannot be reliably forecast). As such, the no-action alternative could have disproportionately high and adverse effects on both tribal and farmworker environmental justice populations.

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 related to these resources would be adverse to not adverse.

3.9.3.2 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 overall 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 median and wet water years.

In dry water years, agricultural production and associated economic contribution would remain stable in Deschutes and Crook Counties but would decline in Jefferson County. In Jefferson County, forage/grain-related employment and income supported by North Unit ID would be fairly stable until around year 2030, when there could be a reduction of up to 7% in the low conservation scenario,[5] but no reduction in the high conservation scenario. Potential dry year reductions in Jefferson County jobs and income are expected to be minimal in the initial years of the permit period, peak in 2030, and then decline to zero by 2049. In addition to effects on North Unit ID, there may also be slight effects on agricultural production values and associated employment/income in dry years in Lone Pine ID in Crook County, but these effects represent 0% of county-level employment and income and are only for the first few years of the permit term (see Appendix 3.5-A for detailed results by district).[6]

Across all water year types, total jobs and income supported by grain/forage production are expected to remain stable in Crook and Deschutes Counties, and decline by up to 2% in Jefferson County. As a proportion of all farm employment and income (grain/forage and other crop production), impacts of the proposed action in Jefferson County across all water year types are expected to be less than 1%.

Table 3.9-9 presents a reasonable range of potential long-term effects in the study area. While all farms would be affected, 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, even in dry water year types, as a proportion of total economic activity at the county and study area levels, the farm-level reductions represent 0.3% of total employment and earnings in Jefferson County, the most impacted county in the study area. As such, effects even in dry years are considered not adverse for all counties in the study area.

[5] As a proportion of all farm jobs in Jefferson County (not just those related to forage and grain), the maximum expected dry year impact is expected to be 2.5% of farm employment.

[6] Water supply modeling indicates that Ochoco ID would experience effects in very dry 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.

Effects in extreme dry years would be larger, but would still likely be not adverse.[7] If an agricultural water market that facilitated transfer of water between districts were implemented in the Deschutes Basin, then the distribution of effects on economic opportunity may shift between the counties. e.g., if irrigation water were transferred to Jefferson County from Deschutes County, effects in Jefferson County may diminish and effects in Deschutes County may increase.

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). Jefferson County produces approximately 45% of the world's supply of carrot seed (Central Oregon Agriculture Research and Extension Center undated), and the crop has an estimated farmgate value of approximately $19.5 million annually (U.S. Department of Agriculture 2019), which disproportionately (relative to acreage) contributes to the local economy. 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-A (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 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

[7] Based on the percent change in water supplies in extreme dry years compared to dry years, it is possible that economic impacts could be up to 50% greater. For example, for the proposed action, the Jefferson county-level employment effect of -0.3% in a dry year compared to the no-action alternative may be an effect of -0.45% in an extreme dry year.

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).[8]

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 relatively 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 North Unit ID farms are viable under existing conditions, they are likely viable under proposed action conditions). Finally, irrigated farmland has more value than dryland, so farmland values would likely decline with reduced irrigation water supplies. While decreased land value is an economic cost to farm owners selling farmland and may adversely affect some farms' viability, it is also a benefit to farmers who are purchasing or leasing land. As such, changes in land values are not expected to affect the overall long-term economic contribution or viability of agriculture in the region.

[8] In years 1 through 7 of the permit term under the proposed action from May through September, reduced water available for diversion (compared to the no-action alternative) to North Unit ID in a dry water year is estimated at 10,100 acre-feet per year, but conserved water available to North Unit ID in year 1 is estimated to be at least 5,200 acre-feet per year, rising to at least 10,400 acre-feet per year by year 3 (low conservation scenario). In years 8 through 12 from May through September, reduced water available for diversion to North Unit ID in a dry water is estimated to be at least 33,100 acre-feet per year. But conserved water available to North Unit ID in year 8 is estimated to be at least 23,400 acre-feet per year, rising to at least 28,600 acre-feet per year by year 10 (low conservation scenario). In permit years 13 through 30 from May through September, reduced water available for diversion to North Unit ID in a dry water year is estimated at 53,300 acre-feet per year, but conserved water available to North Unit ID in year 13 is estimated to be at least 36,400 acre-feet per year, rising to at least 50,800 by year 22 (low conservation scenario).

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	0	0
Income (Millions)	$0	$0	-$0.1 to $0	$0
% Change (Forage Production Contribution)	0%	0%	0%	0%
Deschutes				
Employment (Full- and part-time jobs)	0	0	0%	0%
Income (Millions)	$0	$0	$0.0	$0.0
% Change (Forage Production Contribution)	0%	0%	0%	0%
Jefferson				
Employment (Full- and part-time jobs)	0	0	-30 to 0	-10
Income (Millions)	$0	$0	-$0.8 to $0	-$0.3 to $0
% Change (Forage Production Contribution)	0%	0%	-7 to 0%	-2 to 0%
Study Area				
Employment	0	0	-40 to 0	-10 to -0
Income (Millions)	$0	$0	-$0.8 to -$0	-$0.3 to $0
% Change (Forage Production Contribution)	0%	0%	-3 to 0%	-1 to 0%

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. However, to the extent that decreased farm employment leads to migrant farmworkers or other farmworkers relocating outside of the study area, the contraction in the local economy may be more permanent.

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 are concentrated in North Unit ID and Jefferson County.

Decreased employment and income opportunities in all 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, the proposed action would result in adverse effects on whitewater sports in the Upper Deschutes River, shore and lake-based recreation at Wickiup Reservoir (due to projected lower reservoir levels and associated lower opportunities and use), and redband trout fishery recreation in Wickiup Reservoir and portions of the Crooked River. Overall, effects on recreation and associated economic values under the proposed action compared to the no-action alternative are not expected to reduce overall recreational economic values in the Upper Deschutes area, as recreational opportunities would remain plentiful in this area and would be improved through improved ecological conditions.

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, though there would be adverse effects on whitewater sports in the Upper Deschutes River Basin, shore and lake-based recreation at Wickiup Reservoir (due to projected lower reservoir levels and associated lower opportunities and use), and redband trout fishery recreation in Wickiup Reservoir and portions of the Crooked River. Adverse effects in Wickiup Reservoir and the Upper Deschutes would be relatively minor in the first 7 years. Starting at year 8, greater minimum fall/winter flows downstream of Wickiup Reservoir and summer flow caps would minimize extreme high water events favorable to the most popular and economically important whitewater reaches near Bend. Due to timing of reduced flows and flow caps, guides and other businesses that cater to whitewater sports may have time to anticipate and adapt to loss of whitewater opportunities, although effects on this sector of the recreation industry would still be adverse. These adverse economic effects are expected to be offset to some degree by improvements in other economically important recreational assets, including more naturally appearing shoreline vegetation, more stable flows, and generally enhanced fish and wildlife habitat

Effect Conclusion: The proposed action would decrease economic value for whitewater sports in Upper Deschutes River reaches downstream of Wickiup and all recreational uses at Wickiup Reservoir, and increase recreational value for aesthetics, bank stability and vegetation, fish and wildlife habitat, and associate recreational values in the Upper Deschutes. Because the overall 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 in the study area is also expected to be not adverse.

