



Columbia River System Operations Final Environmental Impact Statement July 2020

Co-lead Agencies:

U.S. Army Corps of Engineers – Northwestern Division

Bureau of Reclamation – Columbia-Pacific Northwest Region

Bonneville Power Administration (DOE/EIS-0529)



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TABLE OF CONTENTS

Executive Summary	1
Preface	2
1 Introduction	6
2 Regional Input	9
2.1 Public Scoping.....	9
2.2 Cooperating Agencies.....	9
2.3 Tribal Coordination and Perspective	10
2.4 Areas of Controversy	12
2.5 Issues to be Resolved	15
3 Development and Comparison of Alternatives	15
4 No Action Alternative	19
5 Multiple Objective Alternative 1 (MO1)	20
6 Multiple Objective Alternative 2 (MO2)	22
7 Multiple Objective Alternative 3 (MO3)	24
8 Multiple Objective Alternative 4 (MO4)	29
9 Alternatives Considered but not Evaluated in Detail.....	31
10 Preferred Alternative	32
Acronyms and Abbreviations.....	xli
Glossary.....	xlvi
Datum Conversion.....	lviii
CHAPTER 1 - Introduction	1-1
1.1 Background	1-1
1.2 Purpose and Need for Action	1-4
1.3 Scope of the Project	1-5
1.3.1 Geographic and Temporal Scope.....	1-5
1.4 Columbia River System Operations Interagency Team.....	1-6
1.4.1 Co-Lead Agencies.....	1-6
1.4.2 Co-Lead Agency Framework	1-7
1.4.3 Cooperating Agency Involvement.....	1-7
1.5 National Environmental Policy Act Process and Public Involvement.....	1-9
1.5.1 Overview of the National Environmental Policy Act Process	1-9
1.5.2 Public Involvement	1-11
1.6 Key Issues and Resource Concerns.....	1-15
1.6.1 Issues Identified During Scoping.....	1-15
1.6.2 Resource Concerns	1-16
1.6.3 Climate Change Consideration for the Columbia River System Operations.....	1-19
1.7 Relationship to Other Federal National Environmental Policy Act Efforts, And Other Federal Studies, Documents, and Reports	1-19
1.8 Relevant National Environmental Policy Act and Endangered Species Act Documents and Reports	1-23

Columbia River System Operations Environmental Impact Statement
Table of Contents

1.9	Introduction to Columbia River System Operations	1-24
1.9.1	Federal Dams and Reservoirs	1-25
1.9.2	Storage and Run-of-River Projects.....	1-28
1.9.3	Non-Federal Dams and Reservoirs.....	1-32
1.9.4	System Planning and Operations.....	1-35
1.9.5	Annual Planning.....	1-35
1.9.6	Annual and Short-Term Operation	1-37
1.9.7	Operational Strategies to Meet Other System Uses, Planning and Operations.....	1-40
CHAPTER 2 - Alternatives.....		2-1
2.1	Introduction	2-1
2.2	Overview of Alternatives Development Process	2-1
2.2.1	Objectives.....	2-2
2.2.2	Measures.....	2-3
2.3	Alternative Screening	2-4
2.4	Range of Alternatives	2-5
2.4.1	Introduction.....	2-5
2.4.2	No Action Alternative	2-6
2.4.3	Multiple Objective Alternative 1.....	2-38
2.4.4	Multiple Objective Alternative 2.....	2-48
2.4.5	Multiple Objective Alternative 3.....	2-55
2.4.6	Multiple Objective Alternative 4.....	2-62
2.5	Alternatives Considered but Removed from Further Consideration	2-70
2.5.1	Single Objective Focus Alternative for Increased Spill to 125 Percent TDG with Extended Duration	2-71
2.5.2	Single Objective Focus Juvenile Anadromous Fish Survival Alternative	2-71
2.5.3	Single Objective Focus Adult Anadromous Fish Survival Alternative	2-71
2.5.4	Single Objective Focus ESA-Listed Resident Fish Survival Alternative.....	2-72
2.5.5	Single Objective Focus on Hydropower Generation Alternative.....	2-72
2.5.6	Single Objective Focus Water Management Alternative	2-72
2.5.7	Single Objective Focus Water Supply Alternative	2-73
2.5.8	Single Objective Focus Lower Snake River Dam Breaching Alternative	2-74
2.5.9	Multiple Objective Alternative Crosswalk.....	2-74
2.5.10	Other Proposals and Measures Considered but Removed from Further Consideration	2-79
CHAPTER 3 - Affected Environment and Environmental Consequences		3-1
3.1	Introduction and Background.....	3-1
3.1.1	Assumptions	3-4
3.1.2	Resources Screened from Further Analysis	3-4
3.1.3	Summary of Environmental Consequences	3-5
3.2	Hydrology and Hydraulics.....	3-16
3.2.1	Introduction and Background.....	3-16
3.2.2	Area of Analysis	3-19

Columbia River System Operations Environmental Impact Statement
Table of Contents

3.2.3	Affected Environment	3-22
3.2.4	Environmental Consequences	3-30
3.3	River Mechanics	3-188
3.3.1	Area of Analysis	3-188
3.3.2	Affected Environment	3-191
3.3.3	Environmental Consequences	3-212
3.3.4	Tribal Interests.....	3-237
3.4	Water Quality.....	3-238
3.4.1	Area of Analysis	3-239
3.4.2	Affected Environment	3-240
3.4.3	Environmental Consequences	3-250
3.4.4	Tribal Interests.....	3-288
3.5	Aquatic Habitat, Aquatic Invertebrates, and Fish	3-291
3.5.1	Introduction.....	3-291
3.5.2	Affected Environment	3-292
3.5.3	Environmental Consequences	3-384
3.5.4	Tribal Interests.....	3-683
3.6	Vegetation, Wetlands, Wildlife, and Floodplains.....	3-686
3.6.1	Area of Analysis	3-686
3.6.2	Affected Environment	3-701
3.6.3	Environmental Consequences	3-717
3.6.4	Tribal Interests.....	3-813
3.7	Power Generation and Transmission.....	3-815
3.7.1	Introduction and Background.....	3-815
3.7.2	Affected Environment	3-818
3.7.3	Environmental Consequences	3-848
3.7.4	Tribal Interests.....	3-1005
3.8	Air Quality and Greenhouse Gases	3-1006
3.8.1	Introduction.....	3-1006
3.8.2	Affected Environment	3-1007
3.8.3	Environmental Consequences	3-1025
3.8.4	Tribal Interests.....	3-1067
3.9	Flood Risk Management.....	3-1069
3.9.1	Introduction and Background.....	3-1069
3.9.2	Area of Analysis	3-1071
3.9.3	Affected Environment	3-1072
3.9.4	Environmental Consequences	3-1088
3.9.5	Tribal Interests.....	3-1101
3.10	Navigation and Transportation.....	3-1102
3.10.1	Introduction and Background.....	3-1102
3.10.2	Affected Environment	3-1109
3.10.3	Environmental Consequences	3-1127
3.10.4	Tribal Interests.....	3-1203

Columbia River System Operations Environmental Impact Statement
Table of Contents

3.11	Recreation	3-1205
3.11.1	Introduction and Background	3-1205
3.11.2	Affected Environment	3-1208
3.11.3	Environmental Consequences	3-1225
3.11.4	Tribal Interests.....	3-1295
3.12	Water Supply.....	3-1296
3.12.1	Introduction and Background	3-1296
3.12.2	Affected Environment	3-1299
3.12.3	Environmental Consequences	3-1308
3.13	Visual.....	3-1331
3.13.1	Introduction and Background	3-1331
3.13.2	Affected Environment	3-1331
3.13.3	Environmental Consequences	3-1332
3.13.4	Tribal Interest	3-1344
3.14	Noise	3-1346
3.14.1	Introduction and Background	3-1346
3.14.2	Affected Environment	3-1346
3.14.3	Environmental Consequences	3-1348
3.15	Fisheries and Passive Use	3-1355
3.15.1	Introduction and Background	3-1355
3.15.2	Affected Environment	3-1355
3.15.3	Environmental Consequences	3-1380
3.15.4	Tribal Interests.....	3-1388
3.16	Cultural Resources.....	3-1390
3.16.1	Introduction and Background	3-1390
3.16.2	Affected Environment	3-1391
3.16.3	Environmental Consequences	3-1411
3.17	Indian Trust Assets, Tribal Perspectives, and Tribal Interests.....	3-1451
3.17.1	Indian Trust Assets	3-1451
3.17.2	Tribal Perspectives Summaries	3-1456
3.17.3	Tribal Interests.....	3-1470
3.18	Environmental Justice	3-1472
3.18.1	Introduction and Background	3-1472
3.18.2	Affected Environment	3-1473
3.18.3	Environmental Consequences	3-1489
3.19	Implementation and System Cost Analysis.....	3-1565
3.19.1	Summary of Cost Analysis Methodology	3-1566
3.19.2	Summary of Columbia River System Operations Implementation and System Costs.....	3-1570
3.19.3	Summary of Regional Economic Effects of CRSO EIS Implementation and System Expenditures	3-1574

CHAPTER 4 - Climate	4-1
4.1 Climate Change in the Columbia River Basin	4-1
4.1.1 Approach	4-2
4.1.2 Projected Changes in Hydroclimate.....	4-3
4.2 Potential Effects of Climate Change by Resource	4-18
4.2.1 Hydrology and Hydraulics	4-19
4.2.2 River Mechanics	4-23
4.2.3 Water Quality	4-27
4.2.4 Anadromous Fish.....	4-33
4.2.5 Resident Fish, Aquatic Invertebrates, and Aquatic Habitat	4-39
4.2.6 Vegetation, Wetlands, Wildlife, and Floodplains.....	4-48
4.2.7 Power Generation and Transmission.....	4-54
4.2.8 Air Quality and Greenhouse Gases	4-56
4.2.9 Flood Risk Management	4-58
4.2.10 Navigation and Transportation.....	4-60
4.2.11 Recreation	4-62
4.2.12 Water Supply (Irrigation, Municipal, Industrial, Groundwater, and Aquifers).....	4-65
4.2.13 Visual.....	4-67
4.2.14 Noise.....	4-68
4.2.15 Fisheries.....	4-68
4.2.16 Cultural Resources.....	4-69
4.2.17 Indian Trust Assets, Tribal Perspectives, and Tribal Interests.....	4-73
4.2.18 Environmental Justice.....	4-74
CHAPTER 5 - Mitigation	5-1
5.1 Introduction	5-1
5.1.1 Overview of Mitigation.....	5-1
5.1.2 Avoidance and Minimization Measures.....	5-2
5.1.3 Conservation Recommendations per Fish and Wildlife Coordination Act of 1934	5-3
5.1.4 Affected Resources.....	5-3
5.2 Decision Framework and Selection Process	5-4
5.2.1 Existing Programs that Include Mitigation Under the No Action Alternative.....	5-5
5.3 Considerations for Endangered Species Act Compliance	5-15
5.4 Potential Mitigation for Alternatives.....	5-15
5.4.1 Mitigation Measures for Multiple Objective Alternative 1	5-15
5.4.2 Mitigation Measures Proposed for Multiple Objective Alternative 2	5-27
5.4.3 Mitigation Measures Proposed for Multiple Objective Alternative 3	5-34
5.4.4 Mitigation Measures for Multiple Objective Alternative 4	5-47
5.5 Monitoring and Adaptive Management	5-54
5.5.1 Monitoring Strategy	5-54
5.5.2 Adaptive Management.....	5-55

CHAPTER 6 - Cumulative Effects	6-1
6.1 Introduction	6-1
6.1.1 Analysis Approach	6-1
6.1.2 Geographic and Temporal Scope.....	6-1
6.1.3 Identification of Past, Present, and Reasonably Foreseeable Future Actions.....	6-2
6.2 Cumulative Actions Scenario	6-4
6.3 Cumulative Effects Analysis.....	6-18
6.3.1 Analyses.....	6-18
CHAPTER 7 - Preferred Alternative	7-1
7.1 Introduction	7-1
7.2 Ability to Meet the Purpose and Need	7-3
7.3 Evaluation of the No Action Alternative and Multiple Objective Alternatives.....	7-4
7.3.1 No Action Alternative	7-5
7.3.2 Multiple Objective Alternative 1.....	7-6
7.3.3 Multiple Objective Alternative 2.....	7-7
7.3.4 Multiple Objective Alternative 3.....	7-9
7.3.5 Multiple Objective Alternative 4.....	7-14
7.4 Summary	7-16
7.5 Development of the Preferred Alternative.....	7-22
7.6 Description of the Preferred Alternative	7-22
7.6.1 Measures Carried Forward, Modified, or Added from Alternatives in Chapter 2.....	7-24
7.6.2 Preferred Alternative Structural Measures.....	7-25
7.6.3 Preferred Alternative Operational Measures	7-31
7.6.4 Mitigation Measures	7-39
7.7 Effects of the Preferred Alternative	7-51
7.7.1 Hydrology and Hydraulics	7-52
7.7.2 River Mechanics	7-83
7.7.3 Water Quality	7-84
7.7.4 Anadromous Fish.....	7-92
7.7.5 Resident Fish	7-118
7.7.6 Macroinvertebrates.....	7-142
7.7.7 Vegetation, Wildlife, Wetlands, and Floodplains.....	7-145
7.7.8 Special Status Species.....	7-155
7.7.9 Power Generation and Transmission.....	7-160
7.7.10 Air Quality and Greenhouse Gases	7-183
7.7.11 Flood Risk Management	7-184
7.7.12 Navigation and Transportation.....	7-185
7.7.13 Recreation	7-188
7.7.14 Water Supply	7-197
7.7.15 Visual	7-197
7.7.16 Noise.....	7-197
7.7.17 Fisheries and Passive Use	7-197

Columbia River System Operations Environmental Impact Statement
Table of Contents

7.7.18	Cultural Resources	7-198
7.7.19	Indian Trust Assets, Tribal Perspectives, and Tribal Interests	7-203
7.7.20	Environmental Justice.....	7-204
7.7.21	Costs	7-205
7.8	Potential Climate Effects by Resource.....	7-208
7.8.1	Hydrology and Hydraulics	7-209
7.8.2	River Mechanics	7-209
7.8.3	Water Quality	7-209
7.8.4	Anadromous Fish.....	7-210
7.8.5	Resident Fish	7-210
7.8.6	Vegetation, Wildlife, Wetlands, and Floodplains.....	7-210
7.8.7	Power Generation and Transmission.....	7-210
7.8.8	Air Quality and Greenhouse Gases	7-211
7.8.9	Flood Risk Management	7-211
7.8.10	Navigation and Transportation.....	7-211
7.8.11	Recreation	7-211
7.8.12	Water Supply	7-211
7.8.13	Visual	7-212
7.8.14	Noise.....	7-212
7.8.15	Fisheries and Passive Use	7-212
7.8.16	Cultural Resources.....	7-212
7.8.17	Indian Trust Assets, Tribal Perspectives, and Tribal Interests	7-212
7.8.18	Environmental Justice.....	7-212
7.9	Cumulative Effects of the Preferred Alternative.....	7-213
7.9.1	Analysis Approach	7-213
7.9.2	Geographic and Temporal Scope.....	7-213
7.9.3	Cumulative Actions Scenario	7-213
7.9.4	Hydrology and Hydraulics.....	7-217
7.9.5	River Mechanics	7-217
7.9.6	Water Quality	7-217
7.9.7	Anadromous Fish.....	7-218
7.9.8	Resident Fish	7-219
7.9.9	Vegetation, Wildlife, Wetlands, and Floodplains.....	7-219
7.9.10	Power Generation and Transmission.....	7-220
7.9.11	Air Quality and Greenhouse Gases	7-222
7.9.12	Flood Risk Management	7-222
7.9.13	Navigation and Transportation.....	7-223
7.9.14	Recreation	7-223
7.9.15	Water Supply	7-225
7.9.16	Visual	7-225
7.9.17	Noise.....	7-226
7.9.18	Fisheries and Passive Use	7-226
7.9.19	Cultural Resources.....	7-227

Columbia River System Operations Environmental Impact Statement
Table of Contents

7.9.20	Indian Trust Assets, Tribal Perspectives, and Tribal Interests	7-227
7.9.21	Environmental Justice.....	7-228
7.10	Unavoidable Adverse Effects.....	7-228
7.11	Relationship between Short-Term Uses and Long-Term Productivity	7-229
7.12	Irreversible and Irretrievable Commitment of Resources	7-229
7.13	Intentional Destructive Acts	7-230
7.14	Conclusion	7-231
CHAPTER 8 - Compliance with Environmental Laws, Regulations, and Executive Orders.....		8-1
8.1	National Environmental Policy Act	8-1
8.2	Endangered Species Act	8-1
8.3	Fish and Wildlife Conservation	8-2
8.3.1	Fish and Wildlife Conservation Act of 1980	8-2
8.3.2	Fish and Wildlife Coordination Act of 1934	8-2
8.3.3	Migratory Bird Treaty Act and Executive Order 13186, Responsibilities of Federal Agencies to Protect Migratory Birds	8-3
8.3.4	Marine Mammal Protection Act	8-3
8.3.5	Magnuson-Stevens Fishery Conservation and Management Act.....	8-4
8.3.6	Pacific Northwest Electric Power Planning and Conservation Act	8-4
8.3.7	Bald and Golden Eagle Protection Act	8-4
8.4	Cultural Resources.....	8-5
8.4.1	National Historic Preservation Act.....	8-5
8.4.2	Archaeological Resources Protection Act	8-5
8.4.3	Antiquities Act	8-6
8.4.4	Native American Graves Protection and Repatriation Act.....	8-6
8.4.5	American Indian Religious Freedom Act.....	8-6
8.4.6	Paleontological Resources Preservation Act.....	8-7
8.4.7	Curation of Federally Owned and Administered Collections	8-7
8.5	Clean Water Act of 1972	8-7
8.6	Clean Air Act of 1972.....	8-9
8.7	Farmland Protection Policy Act	8-10
8.8	Federal Noxious Weed Act	8-11
8.9	Recreation Resources.....	8-11
8.9.1	Federal Water Project Recreation Act	8-11
8.9.2	Wild and Scenic Rivers Act.....	8-11
8.10	Rivers and Harbors Appropriation Act of 1899.....	8-12
8.11	Hazardous Waste	8-12
8.11.1	Comprehensive Environmental Response, Compensation, and Liability Act	8-12
8.11.2	Resource Conservation and Recovery Act	8-12
8.11.3	Toxic Substances Control Act.....	8-13
8.12	Executive Order 11990, Protection of Wetlands	8-13
8.13	Executive Order 11988, Floodplain Management	8-13
8.14	Executive Order 12898, Environmental Justice	8-14

Columbia River System Operations Environmental Impact Statement
Table of Contents

8.15	Executive Order 13112, Invasive Species, Safeguarding the Nation from the Impacts of Invasive Species	8-14
8.16	Executive Order 13007, Indian Sacred Sites	8-14
8.17	Executive Order 11593, Protection and Enhancement of the Cultural Environment.....	8-15
8.18	Executive Order 13175, Consultation and Coordination with Indian Tribal Governments.....	8-15
8.19	Secretarial Order 3175, U.S. Department of the Interior Responsibilities for Indian Trust Assets	8-15
CHAPTER 9 - Coordination and Public Involvement Process.....		9-1
9.1	Federal Register Notices and Public Meetings	9-1
9.1.1	Notice of Intent and Public Scoping Meetings.....	9-1
9.1.2	Public Scoping Comments	9-3
9.1.3	Public Review of the Draft Environmental Impact Statement	9-4
9.1.4	Public Comments of the Draft Environmental Impact Statement.....	9-5
9.2	Public Communication Tools	9-5
9.2.1	News Releases and Advertisements	9-5
9.2.2	Mailing Lists.....	9-5
9.2.3	Website	9-5
9.2.4	Newsletters and Electronic Public Updates	9-6
9.2.5	In Progress Public Update Webinars.....	9-6
9.2.6	Videos.....	9-6
9.3	Federally Recognized Tribes and Tribal Entities	9-6
9.3.1	Tribal Engagement During Public Scoping	9-6
9.3.2	Tribal Engagement during Draft EIS Review and Comment Period.....	9-7
9.3.3	Government-to-Government Consultation and Tribal Engagement.....	9-7
9.4	Cooperating Agencies.....	9-9
9.4.1	Overview of the Cooperating Agencies' Comments of Draft EIS.....	9-11
CHAPTER 10 - Preparers.....		10-1
CHAPTER 11 - References		11-1
CHAPTER 12 - List of Appendices		12-1
CHAPTER 13 - Index		13-1

List of Figures

Figure 1-1. Geographic Locations of the Columbia River System Projects	1-2
Figure 1-2. The Environmental Impact Statement National Environmental Policy Act Overview Process.....	1-10
Figure 1-3. Map of Public Scoping Meeting Locations.....	1-12
Figure 1-4. Graphic Representation of Storage and Run-of-River Projects	1-28
Figure 1-5. Comparison of Major Western River Basins.....	1-29
Figure 1-6. Median Hydrographs of Dry, Average, and Wet Years at Libby Project	1-31
Figure 1-7. Columbia River Watershed System	1-32
Figure 1-8. Seasonal Operations of Columbia River System	1-38
Figure 1-9. Passage Routes of Juvenile Salmon for Conventional Spill and Spillway Weir Routes.....	1-45
Figure 3-1. Columbia River Basin.....	3-17
Figure 3-2. Columbia River Basin Regions (Regions A, B, C, and D)	3-19
Figure 3-3. Columbia River Stream Flows as Measured at The Dalles, Oregon, October 2016–September 2017.....	3-23
Figure 3-4. Water Surface Profiles for the Columbia River System Hydraulic Model Reaches.....	3-24
Figure 3-5. Water Surface and Ground Surface Profiles of Typical Hydraulic Reach, and the Three Zones of Influence	3-25
Figure 3-6. Map of Hydraulic Reaches Showing the Zones of Influence	3-26
Figure 3-7. Seasonal Operations at Major Columbia River System Storage Dams.....	3-34
Figure 3-8. Lake Koochanusa Summary Hydrograph for No Action Alternative	3-48
Figure 3-9. Libby Dam Outflow Summary Hydrograph for No Action Alternative	3-49
Figure 3-10. Bonners Ferry Flow Summary Hydrograph for No Action Alternative.....	3-50
Figure 3-11. Hungry Horse Reservoir Summary Hydrograph for No Action Alternative	3-51
Figure 3-12. Hungry Horse Dam Outflow Summary Hydrograph for No Action Alternative.....	3-52
Figure 3-13. Columbia Falls Flow Summary Hydrograph for No Action Alternative	3-53
Figure 3-14. Lake Pend Oreille Summary Hydrograph for No Action Alternative	3-54
Figure 3-15. Lake Roosevelt Summary Hydrograph for No Action Alternative.....	3-55
Figure 3-16. Grand Coulee Dam Outflow Summary Hydrograph for No Action Alternative.....	3-56
Figure 3-17. Dworshak Reservoir Summary Hydrograph for No Action Alternative.....	3-58
Figure 3-18. Dworshak Dam Outflow Summary Hydrograph for No Action Alternative.....	3-59
Figure 3-19. John Day Dam Operating Range for No Action Alternative	3-60
Figure 3-20. McNary Dam Outflow Summary Hydrograph for No Action Alternative	3-61
Figure 3-21. Lake Koochanusa Summary Hydrograph for Multiple Objective Alternative 1.....	3-63
Figure 3-22. Lake Koochanusa Water Year Type Hydrographs for Multiple Objective Alternative 1.....	3-65
Figure 3-23. Lake Koochanusa Summer Elevations for Multiple Objective Alternative 1	3-65
Figure 3-24. Libby Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 1	3-66
Figure 3-25. Hungry Horse Reservoir Summary Hydrograph for Multiple Objective Alternative 1	3-69

Columbia River System Operations Environmental Impact Statement
Table of Contents

Figure 3-26. Hungry Horse Reservoir Water Year Type Hydrographs for Multiple Objective Alternative 1 3-70

Figure 3-27. Hungry Horse Reservoir Summer Elevations for Multiple Objective Alternative 1 3-70

Figure 3-28. Hungry Horse Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 1 3-71

Figure 3-29. Lake Roosevelt Inflow Summary Hydrograph for Multiple Objective Alternative 1 3-75

Figure 3-30. Lake Roosevelt Summary Hydrograph for Multiple Objective Alternative 1 3-76

Figure 3-31. Lake Roosevelt Water Year Type Hydrographs for Multiple Objective Alternative 1 3-78

Figure 3-32. Grand Coulee Dam Outflow Summary Hydrograph for Multiple Objective Alternative 1 3-79

Figure 3-33. Grand Coulee Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 1 3-82

Figure 3-34. Dworshak Reservoir Summary Hydrograph for Multiple Objective Alternative 1 3-84

Figure 3-35. Dworshak Reservoir Water Year Type Hydrographs for Multiple Objective Alternative 1 3-85

Figure 3-36. Dworshak Dam Outflow Summary Hydrograph for Multiple Objective Alternative 1 3-86

Figure 3-37. Dworshak Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 1 3-87

Figure 3-38. John Day Dam Operating Range for Multiple Objective Alternative 1..... 3-89

Figure 3-39. McNary Dam Outflow Summary Hydrograph for Multiple Objective Alternative 1 3-90

Figure 3-40. McNary Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 1 3-91

Figure 3-41. Lake Kocanusa Summary Hydrograph for Multiple Objective Alternative 2..... 3-94

Figure 3-42. Lake Kocanusa Water Year Type Hydrographs for Multiple Objective Alternative 2 3-96

Figure 3-43. Lake Kocanusa Summer Elevations for Multiple Objective Alternative 2 3-96

Figure 3-44. Libby Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 2 3-97

Figure 3-45. Hungry Horse Reservoir Summary Hydrograph for Multiple Objective Alternative 2 3-100

Figure 3-46. Hungry Horse Reservoir Water Year Type Hydrographs for Multiple Objective Alternative 2 3-101

Figure 3-47. Hungry Horse Reservoir Summer Elevations for Multiple Objective Alternative 2 3-102

Figure 3-48. Hungry Horse Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 2 3-102

Figure 3-49. Albeni Falls Dam Outflow Summary Hydrograph for Multiple Objective Alternative 2 3-105

Columbia River System Operations Environmental Impact Statement
Table of Contents

Figure 3-50. Albeni Falls Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 2 3-106

Figure 3-51. Lake Roosevelt Inflow Summary Hydrograph for Multiple Objective Alternative 2 3-107

Figure 3-52. Lake Roosevelt Summary Hydrograph for Multiple Objective Alternative 2 3-109

Figure 3-53. Lake Roosevelt Water Year Type Hydrographs for Multiple Objective Alternative 2 3-110

Figure 3-54. Grand Coulee Dam Outflow Summary Hydrograph for Multiple Objective Alternative 2 3-113

Figure 3-55. Grand Coulee Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 2 3-113

Figure 3-56. Dworshak Reservoir Summary Hydrograph for Multiple Objective Alternative 2 3-115

Figure 3-57. Dworshak Reservoir Water Year Type Hydrographs for Multiple Objective Alternative 2 3-116

Figure 3-58. Dworshak Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 2 3-117

Figure 3-59. John Day Dam Operating Range for Multiple Objective Alternative 2 3-120

Figure 3-60. McNary Dam Outflow Summary Hydrograph for Multiple Objective Alternative 2 3-121

Figure 3-61. McNary Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 2 3-123

Figure 3-62. Lake Koochanusa Summary Hydrograph for Multiple Objective Alternative 3 3-125

Figure 3-63. Lake Koochanusa Water Year Type Hydrographs for Multiple Objective Alternative 3 3-127

Figure 3-64. Lake Koochanusa Summer Elevations for Multiple Objective Alternative 3 3-127

Figure 3-65. Libby Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 3 3-128

Figure 3-66. Hungry Horse Reservoir Summary Hydrograph for Multiple Objective Alternative 3 3-132

Figure 3-67. Hungry Horse Reservoir Water Year Type Hydrographs for Multiple Objective Alternative 3 3-133

Figure 3-68. Hungry Horse Reservoir Summer Elevations for Multiple Objective Alternative 3 3-133

Figure 3-69. Hungry Horse Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 3 3-134

Figure 3-70. Lake Roosevelt Inflow Summary Hydrograph for Multiple Objective Alternative 3 3-138

Figure 3-71. Lake Roosevelt Summary Hydrograph for Multiple Objective Alternative 3 3-139

Figure 3-72. Lake Roosevelt Water Year Type Hydrographs for Multiple Objective Alternative 3 3-140

Figure 3-73. Grand Coulee Dam Outflow Summary Hydrograph for Multiple Objective Alternative 3 3-141

Columbia River System Operations Environmental Impact Statement
Table of Contents

Figure 3-74. Grand Coulee Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 3 3-144

Figure 3-75. Lower Snake River Water Surface Profiles for Multiple Objective Alternative 3 3-147

Figure 3-76. John Day Dam Operating Range for Multiple Objective Alternative 3..... 3-148

Figure 3-77. McNary Dam Outflow Summary Hydrograph for Multiple Objective Alternative 3 3-149

Figure 3-78. McNary Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 3 3-150

Figure 3-79. Lake Kocanusa Summary Hydrograph for Multiple Objective Alternative 4..... 3-153

Figure 3-80. Lake Kocanusa Water Year Type Hydrographs for Multiple Objective Alternative 4 3-154

Figure 3-81. Lake Kocanusa Summer Elevations for Multiple Objective Alternative 4 3-155

Figure 3-82. Libby Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 4 3-156

Figure 3-83. Hungry Horse Reservoir Summary Hydrograph for Multiple Objective Alternative 4 3-160

Figure 3-84. Hungry Horse Reservoir Water Year Type Hydrographs for Multiple Objective Alternative 4 3-161

Figure 3-85. Hungry Horse Reservoir Summer Elevations for Multiple Objective Alternative 4 3-161

Figure 3-86. Hungry Horse Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 4 3-163

Figure 3-87. Lake Pend Oreille Summary Hydrograph for Multiple Objective Alternative 4 .. 3-165

Figure 3-88. Lake Pend Oreille Water Year Type Hydrographs for Multiple Objective Alternative 4 3-166

Figure 3-89. Lake Pend Oreille Summer Elevations for Multiple Objective Alternative 4..... 3-167

Figure 3-90. Albeni Falls Dam Outflow Summary Hydrograph for Multiple Objective Alternative 4 3-168

Figure 3-91. Albeni Falls Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 4 3-170

Figure 3-92. Lake Roosevelt Inflow Summary Hydrograph for Multiple Objective Alternative 4 3-171

Figure 3-93. Lake Roosevelt Summary Hydrograph for Multiple Objective Alternative 4 3-172

Figure 3-94. Lake Roosevelt Peak Elevation Frequency for Multiple Objective Alternative 4 3-174

Figure 3-95. Lake Roosevelt Water Year Type Hydrographs for Multiple Objective Alternative 4 3-175

Figure 3-96. Lake Roosevelt Summer Elevations for Multiple Objective Alternative 4 3-176

Figure 3-97. Grand Coulee Dam Outflow Summary Hydrograph for Multiple Objective Alternative 4 3-177

Figure 3-98. Grand Coulee Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 4 3-180

Figure 3-99. John Day Dam Operating Range for Multiple Objective Alternative 4..... 3-183

Columbia River System Operations Environmental Impact Statement
Table of Contents

Figure 3-100. McNary Dam Outflow Summary Hydrograph for Multiple Objective
Alternative 4 3-184

Figure 3-101. McNary Dam Outflow Water Year Type Hydrographs for Multiple
Objective Alternative 4 3-186

Figure 3-102. Overview Map of Study Area Regions Used for River Mechanics
Assessment 3-188

Figure 3-103. Mean Daily Mean Discharges at U.S. Geological Survey Gages 3-192

Figure 3-104. Reservoir Sediment Profile with Delta and Lakebed Sediment Deposits..... 3-194

Figure 3-105. River Planform Examples of Relatively Different Width to Depth Ratio
Ranges Observed in the Columbia River System Study Area..... 3-209

Figure 3-106. Water Quality Study Area Map 3-240

Figure 3-107. Columbia River System Operations Environmental Impact Statement
Water Quality Modeling Framework 3-251

Figure 3-108. Water Temperature Impact Framework and Decision Criteria 3-253

Figure 3-109. Study Area Map..... 3-293

Figure 3-110. Example Hydrograph Showing the Average Discharge throughout the Year
at Bonneville Dam..... 3-298

Figure 3-111. Combined Annual Salmon and Steelhead Returns (all species) to
Bonneville Dam from 1938-2019. 3-306

Figure 3-112. Ocean Ecosystem Indicators of the Northern California Current 3-307

Figure 3-113. Rank Scores Derived from Ocean Ecosystem Indicators Data 3-308

Figure 3-114. Recent Estimates of Dam Survival at Columbia River System Projects..... 3-310

Figure 3-115. 1998-2019 Annual average survival estimates for Passive Integrated
Transponder–Tagged Yearling Chinook Salmon and Steelhead, Hatchery, and
Wild Fish Combined 3-311

Figure 3-116. 2015–2019 Snake River Salmon and Steelhead Upstream Survival Rates..... 3-311

Figure 3-117. Freshwater Life Phases for Upper Columbia River Spring-Run Chinook
Salmon Evolutionarily Significant Unit 3-316

Figure 3-118. Freshwater Life Phases of Lower Columbia River Chinook Salmon
Evolutionarily Significant Unit 3-317

Figure 3-119. Freshwater Life Phases of Snake River Spring/Summer-Run Chinook
Salmon Evolutionarily Significant Unit 3-318

Figure 3-120. Freshwater Life Phases of Snake River Fall-Run Chinook Salmon..... 3-319

Figure 3-121. Freshwater Life Phases of Snake River Sockeye Salmon Evolutionarily
Significant Unit..... 3-320

Figure 3-122. Freshwater Life Phases of Lower Columbia River Coho Salmon
Evolutionarily Significant Unit 3-322

Figure 3-123. Freshwater Life Phases of Columbia River Chum Salmon Evolutionarily
Significant Unit..... 3-323

Figure 3-124. Freshwater Life Phases of Upper Columbia River Steelhead Distinct
Population Segment..... 3-325

Figure 3-125. Freshwater Life Phases of Middle Columbia River Steelhead Distinct
Population Segment..... 3-326

Figure 3-126. Freshwater Life Phases of Lower Columbia River Steelhead Distinct
Population Segment.....3-327

Figure 3-127. Freshwater Life Phases of Snake River Basin Steelhead Distinct Population
Segment.....3-328

Figure 3-128. Freshwater Life Phases of Columbia River Summer/Fall-Run Chinook
Salmon3-332

Figure 3-129. Freshwater Life Phases of Middle Columbia River Spring-Run Chinook
Salmon Evolutionarily Significant Unit3-333

Figure 3-130. Study Area for Kootenai River (Lake Kocanusa to U.S.-Canada Border)
Region3-351

Figure 3-131. Study Area for the Flathead and Clark Fork Rivers from Hungry Horse
Reservoir Tributaries to Montana-Idaho Border3-356

Figure 3-132. Study Area for Lake Pend Oreille and Pend Oreille River3-363

Figure 3-133. Study Area for Columbia River (U.S.-Canada Border to Chief Joseph Dam)3-366