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, with generally no effects to beneficial effects at the species-level across the study area on plants, wildlife, Oregon spotted frog, and fish habitat for several socioeconomically valuable species (bull trout, redband trout, spring Chinook salmon, sockeye salmon and steelhead trout). However, there may be some adverse effects in some years and in some locations for some species. Further, there may be an adverse effect on spring Chinook salmon and steelhead trout reintroduction in the Crooked River and fish and wildlife habitat in Wickiup Reservoir compared to the no-action alternative, which may affect the socioeconomic value of habitat and species in those locations. These potential adverse effects would be particularly experienced by conservationists, tribal members, and local residents who value species and habitat conservation.

Effect Conclusion: Depending on the species, location, and habitat type, there may be beneficial or adverse effects on habitat and species and associated socioeconomic values. Overall, as species and habitats are anticipated to experience not adverse to beneficial effects, there would likely be no effect to beneficial effects expected on cultural and economic values associated with species and habitat conservation.

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 unlikely to affect urban/suburban uses in median and dry years, as districts providing urban/suburban water such as Arnold ID, Swalley ID, Central Oregon ID, and Ochoco ID are not expected to experience a change in water supplies. In very dry water years, water supplies may be reduced in Arnold ID and Ochoco ID compared to the no-action alternative, which may affect urban/suburban users.

Effect Conclusion: With the possible exception of very dry years, the proposed action is expected to have a not adverse effect on urban or suburban users compared to the no-action alternative.

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 Hydroelectric 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.

The license from the Federal Energy Regulatory Commission (FERC) to operate the Pelton–Round Butte Hydroelectric Project requires the reintroduction of salmon and steelhead upstream of the project. Adverse effects on spring Chinook and steelhead habitat in the Crooked River under the proposed action and action alternatives (Sections 3.4 and 3.8, *Tribal Resources*) could increase fish reintroduction costs. Costs could increase by extending the period some activities may need to occur for reintroduction., and by requiring additional actions to achieve reintroduction goals (e.g., more habitat restoration could be required to offset water management affects). These reintroduction costs are not expected to measurably affect electricity prices or energy generation due to the size of the wholesale energy market, but would likely increase the environmental compliance costs of the project. As such, no adverse effects are expected on hydropower production or the cost of energy to consumers. These increased costs are expected to be borne by the facility owners: Confederated Tribes of Warm Springs (an environmental justice population, as analyzed in Soc-9) and Portland General Electric.

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%) 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	$0	$0 to -$0.7	$0 to -$0.7
2017 Total agricultural production value (Millions)	$44.6	$28.8	$67.4	$140.8
% Effect on total agricultural production value	0%	-0.5 to -1.3%	0 to -1.1%	0 to -0.5%
% Property tax revenue from agricultural/ forestry lands	11%	2%	10%	3%
% Effect on total property tax receipts	0%	0%	0%	0%

Sources: National Agricultural Statistics Service 2019 (Highland Economics analysis, 2017 Census of Agriculture); Deschutes County 2018; Jefferson County 2018; Huber et al. 2017.

To the extent that reduced farm employment and income opportunities in Jefferson County would increase unemployment and poverty, there could be an increase in demand for local social services and an increase in Jefferson County local government spending. Due to the small effect (less than 0.1%) on overall local economic opportunity across all water year types, this effect is expected to also be small.

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. Decreased agricultural employment and income may increase local government spending. However, as the expected average change in annual county employment/ income for each county in the study area is expected to be less than 0.1%, the effect on local government spending is expected to be not adverse.

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 2% 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 (most likely to occur in North Unit ID in Jefferson County) 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 environmental justice 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 Warm Springs (and other tribes outside the study area), likely in a way that appreciably exceeds effects on the general population. These effects are expected to be both beneficial and adverse. However, due to the importance of fishery resources to the Tribes, since effects on fishery resources are generally expected to be beneficial to not adverse (while effects on vegetation and wildlife are expected to be beneficial), the overall species and habitat conservation effect on the Tribes could be beneficial. However, as there may be some adverse effects on spring Chinook salmon and steelhead trout reintroduction in the Crooked River and fish and wildlife habitat in Wickiup Reservoir compared to the no-action alternative, it is possible that the Tribes may experience an adverse effect on their cultural and economic values related to the Crooked River fishery resource. Further, as discussed in SOC-6, environmental compliance costs associated with the Pelton-Round Butte Hydroelectric Project, which is co-owned by the Confederated Tribes of Warm Springs, may increase under the proposed action compared to the no-action alternative. While the magnitude of this potential cost increase is uncertain and is not expected to affect the amount of hydropower production or consumer energy costs as determined in SOC-6, this increased compliance cost is an adverse effect on the tribal environmental justice population that would appreciably exceed effects on the general population.

Potential decreases in farm employment and income opportunities in North Unit ID would affect farm operators and farm workers in Jefferson County. These effects (up to 2.5% of farm employment) would occur in dry years, and are expected to be minimal in the initial years of the permit term, peak in 2030, and decline to zero by 2049. While farm operators are mostly white, farm workers are mostly minority. Adverse effects on the farm economy under the proposed action compared to the no-action alternative would likely result in adverse socioeconomic effects on the environmental justice farmworker populations, as effects on this environmental justice population would likely appreciably exceed effects on the general population.

Effect Conclusion: Effects on tribal cultural and economic values associated with species and habitat conservation may be beneficial, not adverse, or adverse due to the variety of effects on different species and locations. Due to expected adverse effects on fish reintroduction in the Crooked River under the proposed action compared to the no-action alternative, an adverse effect on cultural and economic values associated with species and habitat conservation and with environmental compliance costs for the Pelton-Round Butte Hydroelectric Project may be experienced by the tribal members (an AIAN environmental justice population) of the Confederated Tribes of Warm Springs (and other tribes outside the study area). These adverse effects on tribal cultural and economic values may constitute a disproportionately high and adverse effect on the tribal environmental justice population. Reduced agricultural income and employment opportunities would result in negative economic impacts on minority and low-income farmworkers (an environmental justice population of concern), 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.

3.9.3.3 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 higher effects in Jefferson County (North Unit ID) in a dry year. Under Alternative 3, under the low conservation scenario in a dry year, there may be up to a 22% reduction of forage/grain-related farm employment and income (around year 2030). In contrast to the proposed action, there are also dry year employment and income effects projected under the high conservation scenario (up to a reduction of 8% of forage/grain-related economic activity in the first 20 years of the permit term).

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) in the low conservation scenario, total county employment and income could be reduced by up to 1.4% in Jefferson County. Effects in these years would be considered adverse because they are over 1%. Effects in extreme dry years would be even more adverse.