Figure 3-134. Study Area for Columbia River – Chief Joseph Dam to McNary Dam3-372

Figure 3-135. Study Area for the Snake River.....3-374

Figure 3-136. Study Area for Columbia River – McNary Dam to Bonneville Dam.....3-378

Figure 3-137. Study Area for Columbia River – Below Bonneville Dam.....3-380

Figure 3-138. Hungry Horse Study Area for Vegetation, Wetlands, and Wildlife3-688

Figure 3-139. Libby Study Area for Vegetation, Wetlands, and Wildlife3-689

Figure 3-140. Albeni Falls Study Area for Vegetation, Wetlands, and Wildlife3-690

Figure 3-141. Grand Coulee Study Area for Vegetation, Wetlands, and Wildlife3-691

Figure 3-142. Chief Joseph Study Area for Vegetation, Wetlands, and Wildlife3-692

Figure 3-143. Dworshak Study Area for Vegetation, Wetlands, and Wildlife3-693

Figure 3-144. Lower Granite Study Area for Vegetation, Wetlands, and Wildlife3-694

Figure 3-145. Little Goose Study Area for Vegetation, Wetlands, and Wildlife3-695

Figure 3-146. Lower Monumental Study Area for Vegetation, Wetlands, and Wildlife3-696

Figure 3-147. Ice Harbor Study Area for Vegetation, Wetlands, and Wildlife3-697

Figure 3-148. McNary Study Area for Vegetation, Wetlands, and Wildlife3-698

Figure 3-149. The Dalles and John Day Study Area for Vegetation, Wetlands, and Wildlife ..3-699

Figure 3-150. Bonneville and Lower Columbia River Study Area for Vegetation,
Wetlands, and Wildlife.....3-700

Figure 3-151. Diagram of Upland and Wetland Transition Zones Typical of Proximity to
Water Surface Elevations3-718

Figure 3-152. Crescent Island in McNary Reservoir.....3-730

Figure 3-153. McCormack Slough in the Umatilla National Wildlife Refuge at River Mile
2733-732

Figure 3-154. Blalock Islands Complex in the Lake Umatilla at River Mile 273.....3-732

Figure 3-155. Caspian Tern Nesting Colonies in 2018 at Middle and Long Islands in the
Blalock Islands Complex3-734

Figure 3-156. Map Showing Sensitive Areas Along the Lake Pend Oreille Shoreline.....3-798

Figure 3-157. Shorelines of Denton Slough in Lake Pend Oreille Showing Average Land
Exposure for the No Action Alternative and MO4.....3-799

Figure 3-158. Wetlands within the Clark Fork Delta on Pend Oreille Lake3-800

Columbia River System Operations Environmental Impact Statement
Table of Contents

Figure 3-159. Foundation Island in McNary Pool3-806

Figure 3-160. Transmission Area of Analysis – the Bonneville Service Area and
Transmission Lines3-817

Figure 3-161. Power Area of Analysis – the U.S. Portion of the Western Interconnection
(Black outline) and the Bonneville Service Area (pink shading)3-817

Figure 3-162. Map of Pacific Northwest Generating Resources in 20183-821

Figure 3-163. Breakdown of Annual Generation in the Pacific Northwest by Type from
2002 to 2016.....3-821

Figure 3-164. Annual Variability in Runoff at The Dalles in Million Acre-Feet, 1929 to
20193-823

Figure 3-165. Northwest Transmission Paths.....3-826

Figure 3-166. Balancing Authorities in the Western Interconnection3-829

Figure 3-167. Bonneville Utility Customers in the Pacific Northwest3-831

Figure 3-168. BPA Power Revenues3-836

Figure 3-169. Historical Bonneville Power Rates.....3-840

Figure 3-170. Historical Firm Network Transmission Rates.....3-843

Figure 3-171. Annual Average Retail Price Paid for Residential Electricity by State and the
National Average, 2000 to 2016.....3-845

Figure 3-172. Residential Electricity Consumption.....3-846

Figure 3-173. Median Household Income3-846

Figure 3-174. Residential Electricity Rates3-847

Figure 3-175. Electricity Expenditures per Household3-847

Figure 3-176. Power and Transmission Analytical Framework.....3-850

Figure 3-177. Sample Table of the Change in Bonneville’s Priority Firm Tier 1 Rate, Base
Case Bonneville Finances3-857

Figure 3-179. Monthly CRS Generation (aMW) and Market Price (\$/MWh)3-887

Figure 3-180. Breakdown of an Average Retail Electricity Rate by Component3-889

Figure 3-181. Average Residential Retail Rates in Cents per kWh (left) and Percentage of
Household Income Spent on Electricity (right).....3-891

Figure 3-182. Monthly Hydropower Generation at the CRS Projects, No Action
Alternative and Multiple Objective 1, in aMW, for the Base Case without
Rate Sensitivities or Additional Coal Plant Retirements3-896

Figure 3-183. Monthly CRS Generation (aMW) and Market Price (\$/MWh).3-908

Figure 3-184. Residential Electricity Rate Pressure Effects of Multiple Objective 1 by
Portfolio3-913

Figure 3-185. Monthly Hydropower Generation at the CRS Projects, No Action
Alternative and Multiple Objective 2, in aMW.....3-922

Figure 3-186. Market Prices and Average CRS Hydropower Generation for the Base Case
without Rate Sensitivities or Additional Coal Plant Retirements3-930

Figure 3-187. Residential Rate Pressure Effects under MO2 Relative to the No Action
Alternative3-934

Figure 3-188. Monthly Hydropower Generation at the Columbia River System Projects,
No Action Alternative and Multiple Objective 3, in aMW3-941

Columbia River System Operations Environmental Impact Statement
Table of Contents

Figure 3-189. Monthly Columbia River System Generation (aMW) and Market Price (\$/MWh) 3-965

Figure 3-190. Residential Electricity Rate Pressure Effects by Portfolio for Multiple Objective 3 for the Base Case without Rate Sensitivities or Additional Coal Plant Retirements 3-972

Figure 3-191. Monthly Hydropower Generation at the Columbia River System Projects, No Action Alternative and Multiple Objective 4, in aMW 3-980

Figure 3-192. Monthly CRS Generation (aMW) and Market Price (\$/MWh) under Multiple Objective 4..... 3-993

Figure 3-193. Residential Electricity Rate Pressure Effects by Portfolio for Multiple Objective 4 for the Base Case without Rate Sensitivities or Additional Coal Plant Retirements 3-998

Figure 3-194. Regional Air Pollutant Emissions in 2016 3-1010

Figure 3-195. Energy-Related CO₂ Emissions by Sector..... 3-1019

Figure 3-196. Columbia River System Dams, Leveed Areas, and Important Gages for Flood Risk Management 3-1072

Figure 3-197. Columbia River Streamflows as Measured at The Dalles, Oregon..... 3-1074

Figure 3-198. Locations of Columbia River System Dams, Levees, and Other Dams in Region A..... 3-1077

Figure 3-199. Locations of Columbia River System Dams, Levees, and Other Dams in Region B..... 3-1080

Figure 3-200. Locations of Columbia River System Dams, Levees, and Other Dams in Region C..... 3-1083

Figure 3-201. Locations of Columbia River System Dams, Levees, and Other Dams in Region D..... 3-1086

Figure 3-202. Downbound Freight Shipments on the Snake River, 2000 to 2018, Tons..... 3-1105

Figure 3-203. Upbound Freight Shipments on the Snake River, 2000 to 2018, Tons 3-1105

Figure 3-204. Map of the Columbia-Snake Navigation System 3-1108

Figure 3-205. CSNS Deep and Shallow Draft Freight Tonnage (2000 to 2018) 3-1111

Figure 3-206. Top 10 Commodities (Deep Draft and Shallow Draft) Moving on the CSNS, 2000 to 2018..... 3-1112

Figure 3-207. Tonnage at Major Deepwater Ports on the CSNS (average 2012 to 2016, millions of tons) 3-1113

Figure 3-208. CSNS Lock Freight Volumes by Commodity Group, 2016 to 2018 3-1114

Figure 3-209. CSNS Columbia River Lock Traffic, Number of Vessels Trips and Barges (2000 to 2018) 3-1115

Figure 3-210. CSNS Snake River Lock Traffic, Number of Vessels and Barges (2000 to 2018)..... 3-1116

Figure 3-211. CSNS Imports and Exports by Vessel Draft, 2016 3-1117

Figure 3-212. Tow Configurations that Maximize Chamber Dimensions..... 3-1120

Figure 3-213. Vessels in Navigation Lock..... 3-1126

Figure 3-214. Recent Downriver Grain Shipments (tons) on the Snake River, with No Action Alternative Forecast..... 3-1140

Figure 3-215. No Action Alternative Shipping Routes 3-1142

Columbia River System Operations Environmental Impact Statement
Table of Contents

Figure 3-216. Multiple Objective Alternative 3 Scenario 1: Shipping Routes by Mode3-1167

Figure 3-217. Multiple Objective Alternative 3 Scenario 2 (25 Percent Rail Rate Increase):
Shipping Routes by Mode3-1170

Figure 3-218. Multiple Objective Alternative 3, Scenario 3 (50 Percent Rail Rate
Increase): Shipping Routes by Mode.....3-1173

Figure 3-219. Colfax-Area Farmer Transit Route Under the No Action Scenario.....3-1179

Figure 3-220. Colfax-Area Farmer Transit Route Under Scenarios 1 and 2: No Rail Rate
Increase and 25% Rail Rate Increase.....3-1180

Figure 3-221. Colfax-Area Farmer Transit Route Under Scenario 3: 50% Rail Rate Increase 3-1181

Figure 3-222. Grangeville-Area Farmer Transit Route Under the No Action Alternative.....3-1182

Figure 3-223. Grangeville-Area Farmer Transit Route Under Scenario 1: No Rail Rate
Increase3-1183

Figure 3-224. Grangeville-Area Farmer Transit Route Under Scenarios 2 and 3: 25% and
50% Rate Increase.....3-1184

Figure 3-225. Areas of Analysis for Recreation.....3-1208

Figure 3-226. Commercial Fishing Zones on the Columbia River below McNary Dam3-1356

Figure 3-227. Total Annual Value of Commercial Chinook Salmon and Coho Salmon
Catch in the Columbia River Basin by Stock, 2007–2017, Millions of 2019
dollars3-1364

Figure 3-228. Results of NMFS Community Vulnerability Assessment for Columbia River
Basin Communities Downstream of Klickitat County, Washington3-1373

Figure 3-229. Sediment Deposition in the Snake River Projects.....3-1440

Figure 3-230. Map of Average Sediment Depth by River Mile in the Snake River Projects..3-1440

Figure 3-231. Gully Erosion in an Exposed Drawdown Zone, Lake Roosevelt, 2017.....3-1442

Figure 3-232. Polygonal Crack Formation, Wanapum Drawdown, 20143-1443

Figure 3-233. Low-Income Populations in the Study Area3-1476

Figure 3-234. Minority Populations in the Study Area3-1479

Figure 3-235. Indian Reservations and Off-Reservation Trust Lands within CRSO Regions..3-1481

Figure 3-236. Minority and Low-Income Populations, Indian Reservations, and Off-
Reservation Trust Lands.....3-1483

Figure 3-237. Minority and Low-Income Populations, Indian Reservations, and Off-
Reservation Trust Lands in the Region A.....3-1484

Figure 3-238. Minority and Low-Income Populations, Indian Reservations, and Off-
Reservation Trust Lands in the Region B.....3-1485

Figure 3-239. Minority and Low-Income Populations, Indian Reservations, and Off-
Reservation Trust Lands in the Region C.....3-1486

Figure 3-240. Minority and Low-Income Populations, Indian Reservations, and Off-
Reservation Trust Lands in the Region D.....3-1488

Figure 3-241. Percent of Household Income Spent on Energy (Energy Burden) for
Households Below Poverty Level – Region A3-1502

Figure 3-242. Percent of Household Income Spent on Energy (Energy Burden) for
Households Below Poverty Level – Region B3-1504

Figure 3-243. Percent of Household Income Spent on Energy (Energy Burden) for
Households Below Poverty Level – Region C.....3-1505

Columbia River System Operations Environmental Impact Statement
Table of Contents

Figure 3-244. Percent of Household Income Spent on Energy (Energy Burden) for Households Below Poverty Level – Region D3-1507

Figure 3-245. Percent of Household Income Spent on Energy (Energy Burden) for Households Below Poverty Level – Other Areas3-1508

Figure 4-1. Average Annual Daily Maximum Temperatures for the Columbia River Basin and Pacific Coastal Drainages in Washington and Oregon Through 2100 for RCP 4.5 and 8.54-3

Figure 4-2. Columbia River Basin Snow Water Equivalent on April 1 in the 1980s, and Average Snow Water Equivalent Changes by the 2030s, 2050s (2040–2069), and 2080s (2070–2099)4-5

Figure 4-3. Percent Change in Annual Volume from the Historical Period (1976–2005) and the 2030s (2020–2049) by Season4-6

Figure 4-4. Annual Volume Change from the Historical Period (1976–2005) and the 2030s (2020–2049) by Season4-6

Figure 4-5. Distribution of the RMJOC-II Naturalized Flows, by Month at Libby Dam for the 2030s Time Period for RCP 4.5 and 8.54-7

Figure 4-6. Distribution of the RMJOC-II Naturalized Flows, by Month at Hungry Horse Dam for the 2030s Time Period for RCP 4.5 and 8.54-8

Figure 4-7. Distribution of the RMJOC-II Naturalized Flows, by Month at Albeni Falls Dam for the 2030s Time Period for RCP 4.5 and 8.54-9

Figure 4-8. Distribution of the RMJOC-II Naturalized Flows, by Month, at Grand Coulee Dam for the 2030s Time Period for RCP 4.5 and 8.54-11

Figure 4-9. Distribution of the RMJOC-II Naturalized Flows, by Month at Dworshak Dam for the 2030s Time Period for RCP 4.5 and 8.54-12

Figure 4-10. Distribution of the RMJOC-II Naturalized Flows, by Month at Ice Harbor Dam for the 2030s Time Period for RCP 4.5 and 8.54-13

Figure 4-11. Distribution of the RMJOC-II Naturalized Flows, by Month at The Dalles Dam for the 2030s Time Period for RCP 4.5 and 8.54-15

Figure 4-12. Estimated Sea Level Change Scenarios at Astoria, Oregon.....4-17

Figure 7-1. Lake Koocanusa Summary Hydrograph for the Preferred Alternative7-53

Figure 7-2. Lake Koocanusa Water Year Type Hydrographs for the Preferred Alternative7-55

Figure 7-3. Lake Koocanusa Summer Elevations for the Preferred Alternative7-55

Figure 7-4. Libby Dam Outflow Water Year Type Hydrographs for the Preferred Alternative7-56

Figure 7-5. Hungry Horse Reservoir Summary Hydrograph for the Preferred Alternative7-59

Figure 7-6. Hungry Horse Dam Outflow Water Year Type Hydrographs for the Preferred Alternative7-60

Figure 7-7. Lake Roosevelt Inflow Summary Hydrograph for the Preferred Alternative7-63

Figure 7-8. Lake Roosevelt Summary Hydrograph for the Preferred Alternative7-64

Figure 7-9. Lake Roosevelt Water Year Type Hydrographs for the Preferred Alternative7-65

Figure 7-10. Grand Coulee Dam Outflow Summary Hydrograph for the Preferred Alternative7-67

Figure 7-11. Grand Coulee Dam Outflow Water Year Type Hydrographs for the Preferred Alternative7-68

Columbia River System Operations Environmental Impact Statement
Table of Contents

Figure 7-12. Dworshak Reservoir Summary Hydrograph for the Preferred Alternative 7-70

Figure 7-13. Dworshak Reservoir Water Year Type Hydrographs for the Preferred Alternative 7-71

Figure 7-14. Dworshak Dam Outflow Summary Hydrograph for the Preferred Alternative 7-72

Figure 7-15. Dworshak Dam Outflow Water Year Type Hydrographs for the Preferred Alternative 7-74

Figure 7-16. Normal Operating Range at John Day Dam for the Preferred Alternative and the No Action Alternative 7-76

Figure 7-17. McNary Dam Outflow Summary Hydrograph for the Preferred Alternative 7-77

Figure 7-18. McNary Dam Outflow Water Year Type Hydrographs for the Preferred Alternative 7-79

Figure 7-19. Frequency of Modeled Tailwater Temperature Violations of State Water Quality Standards the Preferred Alternative and No Action Alternative at McNary, John Day, The Dalles, and Bonneville Dams Under a 5-year Range of River and Meteorological Conditions 7-90

Figure 7-20. Monthly Hydropower Generation at the CRS Projects, No Action and Preferred Alternative, in aMW, for the Base Case without Additional Coal Plant Retirements 7-162

Figure 7-21. Market Prices and Average CRS Hydropower Generation under the Preferred Alternative for the Base Case without Additional Coal Plant Retirements 7-172

Figure 7-22. Residential Rate Pressure Effects under the Preferred Alternative Relative to the No Action Alternative 7-177

List of Tables

Table 1-1. Columbia River System Operations Environmental Impact Statement
Cooperating Agencies 1-7

Table 1-2. General Characteristics of the Columbia River System Projects 1-26

Table 1-3. Active Storage Capacity at Columbia River System Storage Projects..... 1-30

Table 1-4. Types of Downstream Fish Passage 1-44

Table 2-1. Spill Priority List 2-15

Table 2-2. Operating Range Elevations for the Lower Snake River and Lower Columbia
River Projects 2-20

Table 2-3. No Action Alternative Measures to Benefit Endangered Species Act–Listed
Fish Species 2-30

Table 2-4. Measures of Multiple Objective Alternative 1 2-38

Table 2-5. Juvenile Fish Passage Spill Measure for Multiple Objective Alternative 1 2-43