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

County	Water Year Type: Wet	Water Year Type: Median	Water Year Type: Dry	Average, All Water Year Types[a]
Crook				
Employment (Full- and part-time jobs)	0	0	0	0
Income (Millions)	\$0	\$0	-\$0.1 to \$0	\$0
% Change (Forage Production Contribution)	0%	0%	-1 to 0%	0%
Deschutes				
Employment (Full- and part-time jobs)	0	0	0	0
Income (Millions)	\$0	\$0	\$0	\$0
% Change (Forage Production Contribution)	0%	0%	0%	0%
Jefferson				
Employment (Full- and part-time jobs)	0	0	-110 to 0	-40 to 0
Income (Millions)	\$0	\$0	-\$2.8 to -\$0	-\$1.0 to \$0
% Change (Forage Production Contribution)	0%	0%	-22 to 0%	-8 to 0%
Study Area				
Employment (Full- and part-time jobs)	0	0	-130 to -0	-50 to 0
Income (Millions)	\$0	\$0	-\$2.8 to \$0	-\$1.0 to \$0
% Change (Forage Production Contribution)	0%	0%	0 to -8%	-3 to 0%

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 (under the low conservation scenario). Effects in other counties would be 0% 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 similar to those described for the proposed action but would occur earlier in the permit term (Table 3.1-1). In addition, flow caps would not be placed on the Upper Deschutes River, so extreme flow events are expected to continue to provide some opportunities for whitewater rafting at popular reaches. However, the absence of a cap would diminish, but not eliminate, the benefits of improved bank stability, shoreline vegetation, and fish and wildlife habitat that would occur under the proposed action. Across the study area, effects on socioeconomic value related to recreation 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 generally be similar to those described for the proposed action but would occur earlier in the permit term and, therefore, would be of longer duration under Alternative 3 than under the proposed action (Table 3.1-1). For some species in some locations (Oregon spotted frog in the Little Deschutes River and Crescent Creek and Wickiup Reservoir and redband trout), the effects under Alternative 3 are less beneficial relative to the proposed action. Overall effects on fish and wildlife habitat are expected to be not adverse to beneficial, the overall effect on socioeconomic value associated with these resources is projected to be beneficial relative to the no-action alternative (but potentially less beneficial than the proposed action). However, as for the proposed action, there may be some adverse effects in some years and in some locations for some species, and these adverse effects would be particularly experienced by conservationists, tribal members, and local residents who hold socioeconomic values for species and habitat conservation.

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 are expected to be of greater magnitude than under the proposed action. Specifically, in contrast to the proposed action (which had no expected dry year adverse effects on urban/suburban users), under Alternative 3, there would be up to a 6% reduction in irrigation diversions available to Arnold ID in dry water years (and no dry year effects on other districts supplying urban/suburban water). As in the proposed action, there could be possible changes in urban/suburban water supply in Ochoco ID in very dry years.

If urban/suburban users were affected in Arnold ID, 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.). 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

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 (Table 3.1-1). 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 in agricultural property value and property taxes would be of greater magnitude, particularly in Jefferson County, than those described for the proposed action. Moreover, 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. However, because the reduction in taxes collected would be relatively small, the effect would be not adverse compared to the no-action alternative. Similarly, because the reduction in average annual employment/income for Jefferson County (and every other county in the study area) across all water year types is expected to be less than 1%, the effect on local government spending associated with increased social services for the unemployed is expected to be not adverse.

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 greater under this alternative due to the larger decline in agricultural production, particularly in Jefferson County.

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 Warm Springs (and other tribes outside the study area) under Alternative 3 compared to the no-action alternative would be similar to those described for the proposed action but would occur throughout the permit term, and would be potentially less beneficial than the proposed action. The potential adverse effects on tribal cultural and economic values could appreciably exceed those experienced by the general population.

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, particularly in Jefferson County. These effects (up to 9.2% of annual Jefferson County farm employment) would occur in dry years, and are expected to peak in 2030. The adverse employment and income effects on the farmworker environmental justice population, particularly in Jefferson County where the farm economy is projected to be most affected, are expected to appreciably exceed the effects experienced by the general population. In sum, effects on cultural and economic values under Alternative 3 associated with species and habitat conservation and the farm economy could represent a disproportionately high and adverse effect on tribal and farmworker environmental justice populations.

3.9.3.4 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 34% reduction in the economic contribution of forage/grain production (peaking in year 2025, with effects expected throughout the duration of the permit term in both conservation scenarios). Deschutes and Crook Counties each are projected to experience up to a 1% reduction in the economic contribution of forage/grain production in the dry year low conservation scenario. Additionally, in contrast to the proposed action and Alternative 3, adverse impacts on economic contribution of forage/grain production in North Unit ID and Jefferson County are expected under the median year low conservation scenario (up to 8%, peaking in Year 2025, and decreasing to zero by Year 2039).

Similar to the proposed action and Alternative 3, on average across all water year types, 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 term in dry water years, total county employment and income could be reduced by up to 1.8% in Jefferson County. As in Alternative 3, effects in these dry years would be considered adverse because they are over 1%. Adverse effects on economic opportunity in Jefferson County would be higher under Alternative 4 than under Alternative 3 or the proposed action.

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	0	0
Income (Millions)	$0	$0	-$0.1 to $0	$0
% Change (Forage Production Contribution)	0%	0%	-1 to 0%	0%
Deschutes				
Employment (Full- and part-time jobs)	0	0	-10 to 0	0
Income (Millions)	$0	$0	-$0.2 to -$0	-$0.1 to $0
% Change (Forage Production Contribution)	0%	0%	-1 to 0%	0%
Jefferson				
Employment (Full- and part-time jobs)	0	-40 to 0	-170 to -10	-70 to 0
Income (Millions)	$0	-$1.0 to $0	-$4.2 to -$0.1	-$1.5 to $0
% Change (Forage Production Contribution)	0%	-8 to 0%	-34 to -1%	-14 to 0%

County	Water Year Type			Average, All Water Year Types[a]
	Wet	Median	Dry	
Study Area				
Employment (Full- and part-time jobs)	0	-50 to 0	-200 to -10	-90 to 0
Income (Millions)	$0	-$1.0 to $0	-$4.4 to -$0.1	-$1.5 to $0
% Change (Forage Production Contribution)	0%	-3 to -0%	-13 to -1%	-5 to 0%

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 Alternative 3 but occur earlier in the permit term (Table 3.1-1). Overall, effects on socioeconomic value related to recreation would be not adverse compared to the no-action alternative for the reasons described for Alternative 3.

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 would be of shorter overall duration than under the proposed action or Alternative 3. Further, for some species, 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 on socioeconomic values associated with species and habitat conservation is expected to be beneficial relative to the no-action alternative. However, as for the proposed action and Alternative 3, there may be some adverse effects in some years and in some locations for some species. These adverse effects would be particularly experienced by conservationists, tribal members, and local residents who hold socioeconomic values for species and habitat conservation.

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 of greater magnitude than those described for the proposed action or Alternative 3, in part due to reduced time to implement water conservation projects. Specifically, under Alternative 4, there would be up to a 7% reduction in irrigation diversions available to Arnold ID in dry water years (and no dry year effects on other districts supplying urban/suburban water). This compares to a 0% dry year change for Arnold ID under the proposed action and a 6% dry year change for Arnold ID under Alternative 3. Further, in the dry year low conservation scenario, effects on Arnold ID under Alternative 4 may span the permit term, and there may be some effects in the initial few years of the permit term in the dry year high conservation scenario.

If urban/suburban users were affected in Arnold ID, 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.). Reduced irrigation diversions under Alternative 4 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

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. Similarly, because the reduction in average annual employment/income for Jefferson County (and every other county in the study area) across all water year types is expected to be less than 1%, the effect on local government spending associated with increased social services for the unemployed is expected to 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 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. Similarly, because the reduction in average annual employment/income for Jefferson County (and every other county in the study area) across all water year types is expected to be less than 1%, the effect on local government spending associated with increased social services for the unemployed is expected to be not adverse.

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 greater magnitude than described for the proposed action (and slightly greater than under Alternative 3) because of a greater reduction in agricultural production value, particularly in Jefferson County.

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 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 and would be of shorter duration. These adverse effects on tribal cultural and economic values could appreciably exceed those experienced by the general population.

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. The employment and income effects on the farmworker environmental justice population, particularly in Jefferson County where the farm economy is projected to be most affected, are expected to appreciably exceed the effects experienced by the general population. Adverse effects on economic opportunity for farmworker populations are expected to peak in year 2025 (with up to a 14% reduction in farm employment) and decrease to zero by year 2039. 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. For the purposes of this analysis, cultural resources are defined as archaeological resources, buildings, structures, districts, objects, and traditionally important places on the landscape. These resources may be historic properties as defined in 36 Code of Federal Regulations Part 800, listed on a state or local historic register, or identified as being important to a particular group through consultation. Section 3.8, *Tribal Resources*, further considers effects on other resources that are of cultural importance, such as traditionally important plants and animals.

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 changes in resource exposure, erosion, or inundation as a result of water level fluctuations. The erosion, exposure, or inundation of a cultural resource can both affect a resource's ability to convey its cultural importance and change the way in which people can access the resource—both negatively (e.g., erosion, looting, loss of access to a traditional gathering place) and positively (e.g., protection from looting, burial and protection from erosion). These factors are already occurring under existing conditions throughout the covered lands and waters and would continue to occur under the no-action alternative. As a result, the specific issue explored in this analysis is the extent to which these factors would vary under the proposed action and Alternatives 3 and 4 (action alternatives) relative to the no-action alternative. This analysis is based on the findings of the RiverWare modeling results (summarized in Appendix 3.2-A, *Water Resources Technical Supplement*). Downstream of the reservoirs, the proposed action and action alternatives would result in reduced flood intensity and duration relative to the no-action alternative. As a result, impacts that could differentially affect cultural resources relative to the no-action alternative are not anticipated; and the cultural resources study area was limited to the reservoirs.

This analysis considers two variables related to water surface elevation (*elevation*) in the five study area reservoirs to determine whether the proposed action and action alternatives could result in impacts on cultural resources. The first variable is total range of elevation change within each reservoir (*range*), if the proposed action and action alternatives would result in a change to the minimum and maximum elevation in a reservoir relative to the no-action alternative. Potential impacts on cultural resources could occur if the elevation for the proposed action and action alternatives either exceeds the maximum elevation or is less than the minimum elevation that is already occurring under the no-action alternative. These impacts include, but are not limited to, exposing cultural resources to erosional forces that they were not previously subject to and/or making previously inaccessible cultural resources accessible to looters. Table 3.10-1 presents the minimum and maximum modeled elevation for each reservoir under each alternative.

Table 3.10-1. Monthly Water Surface Elevation (Feet) Range by Reservoir for Each Alternative

Reservoir		Monthly Elevation			
		No-Acton Alternative	Proposed Action	Alternative 3	Alternative 4
Crane Prairie	Minimum	4,436.40	4,436.40	4,436.40	4,436.40
	Maximum	4,447.30	4,443.46	4,443.46	4,443.46
Wickiup	Minimum	4,285.97	4,302.05	4,289.34	4,289.34
	Maximum	4,337.67	4,337.67	4,337.67	4,337.67
Crescent Lake	Minimum	4,822.28	4,825.89	4,822.18[a]	4,822.17 [a]
	Maximum	4,843.99	4,844.34[a]	4,844.32[a]	4,843.35
Prineville	Minimum	3,129.87	3,131.60	3,128.51[a]	3,127.59[a]
	Maximum	3,235.58	3,235.60[a]	3,235.58	3,235.58
Ochoco	Minimum	3,062.78	3,062.78	3,062.78	3,063.01
	Maximum	3,132.61	3,132.61	3,132.61	3,132.61

[a] Elevation range exceeds that of the no-action alternative (i.e., minimum elevation is lower and/or maximum elevation is higher).

The second variable is the change in the duration which the ground surface at various elevations is exposed, whether the ground surface at various elevations is either subaerially[1] exposed or inundated for different length of time than under the no-action alternative. Potential impacts on cultural resources from change in duration could include, but are not limited to, exposing cultural resources to looting for longer periods or further burying submerged cultural resources under alluvium for longer periods. To determine change in duration across the reservoirs by alternative, the inundation plots were reviewed (Appendix 3.10-A, *Cultural Resource Technical Supplement*).

The description of the existing conditions for cultural resources in the study area is based on background research relating to the prehistory, ethnography, and history of the region. For the Wickiup Reservoir, this information is supplemented by a 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. 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. In addition, FWS is actively consulting with both the Oregon SHPO and the Confederated Tribes of Warm Springs Tribal Historic Preservation Officer to determine if such resources exist. Section 106 consultation is ongoing as of the writing of this document and, as a result, resources identified through consultation are not included in this analysis, but will be considered as part of a Section 106 compliance effort.

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

[1] Occurring in the open air or on the ground surface; not inundated or buried.

fishing locations. Consultation with the Confederated Tribes of Warm Springs is ongoing as of the writing of this document.

The dams and associated infrastructure at each of the five reservoirs meet the minimum age criteria for consideration as cultural resources 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 located more than 100 meters outside of each of the reservoirs maximum pool extent are not considered in this analysis.

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 in a way that differs from the no-action alternative.

- Affects archaeological resources, buildings, structures, objects, and places considered significant to a group or listed on a local or state historic register.
- Affects an archaeological resource that includes human remains.
- Affects a cultural resource that has been determined to be eligible for listing in the NRHP.
- Affects a cultural 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

The study area 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

In anticipation of potential impacts associated with the Wickiup Reservoir, and in support of FWS's Section 106 consultation efforts, a cultural resources records review was conducted for Wickiup Reservoir. Records reviews were not performed at the other reservoir locations. As a result, the findings below are limited to the Wickiup Reservoir.