Table 2-6. Measures of Multiple Objective Alternative 2 2-49

Table 2-7. Measures of Multiple Objective Alternative 3 2-56

Table 2-8. Juvenile Fish Passage Spill Measure for Multiple Objective Alternative 3 2-60

Table 2-9. Measures of Multiple Objective Alternative 4 2-63

Table 2-10. Drawdown to MOP Measure for Multiple Objective Alternative 4 2-69

Table 2-11. List of Draft Single Objective Focus Alternatives 2-70

Table 2-12. Multiple Objective Alternative Crosswalk 2-75

Table 3-1. Summary of Expected Effects by Multiple Objective Alternative 3-6

Table 3-2. Reach-by-Reach Profile Summaries 3-27

Table 3-3. Water Year Type by Seasonal Forecast Volume 3-32

Table 3-4. Summary of Effects of Multiple Objective Alternatives Based on
Hydroregulation Modeling 3-36

Table 3-5. Summary of Spill Operations 3-43

Table 3-6. Middle Columbia River Monthly Average Flows (kcfs) for No Action
Alternative 3-57

Table 3-7. Lower Snake Basin Monthly Average Flows (kcfs) for No Action Alternative 3-59

Table 3-8. Lower Columbia River Monthly Average Flows (kcfs) for No Action Alternative 3-61

Table 3-9. Libby Dam Monthly Average Outflow for Multiple Objective Alternative 1 (as
change from No Action Alternative) 3-67

Table 3-10. Bonners Ferry Monthly Average Flow for Multiple Objective Alternative 1 (as
change from No Action Alternative) 3-68

Table 3-11. Hungry Horse Dam Monthly Average Outflow for Multiple Objective
Alternative 1 (as change from No Action Alternative) 3-72

Table 3-12. Columbia Falls Monthly Average Flow for Multiple Objective Alternative 1
(as change from No Action Alternative) 3-73

Table 3-13. Pend Oreille Basin Monthly Average Flows for Multiple Objective Alternative
1 (as change from No Action Alternative) 3-74

Table 3-14. Grand Coulee Dam Monthly Average Outflow for Multiple Objective
Alternative 1 (as change from No Action Alternative) 3-80

Columbia River System Operations Environmental Impact Statement
Table of Contents

Table 3-15. Middle Columbia River Monthly Average Flows for Multiple Objective Alternative 1 (as change from No Action Alternative)	3-83
Table 3-16. Dworshak Dam Monthly Average Outflow for Multiple Objective Alternative 1 (as change from No Action Alternative)	3-87
Table 3-17. Lower Snake Basin Monthly Average Flows for Multiple Objective Alternative 1 (as change from No Action Alternative)	3-88
Table 3-18. Lower Columbia River Monthly Average Flows for Multiple Objective Alternative 1 (as change from No Action Alternative)	3-92
Table 3-19. Libby Dam Monthly Average Outflow for Multiple Option Alternative 2 (as change from No Action Alternative)	3-98
Table 3-20. Bonners Ferry Monthly Average Flow for Multiple Objective Alternative 2 (as change from No Action Alternative)	3-99
Table 3-21. Hungry Horse Dam Monthly Average Outflow for Multiple Objective Alternative 2 (as change from No Action Alternative)	3-103
Table 3-22. Columbia Falls Monthly Average Flow for Multiple Objective Alternative 2 (as change from No Action Alternative)	3-104
Table 3-23. Pend Oreille Basin Monthly Average Flows for Multiple Objective Alternative 2 (as change from No Action Alternative)	3-106
Table 3-24. Grand Coulee Dam Monthly Average Outflow for Multiple Objective Alternative 2 (as change from No Action Alternative)	3-112
Table 3-25. Middle Columbia River Monthly Average Flows for Multiple Objective Alternative 2 (as change from No Action Alternative)	3-114
Table 3-26. Dworshak Dam Monthly Average Outflow for Multiple Objective Alternative 2 (as change from No Action Alternative)	3-118
Table 3-27. Lower Snake Basin Monthly Average Flows for Multiple Objective Alternative 2 (as change from No Action Alternative)	3-119
Table 3-28. McNary Dam Monthly Average Outflow for Multiple Objective Alternative 2 (as change from No Action Alternative)	3-122
Table 3-29. Lower Columbia River Monthly Average Flows for Multiple Objective Alternative 2 (as change from No Action Alternative)	3-122
Table 3-30. Libby Dam Monthly Average Outflow for Multiple Objective Alternative 3 (as change from No Action Alternative)	3-130
Table 3-31. Bonners Ferry Monthly Average Flow for Multiple Objective Alternative 3 (as change from No Action Alternative)	3-131
Table 3-32. Hungry Horse Dam Monthly Average Outflow for Multiple Objective Alternative 3 (as change from No Action Alternative)	3-135
Table 3-33. Columbia Falls Monthly Average Flow for Multiple Objective Alternative 3 (as change from No Action Alternative)	3-136
Table 3-34. Pend Oreille Basin Monthly Average Flows for Multiple Objective Alternative 3 (as change from No Action Alternative)	3-137
Table 3-35. Grand Coulee Dam Monthly Average Outflow for Multiple Objective Alternative 3 (as change from No Action Alternative)	3-142
Table 3-36. Middle Columbia River Monthly Average Flows for Multiple Objective Alternative 3 (as change from No Action Alternative)	3-145

Columbia River System Operations Environmental Impact Statement
Table of Contents

Table 3-37. McNary Dam Monthly Average Outflow for Multiple Objective Alternative 3 (as change from No Action Alternative)	3-150
Table 3-38. Lower Columbia River Monthly Average Flows for Multiple Objective Alternative 3 (as change from No Action Alternative)	3-151
Table 3-39. Libby Dam Monthly Average Outflow for Multiple Objective Alternative 4 (as change from No Action Alternative)	3-157
Table 3-40. Bonners Ferry Monthly Average Flow for Multiple Objective Alternative 4 (as change from No Action Alternative)	3-158
Table 3-41. Kootenai River stage for Multiple Objective Alternative 4 (as change from No Action Alternative)	3-158
Table 3-42. Percentage of Days Kootenai River Stage Would be Above 1,753 feet NGVD29 at the Bonners Ferry Gage.....	3-159
Table 3-43. Hungry Horse Dam Monthly Average Outflow for Multiple Objective Alternative 4 (as change from No Action Alternative)	3-163
Table 3-44. Columbia Falls Monthly Average Flow for Multiple Objective Alternative 4 (as change from No Action Alternative)	3-164
Table 3-45. Pend Oreille Basin Monthly Average Flows for Multiple Objective Alternative 4 (as change from No Action Alternative)	3-169
Table 3-46. Grand Coulee Dam Monthly Average Outflow for Multiple Objective Alternative 4 (as change from No Action Alternative)	3-178
Table 3-47. Middle Columbia River Monthly Average Flows for Multiple Objective Alternative 4 (as change from No Action Alternative)	3-181
Table 3-48. McNary Dam Monthly Average Outflow for Multiple Objective Alternative 4 (as change from No Action Alternative)	3-185
Table 3-49. Lower Columbia River Monthly Average Flows for Multiple Objective Alternative 4 (as change from No Action Alternative)	3-186
Table 3-50. River Mechanics Study Area National Environmental Policy Act Regions.....	3-189
Table 3-51. Summary of impact assessment thresholds used for River Mechanics assessment.	3-217
Table 3-52. Summary of No Action Alternative River Mechanics Impact Estimates.....	3-219
Table 3-53. Summary of Multiple Objective Alternative 1 River Mechanics Impact Estimates	3-222
Table 3-54. Summary of Multiple Objective Alternative 2 River Mechanics Impact Estimates	3-225
Table 3-55. Summary of Multiple Objective Alternative 3 River Mechanics Impact Estimates	3-229
Table 3-56. Summary of Multiple Objective Alternative 4 River Mechanics Impact Estimates	3-233
Table 3-57. Status and Critical Habitat of Anadromous Columbia River Basin Endangered Species Act–Listed Species.....	3-312
Table 3-58. Non-Endangered Species Act-Listed Anadromous Columbia River Basin Species.....	3-331
Table 3-59. Status and Critical Habitat of Resident Columbia River Basin Endangered Species Act–Listed Species.....	3-338

Columbia River System Operations Environmental Impact Statement
Table of Contents

Table 3-60. Fish Species for Which Surrogates Were Used for Effects Analysis	3-393
Table 3-61. Overview of Alternative Analysis.....	3-395
Table 3-62. Overview of Alternative Analysis (MO1 – MO4).....	3-396
Table 3-63. Juvenile Model Metrics for Upper Columbia River Spring Chinook Salmon (Hatchery and Wild Fish Combined) under the No Action Alternative.....	3-403
Table 3-64. Percent of Days with TDG above 120 Percent and 125 Percent at Bonneville, McNary, and Chief Joseph Dam, in the No Action Alternative.....	3-404
Table 3-65. No Action Alternative Model Metrics for Adult Upper Columbia River Spring- Run Chinook Salmon	3-404
Table 3-66. Juvenile Model Metrics for Upper Columbia River Steelhead (hatchery and wild fish combined) under the No Action Alternative.....	3-405
Table 3-67. Juvenile Model Metrics for Snake River Spring/Summer Chinook Salmon (Hatchery and Wild Fish combined) under the No Action Alternative.	3-413
Table 3-68. Model Metrics Related to Adult Survival and Abundance of Snake River Spring/Summer Chinook Salmon under the No Action Alternative	3-415
Table 3-69. Juvenile Model Metrics for Snake River Steelhead under the No Action Alternative	3-415
Table 3-70. Model Metrics Related to Adult Survival and Abundance of Snake River Steelhead under the No Action Alternative	3-417
Table 3-71. Percent of Days with TDG above 120 Percent and 125 Percent in the No Action Alternative	3-418
Table 3-72. Multiple Objective Alternative 1 Juvenile Model Metrics for Upper Columbia River Spring-Run Chinook Salmon.....	3-484
Table 3-73. Multiple Objective Alternative 1 Model Metrics for Adult Upper Columbia River Spring Chinook Salmon	3-485
Table 3-74. Multiple Objective Alternative 1 Model Metrics for Juvenile Upper Columbia Steelhead.....	3-486
Table 3-75. Multiple Objective Alternative 1 Juvenile Model Metrics for Snake River Spring/Summer Chinook Salmon	3-492
Table 3-76. Multiple Objective Alternative 1 Adult Model Metrics for Snake River Spring/Summer-Run Chinook Salmon.....	3-494
Table 3-77. Juvenile Model Metrics for Snake River Steelhead under Multiple Objective Alternative 1	3-496
Table 3-78. Multiple Objective Alternative 1 Adult Model Metrics for Snake River Steelhead.....	3-497
Table 3-79. Multiple Objective Alternative 2 Juvenile Model Metrics for Upper Columbia River Spring-Run Chinook Salmon.....	3-536
Table 3-80. Multiple Objective Alternative 2 adult model metrics for Upper Columbia River Spring-Run Chinook salmon.....	3-537
Table 3-81. Multiple Objective Alternative 2 Juvenile Model Metrics for Upper Columbia River Steelhead.....	3-538
Table 3-82. Juvenile Model Metrics for Snake River Spring/Summer-Run Chinook Salmon under Multiple Objective Alternative 2.....	3-544

Columbia River System Operations Environmental Impact Statement
Table of Contents

Table 3-83. Multiple Objective Alternative 2 Adult Model Metrics for Snake River Spring/Summer-Run Chinook Salmon.....	3-545
Table 3-84. Multiple Objective Alternative 2 Juvenile Model Metrics for Snake River Steelhead	3-546
Table 3-85. Multiple Objective Alternative 3 Juvenile Model Metrics for Upper Columbia River Spring-Run Chinook Salmon.....	3-582
Table 3-86. Model Metrics Related to Adult Survival and Abundance of Upper Columbia River Spring-Run Chinook Salmon under Multiple Objective Alternative 3.....	3-583
Table 3-87. Multiple Objective Alternative 3 Juvenile Model Metrics for Upper Columbia River Steelhead.....	3-584
Table 3-88. Multiple Objective Alternative 3 Juvenile Model Metrics for Snake River Spring/Summer-Run Chinook Salmon.....	3-589
Table 3-89. Multiple Objective Alternative 3 Adult Model Metrics for Snake River Spring/Summer-Run Chinook Salmon.....	3-589
Table 3-90. Multiple Objective Alternative 3 Juvenile model metrics for Snake River Steelhead	3-592
Table 3-91. Multiple Objective Alternative 3 Adult Model Metrics for Snake River Steelhead	3-592
Table 3-92. Multiple Objective Alternative 4 Juvenile Model Metrics for Upper Columbia River Spring-Run Chinook Salmon.....	3-630
Table 3-93. Model Metrics Related to Adult Survival and Abundance of Upper Columbia River Spring-Run Chinook Salmon under Multiple Objective Alternative 4.....	3-631
Table 3-94. Multiple Objective Alternative 4 Juvenile Model Metrics for Upper Columbia River Steelhead	3-632
Table 3-95. Percent of Days with TDG above 120 Percent and 125 Percent in the No Action Alternative and in Multiple Objective Alternative 4.....	3-634
Table 3-96. Multiple Objective Alternative 4 Juvenile Model Metrics for Snake River Spring/Summer-Run Chinook Salmon.....	3-639
Table 3-97. Multiple Objective Alternative 4 Adult Model Metrics for Snake River Spring/Summer-Run Chinook Salmon.....	3-641
Table 3-98. Multiple Objective Alternative 4 Juvenile Model Metrics for Snake River Steelhead	3-644
Table 3-99. Multiple Objective Alternative 4 Adult Model Metrics for Snake River Steelhead	3-645
Table 3-100. Percent of Days with TDG above 120 Percent and 125 Percent in the No Action Alternative and in Multiple Objective Alternative 4.....	3-648
Table 3-101. Candidate, Endangered, and Threatened Species in the Vicinity of the Columbia River System Operations Study Area.....	3-712
Table 3-102. Sensitive Species that may Occur Within the Analysis Area Boundaries	3-736
Table 3-103. Sensitive Species Effects for MO1	3-752
Table 3-104. Sensitive Species Effects for MO2	3-768
Table 3-105. Estimated Short-term Habitat Losses and Long-term Habitat Gains in the Study Area Under Multiple Objective Alternative 3.....	3-780
Table 3-106. Sensitive Species Analysis for MO3	3-790

Columbia River System Operations Environmental Impact Statement
Table of Contents

Table 3-107. Sensitive Species Effects for MO4	3-810
Table 3-108. Power Generation Capacity in Megawatts (current as of 2018)	3-819
Table 3-109. Non-Federal Projects Downstream of the 14 Columbia River System Projects	3-820
Table 3-110. Power Generation Characteristics of the 14 Columbia River System Projects...	3-822
Table 3-111. Generation at the Columbia River System Projects	3-834
Table 3-112. Generation Costs of the Columbia River System Projects	3-836
Table 3-113. Balancing and Operating Reserves Costs for Replacement Resources (\$1000s)	3-866
Table 3-114. Solar and Battery Resource Need (MW) for the Zero-Carbon 8 th Power Plan Updates (\$/kW).....	3-867
Table 3-115. Natural Gas Resource Need (MW) for the Conventional Least-Cost Portfolio and Potential Overnight Capital Costs (\$/kW)	3-867
Table 3-116. Solar and Battery Resource Need (MW) for the Zero-Carbon Portfolio and Potential Overnight Capital Costs (\$/kW)	3-868
Table 3-117. Natural Gas Resource Need (MW) for the Conventional Least-Cost Portfolio and Potential Overnight Capital Costs (\$/kW)	3-868
Table 3-118. Solar and Battery Resource Need (MW) for the Zero-Carbon Portfolio and Potential Overnight Capital Costs (\$/kW)	3-869
Table 3-119. Natural Gas Resource Need (MW) for the Conventional Least-Cost Portfolio and Potential Overnight Capital Costs (\$/kW)	3-870
Table 3-120. Generating Resource Debt Terms by Developer Type (in years)	3-871
Table 3-121. Increase in Annual Costs for Shorter-Term Financing (20-year cost recovery, in \$ million and %).....	3-871
Table 3-122. Annual Change in Cost of Compliance with GHG Emissions Reduction Policies for MOs, Pacific Northwest, 2030 (\$ in Millions, 2019)	3-875
Table 3-123. Assumed Megawatts of Coal Plant Capacity.....	3-876
Table 3-124. 80-Year Average Monthly Average Electricity Generation (aMW) at the Columbia River System Projects under the No Action Alternative	3-880
Table 3-125. Coal Capacity Assumptions, Zero-Carbon Replacement Resources for All Alternatives.....	3-883
Table 3-126. Weighted Average 2022 Estimated Retail Rates (cents per kWh), 2019 U.S. Dollars.....	3-889
Table 3-127. Average Consumption and Monthly Bills for Each End-User Group under the No Action Alternative, 2019 U.S. Dollars	3-890
Table 3-128. Average Residential Retail Rate (cents per kWh, 2022 to 2040), 2019 U.S. Dollars.....	3-890
Table 3-129. Average Annual Expenditures on Electricity, 2019 U.S. Dollars	3-891
Table 3-130. Average Percent of Median Household Income Spent on Electricity (percent of median household income)	3-891
Table 3-131. Annual Expenditures for Commercial and Industrial End Users under the No Action Alternative, 2019 U.S. Dollars	3-892
Table 3-132. Summary of Effects under the No Action Alternative without Additional Coal Plant Closures	3-893

Columbia River System Operations Environmental Impact Statement
Table of Contents