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 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

As indicated earlier, there are known cultural resources in and around the Wickiup Reservoir; and all of the reservoirs retain the potential to contain as-yet-undocumented cultural resources. As a result, this analysis considers effects on both known and as-yet-undocumented cultural resources.

3.10.3.1 Alternative 1: No Action

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

Continuation of the existing water management operations under the no-action alternative is expected to result in continuation of the existing range of reservoir water surface elevation and duration of ground surface exposure. As a result, in the short term, the no-action alternative would result in no changes to impacts on cultural resources relative to existing conditions.

Over the long term, it is anticipated that climate change could result in decreased spring and summer flows as annual snowpack decreases and the frequency of precipitation events decreases. This could result in a reduced water elevation range and increased ground surface exposure duration for areas that had limited subaerial exposure previously. This, in turn, could expose previously unexposed cultural resources, or increase the duration during which cultural resources that are usually inundated are accessible for looting.

Effect Conclusion: Continuation of existing water management operations under the no-action alternative is likely to result in continued erosion, exposure, and burial of cultural resources in the study area reservoirs at a rate that is consistent with existing conditions. Long term, climate change could incrementally intensify impacts related to looting. As a result, the no-action alternative would have an adverse effect on cultural resources.

3.10.3.2 Alternative 2: Proposed Action

CUL-1: Disturb Cultural Resources

In Crane Prairie Reservoir, the minimum and maximum elevations fall within the range anticipated under the no-action alternative. In Wickiup, Crescent Lake, Prineville, and Ochoco Reservoirs, minimum water elevation is equal to or slightly less (higher elevation) but maximum water elevation is slightly greater (higher elevation) than what is anticipated under the no-action alternative. The largest maximum elevation increase would be up to 7 inches at Crescent Lake Reservoir with the difference in remaining reservoirs less than 1 inch. While water surface elevation range would exceed what is anticipated under the no-action alternative at these reservoirs, the extent of the exceedance is extremely limited and not anticipated to result in impacts on cultural resources that exceed those anticipated under the no-action alternative. Therefore, the proposed action is not expected to result in impacts on cultural resources by exposing them to erosional forces that they were not previously subject to and/or making previously inaccessible cultural resources accessible to looters to a greater extent than the no-action alternative.

In Ochoco and Prineville Reservoirs, the duration of ground surface exposure at various elevations would be nearly the same under the proposed action relative to the no-action alternative. Crescent Lake Reservoir is anticipated to maintain a higher water surface elevation year-round, resulting in significantly reduced duration of subaerial ground surface exposure, a beneficial effect. In Crane Prairie Reservoir, change in duration of maximum water surface elevation be would minimal, but the timeframe would shift by approximately 2 months. During much of the year, the proposed action would maintain a higher water surface elevation than the no-action alternative, but the no-action alternative would maintain a higher water surface elevation during the summer months. As a result, overall, the proposed action would result in significantly reduced duration of subaerial ground surface exposure of areas that would otherwise be exposed, a beneficial effect. Wickiup Reservoir would maintain a lower water surface elevation during the winter, spring, and summer months. Water surface elevation would change minimally in the fall months. Lower average water surface elevation in the winter, spring, and summer months would result in a measurably greater duration of subaerial ground surface exposure at higher elevations in the reservoir, an adverse effect.

Effect Conclusion: While water surface elevation range under the proposed action would remain comparable to the no-action alternative across the study area reservoirs, the duration of ground surface exposure across various elevations would substantively differ from the no-action alternative at the Wickiup Reservoir, Crescent Lake, and Crane Prairie. In Crescent Lake and Crane Prairie Reservoirs, the proposed action would result in an overall reduction in ground surface exposure, which would reduce the amount of time cultural resources would be subject to looting and erosion as reservoir levels oscillate relative to the no-action alternative—a beneficial effect on cultural resources. In Wickiup Reservoir, duration of ground surface exposure at the upper elevations of the reservoir would increase relative to the no-action alternative, increasing the potential for cultural resources to be subject to looting and erosion. Overall, effects on cultural resources under the proposed action would be adverse relative to the no-action alternative, despite beneficial effects in Crane Prairie and Crescent Lake Reservoirs, because of the increased potential for erosion and looting of cultural resources at the Wickiup Reservoir.

3.10.3.3 Alternative 3: Enhanced Variable Streamflows

CUL-1: Disturb Cultural Resources

Under Alternative 3, water surface elevations compared to the no-action alternative would be the same or nearly the same as described for the proposed action at the Crane Prairie, Ochoco, and Wickiup Reservoirs, except that effects in Wickiup Reservoir would begin earlier in the permit term and therefore have a longer duration (Table 3.1-1). At Crescent Lake Reservoir, water surface elevation would exceed both the minimum and maximum pool levels identified in the no-action alternative by approximately 2 inches. In these instances, the extent to which the water surface elevation exceeds the range under the no-action alternative is extremely limited and not anticipated to result in impacts on cultural resources that exceed those anticipated under the no-action alternative. At Prineville Reservoir, water surface elevation would be less than the minimum pool level identified in the no-action alternative by approximately 1 foot. At this magnitude, it is possible that Alternative 3 could expose previously inaccessible cultural resources to looting and erosion relative to the no-action alternative, an adverse effect.

Duration of ground surface exposure under Alternative 3 compared to the no-action alternative would be similar to described for the proposed action at Crane Prairie, Ochoco, and Prineville Reservoirs. Wickiup Reservoir is anticipated to maintain even lower water-surface elevation levels year-round compared to the proposed action, resulting in the potential for cultural resources in the reservoir to be exposed and accessible for looting and erosion for a longer duration, an adverse effect. Crescent Lake Reservoir is anticipated to maintain a slightly lower year-round water surface elevation relative to the proposed action, but this elevation is still higher than what is anticipated to occur under the no-action alternative. As a result, it would still result in significantly reduced duration of subaerial ground surface exposure of areas that would otherwise be exposed under the no-action alternative, a beneficial effect.

Effect Conclusion: Alternative 3 would have no effect on cultural resources related to range of water surface elevation in Crane Prairie, Wickiup, Crescent Lake, and Ochoco Reservoirs compared to the no-action alternative for the reasons described for the proposed action. Alternative 3 would have an adverse effect at Prineville Reservoir, by increasing the potential to expose previously inaccessible cultural resources to looting and erosion relative to the no-action alternative.

Effects on cultural resources under Alternative 3 associated with duration of ground surface exposure at the upper elevations compared to the no-action alternative, would be the same as described for the proposed action in Crane Prairie, Wickiup, Crescent Lake, and Ochoco Reservoirs, except that adverse effects in Wickiup Reservoir would be greater, because the increased duration of exposure would be greater than under the proposed action, and beneficial effects at Crescent Lake Reservoir would be greater, because the reduced duration of exposure would be greater than under the proposed action.

At Prineville Reservoir, minimum water surface elevation would approximately 1 foot lower than the no-action alternative, increasing the potential for exposing previously inaccessible cultural resources to looting and erosion, an adverse effect.

As a result, effects on cultural resources under Alternative 3 would be adverse relative to the no-action alternative for the reasons described above.

3.10.3.4 Alternative 4: Enhanced and Accelerated Variable Streamflows

CUL-1: Disturb Cultural Resources

Under Alternative 4, water surface elevation and duration of ground surface exposure and therefore effects on cultural resources compared to the no-action alternative would be the same or nearly the same as described for Alternative 3, except that both beneficial and adverse effects would occur earlier in the permit term and have a shorter overall duration (Table 3.10-1).

Effect Conclusion: Effects on cultural resources relative to the no-action alternative would be the same as outlined for Alternative 3 above.

3.10.4 National Historic Preservation Act

In addition to the Services obligations under NEPA to assess impacts on cultural resources, 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."[2]

As part of the Services' NHPA compliance process, the Services identify the geographic area of potential effects (APE),[3] 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 Burns Paiute Tribe, 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. Presently, the Services are engaged in the NHPA Section 106 process in consultation with the Oregon SHPO, Confederated Tribes of the Warm Springs Indian Reservation, the Klamath Tribes, the Burns Paiute Tribe, the applicants, the U.S. Forest Service, and the Bureau of Reclamation.

[2] ***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).

[3] 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 resource as defined in Chapter 3, *Affected Environment and Environmental Consequences*.

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.

The effects of climate changes are also considered within the evaluation of cumulative effects by resource. Climate change impacts are inherently cumulative because greenhouse gas emissions from past, present, and reasonably foreseeable actions cumulatively contribute to global climate change.

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). Climate change may result in lower total water supply in the future, which would exacerbate reductions in water supply under the proposed action and alternatives.

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 the Deschutes Basin HCP, Chapter 3, *Scope of the 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 to improve agricultural water use efficiency in the basin. Investments include 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 potential water conservation in the basin related to district water conservation

[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.

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. Although the extent of public lands in the basin is considerable, BLM and USFS management in the basin typically involves projects 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. While these types of projects could occasionally have short-term physical effects that could contribute to cumulative effects on water quality, no specific projects were identified for the cumulative analysis that would be likely to contribute to cumulative effects when considered in combination with effects of the proposed action and alternatives.

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 combination with the 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 discussed in Chapter 3, Section 3.2.3.1, *Alternative 1: No-Action*, are expected to continue this trend. In addition, 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. Effects on water supply may vary. [2] If water saved through conservation in Central Oregon, Lone Pine, or Arnold IDs were available to North Unit ID, it would reduce North Unit ID's demand for stored water from Wickiup Reservoir, which would increase flows below Wickiup Reservoir during the storage season and would have no effect or a minimal effect on irrigation season flows. 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 (Chapter 3, Section 3.2, *Water Resources*), would increase instream flows below irrigation diversions in the Deschutes River and Tumalo Creek and increase irrigation water supplies. Central Oregon ID's Smith Rock-King Way Infrastructure Modernization Project, also assumed under the no-action alternative, would exchange water conserved through piping of Central Oregon ID's Pilot Butte Canal during the irrigation season for North Unit ID stored water in Wickiup Reservoir to be released during the storage season, increasing storage season flows below Wickiup Reservoir.

Effects of canal leakage on the river system, documented in the historical hydrograph in the lower Crooked River near the confluence with the Deschutes River, shows an overall increase in groundwater discharge similar to the estimated annual mean canal losses 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 were implemented, groundwater levels in the middle portion of the basin (approximately the area surrounding Bend, Tumalo, Redmond, and Terrebone; where piping projects are planned) would be affected. In addition, the artificially elevated spring discharges in this lower portion of the basin would be reduced as groundwater discharges return to more natural discharge rate. Because the proposed action and action alternatives would have only minor effects on the regional groundwater system, they would not 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

[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.

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 expected to have only a small effect on surface water flows and no effect on surface water users.

Future climate change is anticipated to alter watershed hydrology and how the Deschutes River system is managed. Climate models predict that average air temperatures in south central Oregon will increase by 1.3 to 4.0 degrees Celsius (°C) by 2050, and from 2.7 to 4.8 °C by 2080 (Halofsky et al. 2019). Climate change effects on hydrology vary across the analysis area due to basin geography, precipitation patterns, and underlying geology (Luce et al. 2019). Generally, anticipated climate change effects include decreased snowpack, earlier snowmelt and runoff, lower summer streamflow, and more frequent high-magnitude storm and runoff events (Luce et al. 2019). 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 (Luce et al. 2019). 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. The timing of these changes is uncertain, but earlier snowmelt could result in summer streamflow losses of 40 to 60% by 2040, approximately 20 years into the analysis period (Luce et al. 2019; Mote et al. 2019).

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. 2019). Earlier runoff would 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 (River Management Joint Operating Committee 2011). 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 runoff-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 periods) 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 (River Management Joint Operating Committee 2011; Luce et al. 2019). 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) (Luce et al. 2019). 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. One of the important water quality changes 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 from return irrigation flows have likely increased algal growth in the rivers (Allan 1995; Dodds 2006; Dodds and Smith 2016; Goldman and Carpenter 1974; McDowell et al. 2009; Paerl and Paul 2012; Raven and Geider 1988; Singh and 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; Dufford 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 and 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 compared to the Upper Deschutes River Subbasin (Gannett et al. 2001). 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 land 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, future groundwater pumping is not expected to affect streamflows and, therefore, is not expected to affect water quality.

[3] An exception is the reach from Osborne Canyon to Opal Springs, which collectively discharges about 1,100 cfs; however, these springs are located near the confluence of the Crooked River and Lake Billy Chinook, so only affects the lowest reach of the river.

Several trends in agriculture could lead to large beneficial effects for water quality in the Deschutes River Basin: district water conservation projects (i.e., piping and lining of irrigation canals), on-farm conservation (e.g., increased use of more efficient irrigation methods, return of irrigation water rights to support instream flows), and trends towards reduction in application rates of fertilizers.