Table 3-133. Monthly Electricity Generation at the Columbia River System Projects under Multiple Objective 1, in aMW.....	3-894
Table 3-134. Coal Capacity Assumptions, Zero-Carbon Replacement Resources under Multiple Objective 1 Relative to the No Action Alternative	3-898
Table 3-135. Average Bonneville Wholesale Power Rate (\$/MWh) Under Multiple Objective 1, for the Base Case as well as the Rate Pressures Associated with Additional Sensitivity Analysis.....	3-904
Table 3-136. Average Bonneville Wholesale Power Rate (\$/MWh) Under Multiple Objective 1, for the Base Case as well as the Rate Pressures Associated with Additional Sensitivity Analysis for the Case, Region Finances	3-907
Table 3-137. Bonneville Financial Analysis Results (in Millions \$2019)	3-909
Table 3-138. Average Annual Social Welfare Effect of Multiple Objective 1 Based on the Market Price of Changes in Pacific Northwest Hydropower Generation (2019 U.S. Dollars)	3-910
Table 3-139. Average Annual Social Welfare Effect of Multiple Objective 1 Based on the Increased Cost of Producing Power to Meet Demand (2019 U.S. Dollars).....	3-911
Table 3-140. Average Residential Rate Pressure Effects by Region with Percentage Change of Multiple Objective 1 Compared to the No Action Alternative	3-912
Table 3-141. Average Upward Retail Rate Pressure Effect under Multiple Objective 1 in 2022 and 2041, Relative to the No Action Alternative.....	3-914
Table 3-142. Percentage of Residential End Users Who Experience Changes in Electricity Expenditures by Size of Expenditure Change in each Portfolio under Multiple Objective 1.....	3-914
Table 3-143. Regional Economic Effects from Changes in Household Spending on Electricity under Multiple Objective 1 by Portfolio	3-915
Table 3-144. Percentage of Commercial and Industrial End Users Who Experience Changes in Electricity Expenditures by Size of Expenditure Change under Multiple Objective 1.....	3-916
Table 3-145. Regional Economic Effects from Changes in Commercial Business Spending on Electricity under Multiple Objective 1.....	3-916
Table 3-146. Regional Economic Effects from Changes in Industrial Business Spending on Electricity under Multiple Objective 1.....	3-917
Table 3-147. Summary of Effects under Multiple Objective 1 without Additional Coal Plant Closures	3-918
Table 3-148. Monthly Electricity Generation at Columbia River System Projects under Multiple Objective 2, in aMW	3-921
Table 3-149. Coal Capacity Assumptions, Zero-Carbon Replacement Resources under Multiple Objective 2 Relative to the No Action Alternative	3-924
Table 3-150. Average Bonneville Wholesale Power Rate (\$/MWh) Under Multiple Objective 2, for the Base Case as well as the Rate Pressures Associated with Additional Sensitivity Analysis.....	3-927
Table 3-151. Bonneville Financial Analysis Results (in Millions \$2019)	3-931

Columbia River System Operations Environmental Impact Statement
Table of Contents

Table 3-152. Average Annual Social Welfare Effect of Multiple Objective 2 Based on the Market Price of Changes in Pacific Northwest Hydropower Generation (2019 U.S. Dollars)	3-931
Table 3-153. Average Annual Social Welfare Effect of Multiple Objective 2 Based on the Reduced Cost of Producing Power to Meet Demand (2019 U.S. Dollars)	3-932
Table 3-154. Average Residential Rate Pressure by Columbia River System Operations Region	3-933
Table 3-155. Percentage of Residential End Users Who Experience Changes in Electricity Expenditures by Size of Expenditure Change in each Portfolio under Multiple Objective 2	3-934
Table 3-156. Regional Economic Effects from Decreases in Household Spending on Electricity under Multiple Objective 2	3-935
Table 3-157. Percentage of Commercial and Industrial End Users Who Experience Changes in Electricity Expenditures by Size of Expenditure Change under Multiple Objective 2	3-936
Table 3-158. Regional Economic Effects from Decreases in Commercial Business Spending on Electricity under Multiple Objective 2	3-936
Table 3-159. Regional Economic Effects from Decreases in Industrial Business Spending on Electricity under Multiple Objective 2	3-937
Table 3-160. Summary of Effects under Multiple Objective 2 without Additional Coal Plant Closures	3-938
Table 3-161. Monthly Hydropower Generation at the Columbia River System Projects, Multiple Objective 3 Relative to the No Action Alternative, in aMW	3-940
Table 3-162. Historical Sustained Ramping Capability (aMW) for the Lower Snake River Projects	3-946
Table 3-163. Summary Annual Fixed Cost Table for Zero-Carbon Portfolio	3-947
Table 3-164. Potential Portfolio of Replacement Resources with Increased Solar	3-948
Table 3-165. Estimates of Generation Input Revenue for Lower Snake River Dams	3-950
Table 3-166. Value of Sustained Ramping Capability	3-951
Table 3-167. Coal Capacity Assumptions, Zero-Carbon Replacement Resources under Multiple Objective 3 Relative to the No Action Alternative	3-952
Table 3-168. Average Bonneville Wholesale Power Rate (\$/MWh) under Multiple Objective 3, for the Base Case as well as the Rate Pressures Associated with Additional Sensitivity Analysis	3-960
Table 3-169. Average Bonneville Wholesale Power Rate (\$/MWh), for the Base Case as well as the Rate Pressures associated with Additional Sensitivity Analysis for the Case, Region Finances	3-964
Table 3-170. Bonneville Financial Analysis Results (in Millions \$2019)	3-966
Table 3-171. Bonneville Outstanding Debt (\$)	3-968
Table 3-172. Average Annual Social Welfare Effect of Multiple Objective 3 Based on the Market Price of Changes in Pacific Northwest Hydropower Generation (2019 U.S. Dollars)	3-968
Table 3-173. Average Annual Social Welfare Effect of Multiple Objective 3 Based on the Increased Cost of Producing Power to Meet Demand (2019 U.S. Dollars)	3-969

Columbia River System Operations Environmental Impact Statement
Table of Contents

Table 3-174. Average Residential Retail Rate Pressure Effect of Multiple Objective 3 by Columbia River System Operations Region	3-970
Table 3-175. Average Upward Retail Rate Pressure Effect in 2022 and 2041 under Multiple Objective 3 Relative to the No Action Alternative for the Base Case without Rate Sensitivities or Additional Coal Plant Retirements	3-970
Table 3-176. Percentage of Residential End Users Who Experience Changes in Electricity Expenditures by Size of Expenditure Change in each Portfolio under Multiple Objective 3	3-972
Table 3-177. Regional Economic Effects from Changes in Household Spending on Electricity	3-973
Table 3-178. Percentage of Commercial and Industrial End Users Who Experience Changes in Electricity Expenditures by Size of Expenditure Change under Multiple Objective 3	3-974
Table 3-179. Regional Economic Effects from Changes in Commercial Business Spending on Electricity	3-975
Table 3-180. Regional Economic Effects from Changes in Industrial Business Spending on Electricity	3-975
Table 3-181. Summary of Effects under Multiple Objective 3 without Additional Coal Plant Closures	3-977
Table 3-182. Columbia River System Monthly Generation under Multiple Objective 4 Relative to the No Action Alternative, aMW	3-979
Table 3-183. Coal Capacity Assumptions, Zero-Carbon Replacement Resources under Multiple Objective 4 Relative to the No Action Alternative	3-984
Table 3-184. Average Bonneville Wholesale Power Rate (\$/MWh) Under Multiple Objective 4, for the Base Case as well as the Rate Pressures Associated with Additional Sensitivity Analysis	3-989
Table 3-185. Average Bonneville Wholesale Power Rate (\$/MWh) Under Multiple Objective 4, for the Base Case as well as the Rate Pressures associated with Additional Sensitivity Analysis for the Case, Region Finances	3-992
Table 3-186. Bonneville Financial Analysis Results (in Millions \$2019)	3-994
Table 3-187. Average Annual Social Welfare Effect of Multiple Objective 4 Based on the Market Price of Changes in Pacific Northwest Hydropower Generation (2019 U.S. Dollars)	3-995
Table 3-188. Average Annual Social Welfare Effect of MO4 Based on the Increased Cost of Producing Power to Meet Demand (2019 U.S. Dollars)	3-995
Table 3-189. Average Residential Retail Rate Pressure Effect by Columbia River System Operating Region under Multiple Objective 4	3-996
Table 3-190. Average Upward Retail Rate Pressure Effect in 2022 and 2041 under Multiple Objective 4 Relative to the No Action Alternative	3-998
Table 3-191. Percentage of Residential End Users Who Experience Changes in Electricity Expenditures by Size of Expenditure Change in Each Portfolio under Multiple Objective 4	3-999
Table 3-192. Regional Economic Effects from Changes in Household Spending on Electricity	3-1000

Columbia River System Operations Environmental Impact Statement
Table of Contents

Table 3-193. Percentage of Commercial and Industrial End Users Who Experience Changes in Electricity Expenditures by Size of Expenditure Change under Multiple Objective 4.....	3-1001
Table 3-194. Regional Economic Effects from Changes in Commercial Business Spending on Electricity	3-1001
Table 3-195. Regional Economic Effects from Changes in Industrial Business Spending on Electricity	3-1002
Table 3-196. Summary of Effects under Multiple Objective 4 without Additional Coal Plant Closures	3-1003
Table 3-197. Estimates of Percent Change in the Annual Payment to the CTCR and Spokane Tribe of Indians, Relative to the No Action Alternative	3-1005
Table 3-198. Nonattainment and Maintenance Areas Within the Columbia River Basin by State.....	3-1009
Table 3-199. State Greenhouse Gas Emissions Reductions Targets	3-1016
Table 3-200. Percent of Electricity Produced from Renewable Sources and Hydropower, and RPS Renewable Energy Targets	3-1018
Table 3-201. Energy-Related Per-Capita Emissions and Carbon Intensity	3-1020
Table 3-202. Summary of Air Quality and Greenhouse Gas Emissions Effects by Alternative	3-1026
Table 3-203. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple Objective Alternative 1, 2022	3-1043
Table 3-204. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple Objective Alternative 1 (2022 to 2041).....	3-1043
Table 3-205. Present Value and Annualized Values of Changes in CO ₂ Emissions in the Pacific Northwest under Multiple Objective Alternative 1 Relative to No Action Alternative (2022 to 2041, 2019 U.S. Dollars).....	3-1046
Table 3-206. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple Objective Alternative 2, 2022	3-1049
Table 3-207. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple Objective Alternative 2 (2022 to 2041).....	3-1049
Table 3-208. Present Value and Annualized Values of Changes in CO ₂ Emissions in the Pacific Northwest under Multiple Objective Alternative 2 Relative to No Action Alternative (2022 to 2041, 2019 U.S. Dollars).....	3-1051
Table 3-209. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple Objective Alternative 3, 2022	3-1057
Table 3-210. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple Objective Alternative 3 (2022 to 2041).....	3-1058
Table 3-211. Navigation CO ₂ Emissions by Type under Multiple Objective Alternative 3 and No Action Alternative in 2022 (MMT CO ₂)	3-1058
Table 3-212. Present Value and Annualized Values of Changes in CO ₂ Emissions in the Pacific Northwest under Multiple Objective Alternative 3 Relative to No Action Alternative (2022 to 2041, 2019 US Dollars).....	3-1060
Table 3-213. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple Objective Alternative 4, 2022	3-1064

Columbia River System Operations Environmental Impact Statement
Table of Contents

Table 3-214. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple Objective Alternative 4 (2022 to 2041).....	3-1064
Table 3-215. Present Value and Annualized Values of Changes in CO ₂ Emissions in the Pacific Northwest under Multiple Objective 4 Relative to No Action Alternative (2022 to 2041, 2019 U.S. Dollars)	3-1066
Table 3-216. Columbia River System Storage Projects	3-1071
Table 3-217. River Reaches in Region A	3-1075
Table 3-218. Population Within Region A 100- and 500-Year Floodplains	3-1077
Table 3-219. River Reaches in Region B	3-1080
Table 3-220. Communities within Region B 100- and 500-Year Floodplains	3-1081
Table 3-221. River Reaches in Region C.....	3-1083
Table 3-222. Population within the 100 and 500-Year Floodplains–Region C	3-1084
Table 3-223. Region D Consequence Areas	3-1085
Table 3-224. Population within the 100 and 500-Year Floodplains–Region D.....	3-1086
Table 3-225. Thresholds for Flood Hazard Categories.....	3-1090
Table 3-226. Flood Risk Annual Exceedance Probabilities under the No Action Alternative in Region A, by Hazard Category	3-1093
Table 3-227. Flood Risk Annual Exceedance Probabilities under the No Action Alternative in Region B, by Hazard Category	3-1093
Table 3-228. Flood Risk Annual Exceedance Probabilities under the No Action Alternative in Region C, by Hazard Category	3-1094
Table 3-229. Flood Risk Annual Exceedance Probabilities under the No Action Alternative in Region D, by Hazard Category	3-1095
Table 3-230. Snake River Freight Volumes by Direction, 2015 to 2018, Thousand Tons.....	3-1106
Table 3-231. Columbia-Snake Navigation System Tonnage, 2000 to 2018.....	3-1110
Table 3-232. Deep-Draft Vessel Calls by Draft and Vessel Type, 2016	3-1116
Table 3-233. Inland Non-Self-Propelled Vessel (Barge) Fleet	3-1118
Table 3-234. Barge Fleet Trips at CSNS Locks	3-1121
Table 3-235. Flow Range Categories for Commercial Navigation on the Columbia-Snake Navigation System (kcfs).....	3-1131
Table 3-236. Average Commercial Navigation Flow Days Under the No Action Alternative, over 50 years	3-1137
Table 3-237. Average Annual Costs of Navigation Operations Under a Range of Flow Scenarios, No Action Alternative (2019 Dollars), 50 years	3-1138
Table 3-238. Modal Transit of Wheat and Barley in Eastern Washington and Idaho Under the No Action Alternative	3-1141
Table 3-239. Economic Effects of Navigation and Transportation Under the No Action Alternative, over 50 years	3-1149
Table 3-240. Changes in Average Commercial Navigation Flow Days Under Multiple Objective Alternative 1 Relative to No Action Alternative, over 50 years	3-1150
Table 3-241. Changes in Average Annual Costs of Commercial Navigation Operations Under Multiple Objective Alternative 1 Relative to No Action Alternative (2019 Dollars), over 50 years	3-1152

Columbia River System Operations Environmental Impact Statement
Table of Contents

Table 3-242. Changes in Economic Effects of Navigation and Transportation Under Multiple Objective Alternative 1 Relative to the No Action Alternative, over 50 years	3-1155
Table 3-243. Changes in Average Commercial Navigation Flow Days Under Multiple Objective Alternative 2 Relative to No Action Alternative, over 50 years	3-1156
Table 3-244. Changes in Average Annual Costs of Commercial Navigation Operations Under Multiple Objective Alternative 2 Relative to No Action Alternative (2019 Dollars), over 50 years	3-1157
Table 3-245. Changes in Economic Effects of Navigation and Transportation Under Multiple Objective Alternative 2 Relative to the No Action Alternative, over 50 years	3-1160
Table 3-246. Multiple Objective Alternative 3 Scenario 1 (No Rail Rate Increase): Changes from No Action Alternative.....	3-1166
Table 3-247. Multiple Objective Alternative 3 Scenario 2 (25 percent Rail Rate Increase): Changes from No Action Alternative.....	3-1169
Table 3-248. Multiple Objective Alternative 3 Scenario 3 (50 Percent Rail Rate Increase): Changes from No Action Alternative.....	3-1172
Table 3-249. Navigation CO ₂ Emissions by Type under Multiple Objective Alternative 3 and No Action Alternative in 2022 (MMT CO ₂).....	3-1192
Table 3-250. Changes in Economic Effects of Navigation and Transportation Under Multiple Objective Alternative 3 Relative to No Action Alternative, over 50 years	3-1195
Table 3-251. Changes in Average Commercial Navigation Flow Days Under Multiple Objective Alternative 4 Relative to No Action Alternative, over 50 years	3-1197
Table 3-252. Changes in Average Annual Costs of Operations Under Multiple Objective Alternative 4 Relative to No Action Alternative (2019 Dollars), 50 years.....	3-1199
Table 3-253. Changes in Costs of Commercial Navigation Operations Under Multiple Objective Alternative 4 Relative to No Action Alternative, over 50 years (2019 Dollars).....	3-1203
Table 3-254. Federal, Tribal, and Other Protected Lands in Region A by Land Manager.....	3-1209
Table 3-255. Federal, Tribal, and Other Protected Lands in Region B by Land Manager.....	3-1212
Table 3-256. Federal, Tribal, and Other Protected Lands in Region C by Land Manager.....	3-1215
Table 3-257. Federal, Tribal, and Other Protected Lands in Region D by Land Manager	3-1217
Table 3-258. Available Recreational Visitation Data for Columbia River Basin Reservoirs and River Reaches.....	3-1221
Table 3-259. Distribution of Recreation Use by Activity for Columbia River Basin Reservoirs and River Reaches	3-1223
Table 3-260. Columbia River System Operations Reservoirs Where a Change in Boat Ramp Accessibility Under Each Alternative is Anticipated	3-1229
Table 3-261. Counties by Columbia River System Region	3-1233
Table 3-262. Summary of Average Annual Effects of Recreation Under the No Action Alternative (2019 Dollars)	3-1238
Table 3-263. Changes in Economic Effects of Recreation Under Multiple Objective Alternative 1 Relative to the No Action Alternative	3-1248

Columbia River System Operations Environmental Impact Statement
Table of Contents

Table 3-264. Changes in Economic Effects of Recreation Under Multiple Objective Alternative 2 Relative to the No Action Alternative	3-1259
Table 3-265. Visitation Estimates for the Lower Snake River in the Long-Term, With and Without Adjusting for Population Growth (excludes recreational fishing), from 2002 EIS.....	3-1269
Table 3-266. Changes in Economic Effects of Recreation Under Multiple Objective Alternative 3 Relative to the No Action Alternative	3-1278
Table 3-267. Changes in Economic Effects of Recreation Under Multiple Objective Alternative 4 Relative to the No Action Alternative	3-1292
Table 3-268. Possible Affected Groundwater Wells and Surface Water Pumps in Region A	3-1300
Table 3-269. Summary of Municipal and Industrial Use by County for Surface and Groundwater in Counties that Border the River Reaches below the Columbia River System Projects in Region A.....	3-1300
Table 3-270. Possible Affected Groundwater Wells and Surface Water Pumps in Region B	3-1301
Table 3-271. Summary of Municipal and Industrial Use by County for Surface and Groundwater in Counties that Border Lake Roosevelt in Region B	3-1301
Table 3-272. Possible Affected Groundwater Wells and Surface Water Pumps in Region C	3-1302
Table 3-273. Minimum Operating Pool Elevations in Region C	3-1302
Table 3-274. Summary of M&I Use by County for Surface and Groundwater in Counties that Border the Lower Snake River in Region C	3-1303
Table 3-275. Number of Irrigation and Municipal and Industrial Diversions (Pumps and Wells) in John Day Reservoir	3-1303
Table 3-276. Summary of Municipal and Industrial Use by County for Surface and Groundwater in Counties that Border the Lower Columbia River in Region D..	3-1304
Table 3-277. Water Supply Socioeconomic Analysis Regions and Analysis Areas	3-1305
Table 3-278. Benefit Values Assuming Dryland Pasture as the Without Condition.....	3-1311
Table 3-279. Irrigation Water Supply Social Welfare Effects under the No Action Alternative	3-1312
Table 3-280. Estimated Gross Value of Production and Associated IMPLAN Sector for the Ice Harbor and Lower Monumental Socioeconomic Analysis Area under the No Action Alternative.....	3-1313
Table 3-281. Weighted Average per Acre-Foot Municipal and Industrial Value.....	3-1322
Table 3-282. Summary of M&I Water Supply Modification Construction Costs.....	3-1322
Table 3-283. Summary of M&I Water Supply Modification Construction Costs.....	3-1322
Table 3-284. Estimated Power Rate and Additional Pumping Costs for Year 1, and Average Annual Rate Increase of the 20-Year Period	3-1328
Table 3-285. Estimated Social Welfare Effects under Multiple Objective Alternative 4.....	3-1328
Table 3-286. Common Noise Levels	3-1346
Table 3-287. Summary of Findings from Primary Studies.....	3-1379
Table 3-288. Archaeological Resource Types and Descriptions.....	3-1394
Table 3-289. Presence of Archaeological Site Types in the Study Area by Project	3-1395
Table 3-290. Presence of Built Environment Resource Types in the Study Area by Project .	3-1408
Table 3-291. Distribution of TCPs.....	3-1409
Table 3-292. Sources of Bathymetric Data	3-1415

Columbia River System Operations Environmental Impact Statement
Table of Contents

Table 3-293. Effects to Archaeological Resources – Acre-Day Calculations by Reservoir and Alternative.3-1420

Table 3-294. Effects to Archaeological Resources – Increases or Decreases in Exposure of Archaeological Resources by Reservoir and Multiple Objective Alternatives ...3-1421

Table 3-295. Effects to Archaeological Resources – Frequency of Reservoir Elevation Changes by Reservoir and Alternative3-1421

Table 3-296. Effects to Archaeological Resources – Average Frequency of Reservoir Elevation Change by Alternative3-1422

Table 3-297. Effects to Archaeological Resources – Amplitude of Reservoir Elevation Changes by Reservoir and Alternative3-1423

Table 3-298. Effects to Archaeological Resources – Changes in Average Amplitude of Reservoir Elevation Change by Alternative3-1424

Table 3-299. Effects to Archaeological Resources – Rate of Reservoir Elevation Changes by Reservoir and Alternative.....3-1425

Table 3-300. Effects to Archaeological Resources – Changes in the Average Frequency of High Draft Rate Events by Reservoir and Alternative3-1426

Table 3-301. Past, Current, and Future Impacts to Traditional Cultural Properties.....3-1429

Table 3-302. Effects to Traditional Cultural Properties by Alternative3-1433

Table 3-303. Structural Measures Planned Under Multiple Objective Alternative 1 Having an Effect on Built Resources3-1434

Table 3-304. Structural Measures Planned Under Multiple Objective Alternative 2 and Their Effect on Built Resources3-1437

Table 3-305. Structural Measures Planned Under Multiple Objective Alternative 3 and Their Effect on Built Resources3-1445

Table 3-306. Structural Measures Planned Under Multiple Objective Alternative 4 and Their Effect on Built Resources3-1449

Table 3-307. Key Treaties with Columbia River Basin Indian Tribes3-1470

Table 3-308. Summary of Race and Ethnicity by States that Intersect Study Area^{1/}3-1478

Table 3-309. Summary of Moderate and Major Direct and Indirect Effects to Environmental Justice3-1563

Table 3-310. Cost Components and Descriptions.....3-1568

Table 3-311. Annual-equivalent Costs under the Alternatives (2019 dollars)3-1573

Table 3-312. Change in Annual-equivalent Costs under the Multiple Objective Alternatives compared to the No Action Alternative (2019 dollars)3-1573

Table 4-1. Relative Change (%) in Unregulated Monthly Streamflow at Libby Dam.....4-8

Table 4-2. Relative Change (%) in Unregulated Monthly Streamflow at Hungry Horse Dam4-9

Table 4-3. Relative Change (%) in Unregulated Monthly Streamflow at Albeni Falls Dam4-10

Table 4-4. Relative Change (%) in Unregulated Monthly Streamflow at Grand Coulee Dam4-11

Table 4-5. Relative Change (%) in Unregulated Monthly Streamflow at Dworshak Dam4-13

Table 4-6. Relative Change (%) in Unregulated Monthly Streamflow at Ice Harbor Dam4-14

Table 4-7. Relative Change (%) in Unregulated Monthly Streamflow at The Dalles Dam.....4-15

Columbia River System Operations Environmental Impact Statement
Table of Contents

Table 4-8. Climate Influenced Processes and Mechanisms That Shape Geomorphological Change in River Basins	4-24
Table 5-1. Mitigation Summary for Multiple Objective Alternative 1	5-24
Table 5-2. Mitigation Summary of Multiple Objective Alternative 2	5-31
Table 5-3. Mitigation Summary of Multiple Objective Alternative 3	5-43
Table 6-1. Reasonably Foreseeable Future Actions and Trends	6-4
Table 6-2. Reasonably Foreseeable Future Actions and Potentially Affected Resources Matrix	6-16
Table 6-3. Reasonably Foreseeable Future Actions Relevant to Hydrology and Hydraulics	6-18
Table 6-4. Hydrology and Hydraulics Direct/Indirect Effects from Multiple Objective Alternative 1 Compared to the No Action Alternative	6-20
Table 6-5. Hydrology and Hydraulics Direct/Indirect Effects from Multiple Objective Alternative 2 Compared to the No Action Alternative	6-21
Table 6-6. Hydrology and Hydraulics Direct/Indirect Effects from Multiple Objective Alternative 3 Compared to the No Action Alternative	6-22
Table 6-7. Hydrology and Hydraulics Direct/Indirect Effects from Multiple Objective Alternative 4 Compared to the No Action Alternative	6-23
Table 6-8. Reasonably Foreseeable Future Actions Relevant to Geomorphology and Sediment.....	6-24
Table 6-9. Multiple Objective Alternative 1 Direct/Indirect Effects Compared to the No Action Alternative	6-26
Table 6-10. Direct/Indirect Effects of Multiple Objective Alternative 2 Compared to the No Action Alternative.....	6-27
Table 6-11. Direct/Indirect Effects of Multiple Objective Alternative 3 Compared to the No Action Alternative.....	6-28
Table 6-12. Effects of Multiple Objective Alternative 4 Compared to No Action Alternative	6-29
Table 6-13. Reasonably Foreseeable Future Actions Relevant to Water Quality	6-30
Table 6-14. Summary of Direct and Indirect Effects to Water Quality	6-33
Table 6-15. Water Quality Direct/Indirect Effects from Multiple Objective Alternative 1 Compared to the No Action Alternative.....	6-38
Table 6-16. Water Quality Direct/Indirect Effects from Multiple Objective Alternative 2 Compared to the No Action Alternative.....	6-40
Table 6-17. Water Quality Direct/Indirect Effects from Multiple Objective Alternative 3 Compared to the No Action Alternative and Multiple Objective Alternatives 1 and 2	6-41
Table 6-18. Water Quality Direct/Indirect Effects from Multiple Objective Alternative 4 Compared to the No Action Alternative and Multiple Objective Alternative 1	6-42
Table 6-19. Reasonably Foreseeable Future Actions Relevant to Anadromous Fish	6-44
Table 6-20. Direct and Indirect Effects on Anadromous Species Compared to the No Action Alternative	6-46
Table 6-21. Reasonably Foreseeable Future Actions Relevant to Resident Fish.....	6-51
Table 6-22. Summary of Direct and Indirect Effects to Resident Fish from Alternatives.....	6-53
Table 6-23. Reasonably Foreseeable Future Actions Relevant to Macroinvertebrates	6-57

Columbia River System Operations Environmental Impact Statement
Table of Contents

Table 6-24. Summary of Direct and Indirect Effects to Macroinvertebrates from Alternatives.....	6-59
Table 6-25. Reasonably Foreseeable Future Actions Relevant to Vegetation, Wildlife, Wetlands, and Floodplains.....	6-63
Table 6-26. Vegetation, Wetlands, Wildlife, and Floodplains Direct and Indirect Effects Summary.....	6-64
Table 6-27. Reasonably Foreseeable Future Actions Relevant to Power and Transmission.....	6-70
Table 6-28. Summary of Direct and Indirect Effects to Power and Transmission (Power and Transmission Effects are Columbia River Basin-Wide)	6-71
Table 6-29. Reasonably Foreseeable Future Actions Relevant to Air Quality and Greenhouse Gases	6-76
Table 6-30. Summary of Direct and Indirect Effects to Air Quality and Greenhouse Gases	6-77
Table 6-31. Reasonably Foreseeable Future Actions Relevant to Flood Risk Management	6-83
Table 6-32. Summary of Direct and Indirect Effects to Flood Risk Management	6-84
Table 6-33. Reasonably Foreseeable Future Actions Relevant to Navigation and Transportation	6-86
Table 6-34. Summary of Direct and Indirect Effects to Navigation.....	6-87
Table 6-35. Reasonably Foreseeable Future Actions Relevant to Recreation	6-90
Table 6-36. Summary of Direct and Indirect Effects to Recreation	6-92
Table 6-37. Reasonably Foreseeable Future Actions Relevant to Water Supply	6-97
Table 6-38. Summary of Direct and Indirect Effects to Water Supply	6-97
Table 6-39. Reasonably Foreseeable Future Actions Relevant to Visual Resources	6-100
Table 6-40. Summary of Direct and Indirect Effects to Visual Resources	6-101
Table 6-41. Reasonably Foreseeable Future Actions Relevant to Noise.....	6-103
Table 6-42. Summary of Direct and Indirect Effects to Noise.....	6-104
Table 6-43. Reasonably Foreseeable Future Actions Relevant to Fisheries.....	6-106
Table 6-44. Direct and Indirect Impact Summary for Fisheries	6-108
Table 6-45. Reasonably Foreseeable Future Actions Relevant to Cultural Resources	6-109
Table 6-46. Summary of Direct and Indirect Effects to Cultural Resources	6-111
Table 6-47. Reasonably Foreseeable Future Actions Relevant to Tribal Interests.....	6-116
Table 6-48. Reasonably Foreseeable Future Actions Relevant to Environmental Justice.....	6-120
Table 6-49. Summary of Direct and Indirect Effects to Environmental Justice.....	6-124
Table 7-1. Evaluation of alternatives. Part 1 indicates whether each alternative met the Purpose and Need Statement of the EIS. Part 2 indicates whether each alternative met the objectives of the EIS. Part 3 summarizes major effects for each of the alternatives.....	7-18
Table 7-2. List of Measures that were Carried Forward, Modified, or Added to the Preferred Alternative from Alternatives in Chapter 2	7-24
Table 7-3. Estimated Juvenile Spring Fish Passage Spill and Performance Standard Spill Operations by Columbia River System Project.....	7-35
Table 7-4. Typical Summer Juvenile Fish Passage Spill Operations by Columbia River System Project	7-36

Columbia River System Operations Environmental Impact Statement
Table of Contents

Table 7-5. Measures Included in the Preferred Alternative to Benefit Endangered Species Act-listed Fish that are Being Carried Forward from Previous Commitments by the Co-Lead Agencies	7-42
Table 7-7. Final List of Measures Incorporated into the Preferred Alternative during the Informal and Formal Endangered Species Act Consultation Process.	7-48
Table 7-8. Libby Dam Monthly Average Outflow for the Preferred Alternative (as change from No Action Alternative).....	7-57
Table 7-9. Bonners Ferry Monthly Average Flow for the Preferred Alternative (as change from No Action Alternative).....	7-58
Table 7-10. Hungry Horse Dam Monthly Average Outflow for the Preferred Alternative (as change from No Action Alternative).....	7-60
Table 7-11. Columbia Falls Monthly Average Flow for the Preferred Alternative (as change from No Action Alternative)	7-61
Table 7-12. Pend Oreille Basin Median Monthly Average Flows for the Preferred Alternative (as change from No Action Alternative)	7-62
Table 7-13. Grand Coulee Dam Monthly Average Outflow for the Preferred Alternative (as change from No Action Alternative).....	7-68
Table 7-14. Middle Columbia River Monthly Average Flows for the Preferred Alternative (as change from No Action Alternative).....	7-69
Table 7-15. Dworshak Dam Monthly Average Outflow for the Preferred Alternative (as change from No Action Alternative)	7-73
Table 7-16. Lower Snake Basin Monthly Average Flows for the Preferred Alternative (as change from No Action Alternative)	7-75
Table 7-17. Normal Operating Ranges at John Day Reservoir for the Preferred Alternative	7-76
Table 7-18. McNary Dam Monthly Average Outflow for the Preferred Alternative (as change from No Action Alternative)	7-77
Table 7-19. John Day Dam Monthly Average Outflow for the Preferred Alternative (as change from No Action Alternative)	7-79
Table 7-20. Lower Columbia River Median Monthly Average Flows for the Preferred Alternative (as change from No Action Alternative)	7-80
Table 7-21. Summary of Spill Operations for the Preferred Alternative and No Action Alternative	7-82
Table 7-22. Preferred Alternative Juvenile Model Metrics for Upper Columbia River Spring-Run Chinook Salmon.....	7-97
Table 7-23. Preferred Alternative Model Metrics for Adult Upper Columbia River Spring Chinook Salmon	7-98
Table 7-24. Preferred Alternative Model Metrics for Juvenile Upper Columbia Steelhead.....	7-99
Table 7-25. Preferred Alternative Juvenile Model Metrics for Snake River Spring/Summer Chinook Salmon	7-104
Table 7-26. Preferred Alternative Adult Model Metrics for Snake River Spring/Summer Chinook Salmon	7-106
Table 7-27. Juvenile Model Metrics for Snake River Steelhead under the Preferred Alternative	7-108

Columbia River System Operations Environmental Impact Statement
Table of Contents

Table 7-28. Preferred Alternative Adult Model Metrics for Snake River Steelhead	7-109
Table 7-29. Sensitive Species Effects for Preferred Alternative.....	7-158
Table 7-30. Monthly Electricity Generation at the Columbia River System Projects under Preferred Alternative (aMW)	7-161
Table 7-31. Coal Capacity Assumptions Zero-Carbon Replacement Resources.....	7-165
Table 7-32. Change in Bonneville’s Priority Firm Tier 1 Rate, Bonneville Finances.....	7-168
Table 7-33. Average Bonneville Wholesale Power Rate (\$/MWh), for the Base Case without Additional Coal Plant Retirements as well as the Rate Pressures Associated with Additional Sensitivity Analysis.....	7-169
Table 7-34. Bonneville Financial Analysis Results Incremental Compared to No Action Alternative	7-174
Table 7-36. Average Annual Social Welfare Effect of the Preferred Alternative based on the Increased Cost of Producing Power to Meet Demand	7-175
Table 7-37. Average Residential Rate Pressure Effects by Columbia River System Operations Region under the Preferred Alternative	7-176
Table 7-38. Percentage of Residential End Users Who may Experience Changes in Electricity Expenditures by Size of Expenditure Change under the Preferred Alternative	7-178
Table 7-39. Regional Economic Effects from Changes in Household Spending on Electricity	7-179
Table 7-40. Percentage of Commercial and Industrial End Users Who Experience Changes in Electricity Expenditures by Size of Expenditure Change under the Preferred Alternative	7-179
Table 7-41. Regional Economic Effects from Changes in Commercial Business Spending on Electricity	7-180
Table 7-42. Regional Economic Effects from Changes in Industrial Business Spending on Electricity	7-180
Table 7-43. Summary of Effects under the Preferred Alternative without Additional Coal Plant Closures	7-182
Table 7-44. Changes in Average Commercial Navigation Flow Days Under the Preferred Alternative Relative to No Action Alternative, over 50 years.....	7-186
Table 7-45. Changes in Average Annual Costs of Commercial Navigation Operations Under the Preferred Alternative Relative to No Action Alternative (2019 dollars), over 50 years.....	7-187
Table 7-46. Changes in Economic Effects of Recreation Under the Preferred Alternative Relative to the No Action Alternative	7-194
Table 7-47. Effects to Archaeological Resources – Acre-Day Calculations by Reservoir and Alternative	7-198
Table 7-48. Effects to Archaeological Resources – Increases or Decreases in Exposure of Archaeological Resources by Reservoir and Multiple Objective Alternatives	7-198
Table 7-49. Effects to Archaeological Resources – Average Frequency of Reservoir Elevation Change by Alternative	7-200
Table 7-50. Effects to Archaeological Resources – Changes in Average Amplitude of Reservoir Elevation Change by Alternative	7-200