- Water conservation projects (see *Water Resources*) reduces the amount of water that needs to be diverted from upstream sources and can result in increased streamflows, providing water resource managers with greater options to restore or maintain water quality. Some of this reduction of irrigation withdrawals is offset by a reduction in groundwater levels and resulting discharge of groundwater to streams and springs, but the net effect is expected to be positive with regard to water quality for streams in the basin.
- Irrigation of fields was historically accomplished through flood irrigation, which is an inefficient method of irrigation compared to more modern techniques such as pivot irrigation with low-head sprinklers. The conversion from flood irrigation and other less efficient means of irrigation to more efficient means of irrigation reduces demand for irrigation water, which improves water quality by allowing greater flows to remain in streams.
- Recent data indicate that there is a trend of reduced fertilizer applications in the United States, Oregon, and likely the basin. Data shows that Oregon experienced a 7% decline in purchased fertilizer between 2002/2006 and 2007/2011 (U.S. Environmental Protection Agency 2020). These national and regional trends in fertilizer usage reflect the high cost of chemical applications, education of the agricultural community to allow for more effective and targeted fertilizer usage, and cultural shifts in farming that reflect a desire to employ organic farming methods. The need for a better understanding of fertilizer requirements for crops is especially important in central Oregon where rapid movement of nitrogen through the soil profile can result in relatively low uptake rates of nitrogen by plants and high rates of transport of nitrogen into aquifers. The reduction in purchase and application of chemical fertilizers will in the short-term diminish the nutrient loads in return irrigation flows and in the long-term reduce the amount of nitrogen entering aquifers.

Water rights transfer projects are led by several groups in the basin. These projects would purchase water rights from landowners thus allowing more water to remain in the stream, would improve water quality.

Restoration projects in the study area are expected to improve water quality over the analysis period. Projects completed for the City of Prineville Wastewater Treatment Wetlands would improve water quality in the Crooked River as the wetland system matures 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.

Future restoration projects planned by the Crooked River Watershed Council are expected to improve water quality in the Crooked River Subbasin over the permit term by addressing contributions from return irrigation flows (Sanders pers. comm.). River restoration projects in the Deschutes River Subbasin are expected to improve water quality by stabilizing stream banks and, thus, reducing suspended solids and increasing water transparency Suspended solids also contain phosphorus, which can become available to aquatic plants when transported in water. Thus, reducing suspended solids has the added benefit to water quality of reducing the contribution of phosphorus to receiving waters and, therefore, reducing a source of nutrients to periphyton.

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 result in cumulative effects when combined with water quality effects of 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 also result in cumulative effects where combined with similar effects of climate change.

Adverse effects of decreased irrigation season flows under the proposed action and action alternatives in certain reaches of the Crooked River could result in cumulative effects where combined with water quality effects of lower summer flows associated with climate change over the permit term. These adverse cumulative effects 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, and as a result of water quality improvements associated with restoration projects.

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. Land development has encroached upon riparian and wetland vegetation communities and has converted native vegetation to agricultural, suburban, and urban land uses, which include agricultural uses for agriculture, and development by both public and private parties. 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.

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. Water conservation projects that entail increased instream flow commitments would alleviate low winter flows that historically occurred during efforts to maximize storage in upstream reservoirs. Projects that are designed to enhance or create riparian or wetland habitat would increase both the extent and quality of riparian and wetland vegetation in the study area. Other projects, such as the canal piping projects, have less clear and potentially adverse consequences for riparian and wetland vegetation. As described in Section 4.3.1 canal leakage rates have been shown to be linked to groundwater seepage and spring discharges in inner-canyon settings along the lower Crooked River. However, potential effects would not overlap with any adverse effects of the proposed action or action alternatives and would therefore not result in a cumulative effect.

Pressure for land development in basin communities could also 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

Past and present 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 increased water demand resulting from continued development and agricultural land use 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 bullhead.

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 and providing improved winter flow conditions that protect overwintering frogs in most reaches of the Upper Deschutes River. 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 cumulative conditions, but could be reduced through Conservation Measure UD-1 under the proposed action and action alternatives; and through 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). Fish passage at Opal Springs Dam was completed and was made operational November of 2019. This removed a barrier to resident and anadromous fish species to the Crooked River that has been in place since 1982. Bull trout moving upstream from Lake Billy Chinook have been observed and captured at Opal Springs Dam at RM 0.8 (FWS unpublished observations 2016–2019), and foraging subadult bull trout have been observed to migrate upstream Opal Springs Dam following construction of fish passage facilities in November 2019. Preliminary fish counts at Opal

Springs Dam as of August 1, 2020, reported 238 bull trout moved upstream through the fish ladder, ranging in length from 190 millimeters (mm) to 390 mm with an average length of 247 mm (Lickwar pers. comm.). The extent of distribution of these fish is unknown; they may occupy habitats throughout the river up to Bowman Dam during the winter when temperatures are favorable. 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 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.

However, projected effects of climate change on streams and reservoirs, described in Section 4.3.1, could result in adverse effects on the distribution and quality of fish and mollusk habitat available in the study area. Changes in precipitation patterns and precipitation type (e.g., a shift from snowpack to rain) due to climate change could affect species habitats by reducing summer streamflows and quantity of fish and mollusk habitat. Expected increase in streamflow variability and frequency of extreme flow events throughout the year would adversely affect habitat forming processes and habitat restoration actions. Projected effects of climate change on water quality described in Section 4.3.2, *Water Quality*, are expected to result in an overall decrease in water quality essential for coldwater fish 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. Water conservation and restoration actions on the Upper Deschutes River would be more beneficial when combined with WR-1 and maximum summer streamflow under the proposed action, compared to the action alternatives. Adverse effects during spring and summer with more years experiencing irrigation storage shortages and more variable streamflows during the irrigation season could be partially offset by water conservation projects as described in Section 4.3.1, but shortages and more variable streamflows would be 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. Similarly, water conservation could result in managed higher winter streamflows in the Upper Deschutes River, resulting in improved habitat for redband trout, lower summer streamflows to more rapidly allow recovery of riparian and wetland habitats, and reduce variability of Wickiup Reservoir elevations and volume.

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 affected 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 are offsetting the effect of these reductions by reducing the amount of diversion 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 Chapter 3, Section 3.5, *Land Use and Agricultural Resources*. 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 land development and changes in agricultural uses and urban development, agricultural practices, water supply infrastructure improvements, public lands management, and restoration projects. Future actions include continued land development, 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, including along federal and state designated scenic river segments, 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 land 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 to allow water managers to avoid the more frequent and earlier use of North Unit ID rental 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 habitat restoration projects (Appendix 2-B). Adverse effects in Wickiup Reservoir would have a cumulative effect given that wildlife and plant species are impaired under current water management operations and 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 (Appendix 2-B) as well as on-farm water use efficiency projects, accounted for in the analysis in Chapter 3, Section 3.9, *Socioeconomics and Environmental Justice*, could reduce socioeconomic effects on agriculture by reducing irrigation canal water losses and preserving agricultural water supplies. However, while the proposed action and action alternatives are not expected to result in conversion of agricultural lands, urban growth in central Oregon cities such as Bend and Prineville that is unrelated to the proposed action and action alternatives 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.

During economic recessions, such as currently being experienced due to the COVID-19 pandemic, any decrease in economic opportunity in the study area due to the proposed action and action alternatives would further reduce employment and income opportunities and compound the socioeconomic hardship being experienced in the community. It may also increase demand on local social service systems that may already be under strain.