Columbia River System Operations Environmental Impact Statement
Table of Contents

Table 7-51. Effects to Archaeological Resources – Changes in the Average Frequency of High Draft Rate Events by Reservoir and Alternative 7-201

Table 7-52. Annual-Equivalent Costs and Change in Costs for the Preferred Alternatives (2019 dollars) 7-207

Table 7-53. Reasonably Foreseeable Future Actions 7-214

Table 7-54. Reasonably Foreseeable Future Actions and Potentially Affected Resources Matrix Under the Preferred Alternative 7-215

Table 7-55. Summary of Environmental Effects 7-232

Table 7-56. Summary of Socioeconomics Effects 7-242

Table 9-1. Columbia River System Operations Environmental Impact Statement Cooperating Agencies 9-9

Table 10-1. List of Preparers 10-1

Columbia River System Operations Environmental Impact Statement
Table of Contents

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ACRONYMS AND ABBREVIATIONS

ACS	U.S. Census Bureau American Community Survey
ADFG	Alaska Department of Fish and Game
AEP	annual exceedance probability
AF/AT	average flow/average temperature
AF/LT	average inflow/low temperature
amsl	above mean sea level
aMW	average megawatt
AQI	Air Quality Index
AR	atmospheric river
ARPA	Archaeological Resources Protection Act
ASW	adjustable spillway weir
BA	balancing authority
BiOp	biological opinion
BMP	best management practice
Bonneville	Bonneville Power Administration
BP-18	Current (2018) Bonneville Power Administration rate case
CAA	Clean Air Act
CAR	Fish and Wildlife Coordination Act Report
Census	U.S. Census Bureau
Census of Agriculture	U.S. Department of Agriculture Census of Agriculture
CEM	conceptual ecological models
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
C.F.R.	Code of Federal Regulations
cfs	cubic feet per second
CH ₄	methane
CIAA	Cumulative Impact Analysis Area
cm	centimeters
CO	carbon monoxide
CO ₂	carbon dioxide
CO ₂ e	carbon dioxide equivalents
COMPASS	Comparative Passage model
Corps	U.S. Army Corps of Engineers
CRITFC	Columbia River Inter-Tribal Fish Commission
CRFM	Columbia River Fish Mitigation Program
CRS	Columbia River System

*Columbia River System Operations Environmental Impact Statement
Acronyms and Abbreviations*

CRSO	Columbia River System Operations
CRT	Columbia River Treaty
CRWMP	Columbia River Water Management Program
CSKT	Confederated Salish and Kootenai Tribes
CSNS	Columbia-Snake Navigation System
CSS	Comparative Survival Study model
CTCR	Confederated Tribes of the Colville Reservation
Cultural Resources Program	Federal Columbia River Power System Cultural Resources Program
CWA	Clean Water Act
CYE	Cabinet-Yaak Ecosystem
DART	University of Washington – Data Access Real Time
dBA	decibels on the A-weighted scale
DM	Departmental Manual
DMMP	Dredged Material Management Plan
DO	dissolved oxygen
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
DPS	distinct population segment
DSI	direct service industry
Ecology	Washington State Department of Ecology
EFH	essential fish habitat
EIA	U.S. Energy Information Administration
EIS	environmental impact statement
EJSCREEN	Environmental Justice Mapping and Screening Tool
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionarily significant unit
F&W Program	Bonneville Power Administration’s Fish and Wildlife Program
FCRPS	Federal Columbia River Power System
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FONSI	Finding of No Significant Impact
FOP	fish operations plan
FPP	fish passage plan
FR	Federal Register
FRM	flood risk management

*Columbia River System Operations Environmental Impact Statement
Acronyms and Abbreviations*

ft/s	feet per second
FY	fiscal year
GAP	Gap Analysis Program
GBT	gas bubble trauma
GHG	greenhouse gas
GIS	geographic information system
GWP	global warming potential
H&H	hydrology and hydraulics
HAB	harmful algae bloom
HAP	hazardous air pollutant
HCNRA	Hells Canyon National Recreation Area
H. Doc.	U.S. Congress House Document
HEC-RAS	Hydraulic Engineering Center River Analysis System
HF/LT	high inflow/low temperature
HMU	Habitat Management Unit
HydSim	Hydro System Simulator
IAPMP	Inland Avian Predator Management Plan
IBA	Important Bird Area
IDAPA	Idaho Administrative Procedures Act
IDEQ	Idaho Department of Environmental Quality
IDFG	Idaho Department of Fish and Game
IDPR	Idaho Department of Parks and Recreation
IEPR	Independent External Peer Review
IFP	improved fish passage
IOU	investor-owned utility
IPCC	Intergovernmental Panel on Climate Change
ISAB	Independent Scientific Advisory Board
ITA	Indian Trust Asset
IWG	Interagency Working Group
kaf	thousand acre-feet
kcfs	thousand cubic feet per second
kg	kilogram
km	kilometers
KTOI	Kootenai Tribe of Idaho
kW	kilowatt
kWh	kilowatt hour
Lakes Commission	Lakes Commission
LCM	Life Cycle Model

*Columbia River System Operations Environmental Impact Statement
Acronyms and Abbreviations*

LCR FNC	Lower Columbia River Federal Navigation Channel
LF/AT	low flow/average temperature
LF/HT	low flow/high temperature
LNG	liquid natural gas
LOLP	loss of load probability
LPS	lamprey passage structures
LRFEP	Lake Roosevelt Fishery Enhancement Program
m	meters
M&I	municipal and industrial
Maf	million acre-feet
Mcy	million cubic yards
MDEQ	Montana Department of Environmental Quality
MFWP	Montana Fish, Wildlife and Parks
mg/L	milligrams per liter
MIP	minimum irrigation pool
MMPA	Marine Mammal Protection Act
MMT	Million metric tons
MO	Multiple Objective Alternative
MOP	minimum operating pool
MOU	memorandum of understanding
MPG	major population group
MW	megawatt
MWh	megawatt per hour
N ₂ O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NASS	National Agricultural Statistics Service
NAVD88	North American Vertical Datum of 1988
NCDE	Northern Continental Divide Ecosystem
NCE	Northern Cascades Ecosystem
nDPS	northern distinct population segment of green sturgeon
NEI	National Emissions Inventory
NEPA	National Environmental Policy Act
NERC	North American Electric Reliability Corporation
NGO	non-governmental organization
NGVD29	National Geodetic Vertical Datum of 1929
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NO ₂	nitrogen dioxide

*Columbia River System Operations Environmental Impact Statement
Acronyms and Abbreviations*

NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
Northwest Power Act	Pacific Northwest Electric Power Planning and Conservation Act
NO _x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NPV	net present value
NRC	Nuclear Research Council
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NT	network integration
NTDE	National Tidal Datum Epoch
NW Council	Northwest Power and Conservation Council
NWFSC	Northwest Fisheries Science Center
NWHI	Northwest Habitat Institute
NWI	National Wetlands Inventory
NWR	National Wildlife Refuge
NWRFC	Northwest River Forecast Center
O ₃	ozone
OAR	Oregon Administrative Rule
ODA	Oregon Department of Agriculture
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
OMB	Office of Management and Budget
OPRD	Oregon Parks and Recreation Department
ORS	Oregon Revised Statute
OWRD	Oregon Water Resources Department
PAD-US	Protected Areas Database of the United States
PCBs	polychlorinated biphenyls
PF	Priority Firm
PFMC	Pacific Fishery Management Council
PIT	passive integrated transponder
PITPH	probability of passing powerhouses
PM	particulate matter
PNCA	Pacific Northwest Coordination Agreement
ppm	parts per million
PRPA	Paleontological Resources Preservation Act
PSC	Pacific Salmon Commission

*Columbia River System Operations Environmental Impact Statement
Acronyms and Abbreviations*

PSMP	Lower Snake River Programmatic Sediment Management Plan
PTP	point-to-point
PUD	public utility district
RCP	Resource Concentration Pathway
REC	renewable energy certificate
Reclamation	U.S. Bureau of Reclamation
ResSim	Hydrologic Engineering Center Reservoir System Simulation
RF	radiative forcing
RFFA	reasonably foreseeable future actions
RHWM	rate period high water mark
RM	river mile
RM&E	research, monitoring, and evaluation
RMJOC	River Management Joint Operating Committee
ROD	Record of Decision
RPA	reasonable and prudent alternative
RPS	Renewable Portfolio Standard
RSLC	relative sea level change
RT	retention time
RUVD	Recreation Use Valuation Database
SAR	smolt to adult return rate
SCC	social cost of carbon
SCENT	Snake Columbia Economic Navigation Tool
sDPS	southern distinct population segment of green sturgeon
SIP	state implementation plan
SKQ	Seli's Ksanka Qlispe'
SO ₂	sulfur dioxide
SOR	Columbia River System Operation Review
SRD	storage reservation diagram
SWS	selective withdrawal system
Systemwide PA	2009 Systemwide Programmatic Agreement for the Management of Historic Properties Affected by the Multipurpose Operations of Fourteen Projects of the Federal Columbia River Power System
TCL	traditional cultural landscape
TCP	traditional cultural property
TDG	total dissolved gas
TEV	total economic value
TIR	transport to in-river SAR ratio
TMDL	total maximum daily load

*Columbia River System Operations Environmental Impact Statement
Acronyms and Abbreviations*

TMT	Technical Management Team
Treaty Review	Columbia River Treaty 2014/2024 Review
TRM	tiered rate methodology
UDV	unit day value
URC	upper rule curve
U.S.C.	United States Code
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGCRP	U.S. Global Change Research Program
USGS	U.S. Geological Survey
VarQ	variable discharge storage regulation procedure
VDL	variable draft limit
VOC	volatile organic compound
W/D	width to depth
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WECC	Western Electricity Coordination Council
WQS	water quality standard
WMA	Wildlife Management Area
WMP	water management plan
WNWCB	Washington Noxious Weed Control Board
WSE	water surface elevation
WSPRC	Washington State Parks and Recreation Commission
WTP	willingness-to-pay
WTT	water travel time

GLOSSARY

Access point: A place where people access a site for recreation. An access point might include a boat launch, a campground, a parking area, etc. A recreation area may contain one or more access points.

Acre-foot: The volume of water that will cover an area of 1 acre to a depth of 1 foot.

Ambient air: Ambient air is the air surrounding a particular spot, such as a powerplant.

Anadromous fish: Fish, such as salmon or steelhead trout, that hatch in fresh water, migrate to and mature in the ocean, and return to fresh water as adults to spawn.

Annual operating plan: A yearly plan for operating projects on the Columbia River. Such a plan is specifically required by the Columbia River Treaty and by the Pacific Northwest Coordination Agreement.

Aquifer: Any geological formation containing water, especially one that supplies water to wells, springs, etc.

Artifact: An object of any type made by human hands. Tools, weapons, pottery, and sculptured and engraved objects are artifacts.

Augment: Increase; in this application, to increase river flows above levels that would occur under normal operation by releasing more water from storage reservoirs.

Average megawatt (aMW): A unit of energy that represents 1 megawatt of electric power capacity continuously over a year. One aMW is equal to 8,760 megawatts per hour.

British Columbia Hydro and Power Authority: This Canadian Crown corporation was formed in 1962 following the merger of an expropriated private utility and the B.C. Power Commission.

Balancing authority: The responsible entity that integrates resource plans ahead of time, maintains load interchange-generation balance within a balancing authority area, and supports interconnection frequency in real time.

Balancing authority area: The collection of generation, transmission, and loads within the metered boundaries of the balancing authority. The balancing authority maintains load-resource balance within this area.

Baseload: In a demand sense, a load that varies only slightly over a specified time period. In a supply sense, a plant that operates most efficiently at a relatively constant level of generation.

Bypass system: Structure in a dam that provides a route for fish to move through or around the dam without going through the turbines.

Capacity: The maximum load that a generator, piece of equipment, substation, transmission line, or system can carry under existing service conditions. Baseload capacity is the power output that can be continuously produced to run at least 70 percent of the time. Firm capacity is the capacity whose availability is ensured to the purchaser.

Columbia River Treaty (CRT): A treaty signed by the United States and Canada on September 16, 1964, for joint development of the Columbia River. Under the treaty Canada built three large storage dams (Duncan, Keenleyside, and Mica) on the upper reaches of the Columbia River, which originates in Canada. It is a U.S.-Canadian agreement for bilateral development and management of the Columbia River to achieve flood control and increased power production.

Consumer surplus: Economic value received by the consumer of a good, service, or resource (e.g., by a recreational user) that is above the price actually paid.

Cubic feet per second (cfs): A unit of measurement pertaining to flow or discharge of water. One cfs is equal to 449 gallons (1.7 cubic meters) per minute.

Cultural resources: The non-renewable evidence of human occupation or activity as seen in any district, site, building, structure, artifact, ruin, object, work of art, architecture, or natural feature that was part of human history at the national, state, or local level.

Demand: For electrical energy, the rate at which it is used, whether at a given instant or averaged over any designated period of time.

Depletion: Withdrawal of water from a stream, thereby reducing the volume of instream flow.

Discharge: Volume of water flowing at a given time, usually expressed in cubic feet per second.

Dissolved gas concentrations: The amount of chemicals normally occurring as gases, such as nitrogen and oxygen, which are held in solution in water, expressed in units such as milligrams of the gas per liter of liquid.

Draft: Release of water from a storage reservoir.

Draft rate: The rate at which water, released from storage behind a dam, reduces the elevation of the reservoir.

Drawdown: The distance that the water surface of a reservoir is lowered from a given elevation as water is released from the reservoir. Also refers to the act of lowering reservoir levels.

Economic value: The difference between the maximum amount a recreationist would be willing to pay to participate in a recreational activity and the actual cost of participating in that activity. This is referred to by economists as consumer surplus or net economic value.

Electricity: Electric current used or regarded as a source of power.

Endangered: A plant or animal species which is in danger of extinction throughout all or a significant portion of its range because its habitat is threatened with destruction, drastic modification, or severe curtailment, or because of overexploitation, disease, predation, or other factors; federally endangered species are officially designated by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service and published in the *Federal Register*.

Endemic: Native or limited to a certain region.

Energy: As commonly used in the electric utility industry, electric energy means kilowatt-hours, or joules (the level of power delivered multiplied by the amount of time that the level of power is delivered). Used interchangeably with, although technically not a synonym of, power.

Entrainment: The drawing of fish and other aquatic organisms into tubes or tunnels carrying water for cooling purposes into thermal plants, or for power generating purposes into hydroelectric plants. Entrainment increases mortality rates for those organisms.

Firm energy: Energy considered ensurable to the customer to meet all agreed-upon portions of the customer's load requirements over a defined period. As defined in Bonneville Power Administration's system, electric energy produced under critical water conditions.

Fishery: Generally defined as a group of individuals or vessels that catch finfish or harvest shellfish, with specific commonalities in activity, including the fish species or stock targeted, the gear used, the location of activity, and the season of activity.

Fish hatchery: A facility in which fish eggs are incubated and hatched and juvenile fish are reared for release to rivers or lakes.

Fish ladders: A series of ascending pools constructed to enable salmon or other fish to swim upstream around or over a dam.

Fish passage facilities: Features of a dam that enable fish to move around, through, or over without harm. Generally an upstream fish ladder or a downstream bypass system.

Flow: The volume of water passing a given point per unit of time.

Flowgates: Flowgates are points along a transmission system through which the power flow is measured.

Forebay: The portion of the reservoir at a hydroelectric plant which is immediately upstream of the generating station.

Freshet: A rapid temporary rise in streamflow caused by heavy rains or rapid snowmelt.

Full pool: The maximum level of a reservoir under its established normal operating range.

Generation: The act of producing electricity from other forms of energy or the amount of electrical energy produced.

Historical streamflow record: The unregulated streamflow database of the 50 years beginning in July 1928; data is modified to adjust for factors such as irrigation depletions and evaporations for the particular operating year being studied.

Hydraulic head: The vertical distance between the surface of the reservoir and the surface of the river immediately downstream from the turbines and dam.

Hydroelectric: The production of electric power through use of the gravitational force of falling water.

Hydrology: The science of dealing with the continuous cycle of evapotranspiration, precipitation, and runoff.

Hydroregulation model: A computer-based mathematical model that simulates the regulation of water in the coordinated operation of a river system.

Inflow: Water that flows into a reservoir or forebay during a specified period.

Intake: The entrance to a conduit through a dam or water facility.

Interruptible: A supply of power which, by agreement, can be shut off on relatively short notice (from minutes to a few days).

Intertie: A transmission line or system of transmission lines permitting a flow of energy between major power systems. The Bonneville Power Administration transmission grid has interties to British Columbia, Canada; California; and eastern Montana.

Jobs: Combined full- and part-time jobs on an annualized basis.

Juvenile: The early stage in the life cycle of anadromous fish when they migrate downstream to the ocean.

kcfs: Thousand cubic feet per second; a measurement of water flow equivalent to 1,000 cubic feet of water passing a given point in one second.

Labor income: includes employee compensation and proprietary income. Employee compensation consists of wage and salary payments as well as benefits (e.g., health and retirement benefits) and employer paid payroll taxes (e.g., employer social security contributions and unemployment taxes). Proprietary income consists of payments received by self-employed individuals (such as doctors and lawyers) and unincorporated business owners.