4.3.9 Cultural Resources

Past and present actions have had and continue to have adverse effects on cultural resources in Wickiup Reservoir; and are likely to continue to have adverse effects on as-yet-undocumented cultural resources in the Crane Prairie, Crescent Lake, Ochoco, and Prineville Reservoirs. Operation of the reservoir for irrigation water supply has resulted in fluctuating water surface elevations, which can facilitate both the erosion of cultural resources and access to cultural resources for looting.

The proposed action would result in potential small but measurable adverse effects on cultural resources related to exposure of known and as-yet undocumented cultural resources to erosional forces and looting in the Wickiup Reservoir. The action alternatives would result in the same small but measurable adverse effects in the Wickiup and Prineville Reservoirs. Finally, the proposed action would also result in potential measurable beneficial effects on cultural resources related to reduced exposure of cultural resources to erosion and looting in the Crescent Lake and Crane Prairie Reservoirs.

Over the long term, it is anticipated that climate change could incrementally reduce water surface elevation levels and result in longer periods during which water levels in each of the reservoirs are low for both the no-action alternative and action alternatives. This, in turn, would increase the duration during which cultural resources that are usually inundated would be accessible for looting; exacerbating adverse effects on cultural resources. District water conservation projects would have an uncertain effect on reservoir fluctuations but could potentially result in longer periods during which water levels in each of the reservoirs are high for both the no-action and action alternatives. This would reduce the amount of time during which intermittently inundated cultural resources would be subaerially exposed, reducing the time when these resources would be accessible for looting—a beneficial effect for cultural 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

The proposed action and action alternatives were designed to incorporate conservation measures to minimize and mitigate take of covered species while avoiding, minimizing, and/or mitigating adverse impacts on other aspects of the environment, where practicable. As described in Chapter 2, *Proposed Action and Alternatives*, the proposed action and action alternatives all require the implementation of conservation strategies that would ensure any adverse effects from the potential take of the covered species is offset consistent with Endangered Species Act Section 10(a)(2)(B) issuance criteria.

As described in Chapter 3, *Affected Environment and Environmental Consequences*, potential effects associated with the proposed action and action alternatives would be not adverse or beneficial compared to the no-action alternative for the majority of resources evaluated. However, due to the nature of the Deschutes Basin HCP and associated covered activities, the proposed action and action alternatives necessarily alter surface water levels and instream flows, and with such changes, some adverse impacts cannot be avoided. The proposed action and action alternatives would have potential adverse effects on water quality in Wickiup Reservoir and portions of the Crooked River (Section 3.3), non-covered game fish species (Section 3.4), whitewater sporting opportunities in the Upper Deschutes River (Section 3.7), tribal resources related to salmon and steelhead reintroduction (Section 3.8), socioeconomics (Section 3.9), and cultural resources in Wickiup Reservoir (Section 3.10). Alternatives 3 and 4 would also have adverse effects on water quality in the Upper Deschutes River and on cultural resources in Prineville Reservoir.

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 action alternatives 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 action alternatives, 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 Irrigation District (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	21
Jennifer O'Reilly	FWS	Biological Resources (Oregon Spotted Frog, Vegetation, and Wildlife) Reviewer	MS Environmental and Forest Biology; BS Environmental Science and Water Resources	26
Peter Lickwar	FWS	Biological Resources (Fish and Mollusks) Reviewer	MS Ecology and Forestry; BS Biology and Zoology	29
Dave Zippin, PhD	ICF	Project Director	PhD Plant Ecology and Conservation Biology; BS Ecology, Behavior and Evolution	30
Steve Centerwall	ICF	Project Manager	BS Environmental Policy Analysis and Planning	34
Deborah Bartley	ICF	Deputy Project Manager	BA Political Science	21
Laura Zanetto	ICF	Project Coordinator	BLA Bachelor of Landscape Architecture	9
Joe Bashore	ICF	Project Support	BS Environmental Management and Protection	4
Lydia Dadd	ICF	Project Support	BS Environmental Studies	1
Stephanie Monzon	ICF	Lead Editor	MA and BA English	21
Saadia Byram	ICF	Editor	N/A	26
Laura Cooper	ICF	Editor	BA English	15
Kristen Lundstrom	ICF	Editor	BA English	15
Christine McCrory	ICF	Editor	PhD Candidate Germanic Languages and Literatures	16
Anthony Ha	ICF	Publication Specialist	BA English	15
Jesse Cherry	ICF	Publication Specialist	BA Human Rights	9
Matt Wood	ICF	GIS	MS Geography; BS Environmental Biology/Zoology	10
Brad Stein	ICF	GIS	BS International Affairs	20
Emma Brenneman	ICF	GIS	MS Geography BA Environmental Geography BA Spanish Literature	3

Preparer Name	Entity	Role	Education	Years of Experience
Greg Blair	ICF	Aquatic Resources (Fish); Tribal Resources	MS and BS Fisheries	29
Laura McMullen, PhD	ICF	Aquatic Resources (Mollusks)	PhD Zoology; BS Biology	9
Chris Earle, PhD	ICF	Vegetation and Terrestrial Wildlife	PhD Forest Ecology; MS Geosciences; BA Biology, Geology	26
Colleen Lingappaiah	ICF	Land Use	BA Biology	27
Jennifer Ban	ICF	Aesthetics and Visual Resources	BLA Bachelor of Landscape Architecture	21
Steve Hall	ICF	Recreation	BS Wildlife and Wildland Recreation Management	33
Alex Stevenson	ICF	Cultural Resources	MS Archaeology; BA Anthropology	17
Tait Elder	ICF	Cultural Resources	MA Archaeology; BA Anthropology	16
Matty Evoy-Mount	ICF	Response to Comments	BA Environmental Studies	11
Vicki Heron	ICF	Response to Comments	MS Soils and Environmental Pollution BS Geography	17
Troy Brandt	River Design Group	Hydrology, Climate	MS Environmental Studies - Aquatic Ecology; BS Environmental Biology	21
Chris Nelson	River Design Group	RiverWare Model Output Post-Processing	PE CFM; BS Civil Engineering (Bio-Resources)	19
Wendy Wente, PhD	Mason, Bruce, & Girard, Inc.	Oregon Spotted Frog	PhD Ecology, Evolution and Animal Behavior; BS Zoology	28
Joseph Eilers	MaxDepth Aquatics, Inc.	Water Quality	MS Water Resources; BA Biological Sciences	43
Barbara Wyse	Highland Economics	Agricultural Resources, Socioeconomics and Environmental Justice	MS Agricultural and Natural Resource Economics; BA Environmental Sciences and Policy	16
Adam Sussman	GSI Water Solutions	Groundwater Resources and Water Storage and Supply	MS Resource Geography; BS Environmental Studies and Physical Geography	27
Bruce Brody-Heine	GSI Water Solutions	Groundwater Resources	MS Contaminant Hydrogeology; BS Geology	31
Owen McMurtrey	GSI Water Solutions	Water Storage and Supply	MS Water Resource Policy and Management; BA Environmental Studies	6

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)