Levee: An embankment constructed to prevent a river from overflowing.

Littoral zone: The shallower waters near the shore of a reservoir or lake.

Load: The amount of electric power or energy delivered or required at any specified point or points on a system. Load originates primarily at the energy-consuming equipment of customers.

Load shaping: The adjustment of storage releases so that generation and load are continuously in balance.

Lock: A chambered structure on a waterway closed off with gates for the purpose of raising or lowering the water level within the lock chamber so ships can move from one elevation to another along the waterway.

Low pool: At or near the minimum level of a reservoir under its established normal operating range.

Macrophytes: Aquatic plants that are macroscopic, or large enough to be seen with the naked eye.

Mainstem: The principal river in a basin, as opposed to the tributary streams and smaller rivers that feed into it.

Megawatt (MW) and kilowatt (kW): A watt is a measure of a unit of power. One megawatt represents 1,000 kilowatts or 1 million watts. MW is a standard metric describing electric power generating capacity.

Megawatt hours (MWh) and kilowatt hours (kWh): MWh and kWh are energy measurements denoting electricity production or consumption. One MWh equals 1,000 kWh. In the electricity context, power (MW) is the rate of producing, transferring, or using energy, and energy (MWh) is power used over a period of time.

Middle Columbia: The section of the Columbia River from the U.S.-Canada border to its confluence with the Snake River.

Model: A mathematical function with parameters that can be adjusted so that the function closely describes a set of empirical data. A “mathematical” or “mechanistic” model is usually based on biological or physical mechanisms and has model parameters that have real-world interpretations. In contrast, “statistical” or “empirical” models involve curve-fitting to data where the math function used is selected for its numerical properties. Extrapolation from mechanistic models (e.g., pharmacokinetic equations) usually carries higher confidence than extrapolation using empirical models (e.g., logic).

Minimum operating pool (MOP): The minimum elevation of the established normal operating range of a reservoir.

Operating limits: Limits or requirements that must be factored into the planning process for operating reservoirs and generating projects. (Also see operating requirements, below.)

Operating requirements: Guidelines and limits that must be followed in the operation of a reservoir or generating project. These requirements may originate in authorizing legislation, physical plant limitations, or other sources. Non-power operating requirements pertain to navigation, flood control, recreation, irrigation, and other non-power uses of a river.

Operating rule curve: A curve, or family of curves, indicating how a reservoir is to be operated under specific conditions and for specific purposes.

Operating year: The 12-month period from August 1 through July 31.

Outages: Periods, both planned and unexpected, during which the transmission of power stops or a particular power-producing facility ceases to provide generation.

Outflow: The volume of water per unit of time discharged at a hydroelectric project.

Pacific Northwest Coordination Agreement: A binding agreement among Bonneville Power Administration, the U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, and the major generating utilities in the Pacific Northwest that stemmed from the Columbia River Treaty. The agreement specifies a multitude of operating rules, criteria, and procedures for coordinating operation of the system for power production. It directs operation of major generation facilities as though they belonged to a single owner.

Pacific Northwest Electric Power Planning and Conservation Act: In December 1980, Congress passed this Act, Public Law 96-501 (referred to as the Northwest Power Act). This act authorized the four Pacific Northwest States— Idaho, Montana, Oregon, and Washington—to enter into an interstate compact for long-range planning and protection of shared resources. As a result of the act, each of the four states passed enabling legislation to create the Northwest Power Planning Council in April 1981.

Particulates: Substances that consist of minute separate particles, such as dust or soot.

Peak load: The maximum load in a stated period of time. It may be the maximum load at a given instant in the stated period or the maximum average load within a designated interval of the stated period of time. Peak can also be used to refer to the maximum capacity or energy.

Peaking or peaking capacity: The generating capacity available to assist in meeting that portion of the load that is above baseload. Alternatively, the maximum output of a generating plant or plants during a specified peak-load period.

Phytoplankton: The plant portion of floating or weakly swimming organisms, often microscopic in size, in a body of water.

Pool: Reservoir; a body of water impounded by a dam.

Power: The rate of energy production or transfer. Power is expressed in watts and used interchangeably with energy, although it is technically not a synonym of energy. Power delivered to a load is also called demand.

Project outflow: The volume of water per unit of time discharged from a project.

Record of Decision (ROD): A document notifying the public of a decision made, together with the reasons for making that decision. Records of Decision are published in the *Federal Register*.

Recreation area: A reservoir, river reach between reservoirs, or the Pacific Ocean off the coast of Oregon and Washington, used for recreation. A recreation area may have one or more access points.

Redds: Salmon spawning nests in gravel.

Refill: The point at which the hydro system is considered “full” from the seasonal snowmelt runoff. Also refers to the annual process of filling a reservoir.

Regional economic contributions: These reflect economic activity within a specific geographic region supported by expenditures for a particular economic sector (e.g., recreational visitation). Contributions are often measured in terms of sales (spending), jobs, income, and value added, though other measures may be used.

Reliability: For a power system, a measure of the degree of certainty that the system will continue to meet load for a specified period of time.

Reservoir elevations: The levels of the water stored behind dams.

Reservoir storage: The volume of water in a reservoir at a given time.

Resident fish: Fish species that reside in fresh water throughout their lives.

Residualize: When migrating juvenile salmonid smolts lose their urge to migrate, physiologically revert to their freshwater life form, and remain in fresh water rather than migrate to sea.

Riprap: Broken rock, cobbles, or boulders placed on the bank of a stream or river for protection against the erosive action of water.

Rule curves: Water levels, represented graphically as curves, that guide reservoir operations.

Run-of-river dams: Hydroelectric generating plants that operate based only on available streamflow and some short-term storage (hourly, daily, or weekly).

Run-of-river reservoirs: The pools or impoundments formed behind run-of-river dams.

Salmonids: Fish of the family Salmonidae, such as salmon, trout (including steelhead), char, and whitefish.

Scoping: The process of defining the scope of a study, primarily with respect to the issues, geographic area, and alternatives to be considered. The term is typically used in association with environmental documents prepared under the National Environmental Policy Act.

Secondary energy: Hydroelectric energy in excess of firm energy, often used to displace thermal resources. Sometimes called non-firm energy.

Sedimentation: The settling of material (such as dust or other particles) into water and eventual deposition on the bottoms of streams and rivers.

Shaping: The scheduling and operating of generating resources to meet changing load levels. Load shaping on a hydro system usually involves the adjustment of reservoir releases so that generation and load are continuously in balance.

Simulation: The representation of an actual system by analogous characteristics of a device that is easier to construct, modify, or understand, or by mathematical equations.

Smolt: A juvenile salmon or steelhead migrating to the ocean and undergoing physiological changes to adapt its body from a freshwater to a saltwater environment.

Spawning: The releasing and fertilizing of eggs by fish.

Spending: Equivalent to the sales by firms in the region. This can be expressed in terms of (1) recreation expenditures, and/or (2) final demand, which is the total sales by firms in the region from all buyers, including recreationists, as well as businesses and households in subsequent rounds of spending.

Spill: Water passed over a spillway without going through turbines to produce electricity. Spill can be forced, when there is no storage capability and flows exceed turbine capacity, or planned, for example, when water is spilled to enhance juvenile fish passage.

Spillway: Overflow structure of a dam

Stochastic: Involving chance or probability.

Storage reservoirs: Reservoirs that have space for retaining water from springtime snowmelts. Retained water is released as necessary for multiple uses: power production, fish passage, irrigation, and navigation.

Streamflow: The rate at which water passes a given point in a stream, usually expressed in cubic feet per second.

Subyearlings: Juvenile fish less than 1 year old.

Surplus energy: Energy generated that is beyond the immediate needs of the producing system. This energy may be sold on an interruptible basis or as firm power.

System flood control: Flood protection for the Portland, Oregon, and Vancouver, Washington, metropolitan area that is coordinated among all of the storage reservoirs in the Columbia River system.

Tailrace: The canal or channel that carries water away from a dam.

Tailwater: The water surface immediately downstream from a dam or hydroelectric powerplant.

Threatened: Legal status afforded to plant or animal species that are likely to become endangered within the foreseeable future throughout all or a significant portion of their range, as determined by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service.

Transmission path: A path refers to a route over which the power flows from one point to another (i.e., the direction power flows across a transmission line).

Tules: The name commonly applied to fall chinook salmon originating on the lower Columbia River.

Turbidity: A measure of the optical clarity of water, which depends on the light scattering and absorption characteristics of suspended and dissolved material in the water.

Turbine: Machinery that converts kinetic energy of a moving fluid, such as falling water, to mechanical or electrical power.

Upper rule curve (URC): The flood control rule curve for a storage reservoir which typically is the uppermost of the family of rule curves used to guide reservoir operations.

Upriver brights: The name commonly applied to fall chinook salmon originating on the middle Columbia River, primarily in the area below Priest Rapids Dam.

Velocity: Speed; the rate of linear motion in a given direction.

Water conditions: The overall supply of water to operate the Pacific Northwest hydroelectric generating system at any given time, taking into account reservoir levels, snowpack, any needs to provide water or retain water to meet various operating constraints (such as the water budget, flood control, flow constraints, etc.), weather conditions, and other factors.

Water particle travel time: The theoretical time that a water particle would take to travel through a given reservoir or river reach. It is calculated by dividing the flow (volume of water per unit time) by the cross-sectional area of the channel.

Water retention time: The length of time that a particle of water is resident in a lake or reservoir, based on rates of inflow, outflow, and circulation within the waterbody.

Water rights: Priority claims to water. In Western states, water rights are based on the principle “first in time, first in right,” meaning older claims take precedence over newer ones.

Water year: One hydrologic cycle corresponding to Bonneville Power Administration’s fiscal year, October 1 through September 30. Depending on streamflows a water year may be defined as high, low, or average, or *critical*. The **critical water year** is a sequence of streamflows under which the regional hydro system could produce an amount of power equal to that which could have been produced during the historical critical period, given today’s generating facilities and constraints.

Yearlings: One-year-old juvenile salmon and steelhead.

Zooplankton: Aquatic animals that cannot actively swim against the current and cannot make their own food by photosynthesis.

DATUM CONVERSION

This table shows the vertical datum adjustment from NGVD29 to NAVD88 for the 14 CRS projects.

Vertical Datum Adjustment

Location	Datum Adjustment (feet)
Albeni Falls Dam	3.9
Bonneville Dam	3.3
Chief Joseph Dam	4.0
Dworshak Dam	3.3
Grand Coulee Dam	3.9
Hungry Horse Dam	3.9
Ice Harbor Dam	3.4
John Day Dam	3.2
Libby Dam	3.9
Little Goose Dam	3.2
Lower Granite Dam	3.4
Lower Monumental Dam	3.3
McNary Dam	3.3
The Dalles Dam	3.3

CHAPTER 1 - INTRODUCTION

1.1 BACKGROUND

The Columbia River is one of the greatest natural resources in the western United States. The river and its tributaries impact nearly every resident of the Northwest in some way, by providing hydroelectric power, recreation opportunities, navigation, irrigation for crops, and more. The Columbia River System's Federal and non-Federal dams also provide hydroelectric energy production for about half of regional demands. For thousands of tribal members whose societies have been shaped over millennia by their proximity to and relationship with the Columbia River and its tributaries, these water bodies are also an essential source of life and a foundation of tribal spiritual and cultural connections. Many tribes have not only lost access to traditional places on the river, but have lost access to the one thing that all these places had in common, which bound them together—the salmon.

Today, a variety of projects in the Northwest waterways are operated for hydropower and other purposes. There are approximately 375 major projects; 141 are owned by Federal agencies, and 221 are owned by non-Federal entities. Of the 141 Federal projects, 31 generate hydropower in addition to serving other purposes. These 31 multi-purpose dam and reservoir projects make up the Federal Columbia River Power System (FCRPS), constructed and operated by the U.S. Army Corps of Engineers (Corps) and the U.S. Bureau of Reclamation (Reclamation). The Bonneville Power Administration (Bonneville) markets and delivers electric power from the FCRPS. Each project within the FCRPS is operated to meet various congressionally authorized purposes and other system-wide purposes.

Fourteen of the FCRPS projects are operated as a coordinated system known as the Columbia River System (CRS) within the interior Columbia River Basin in the states of Idaho, Montana, Oregon, and Washington. The 14 CRS projects ("project" is used to collectively refer to a dam and its associated reservoir) are Libby, Hungry Horse, Albeni Falls, Grand Coulee, Chief Joseph, Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. Projects in the upper Snake, Willamette, and Rogue River Basins are excluded from the CRS because these are coordinated and operated separately. Projects in Canada are not operated by the co-lead agencies. Figure 1-1 shows the geographic locations of the 14 CRS projects. The CRS consists of subbasins, each having distinct topographic, meteorological, and/or hydrologic characteristics. These subbasins are grouped into four regions, A to D, shown in Figure 1-1, that are referred to throughout this environmental impact statement (EIS). The Corps, Reclamation, and Bonneville are preparing this EIS, as co-lead agencies, under the requirements of the National Environmental Policy Act (NEPA), to identify the environmental impacts associated with the operation, maintenance, and configuration (management) of the CRS.

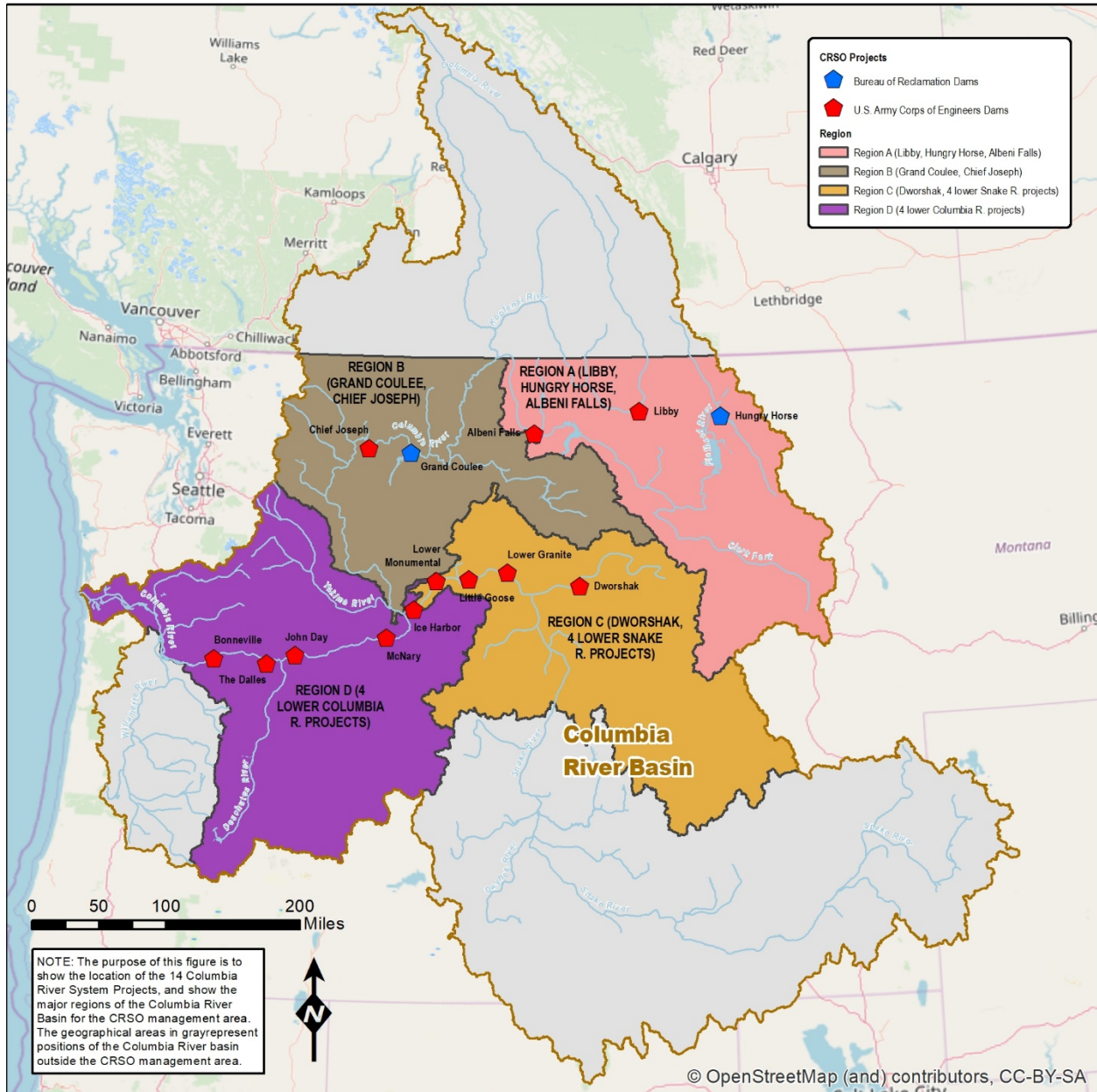


Figure 1-1. Geographic Locations of the Columbia River System Projects

The U.S. Congress authorized the Corps and Reclamation to construct, operate, and maintain the CRS projects to meet multiple specified purposes, including flood risk management (FRM), navigation, hydropower production, irrigation, fish and wildlife conservation, recreation, and municipal and industrial (M&I) water supply. However, not every project is authorized for all of these purposes. Bonneville is authorized to market and transmit the power generated by these coordinated system operations. The following list provides more detail about these purposes:

- FRM. Storage projects allow water managers to store water in times of high flow volume to reduce the likelihood of flooding throughout the system.
- Water Supply/Irrigation. Some projects are operated for the storage and delivery of irrigation and M&I water. For example, water pumped from Lake Roosevelt behind Grand Coulee Dam is delivered downstream to Banks Lake for irrigation and M&I. John Day is operated to meet elevation requirements to allow for pumping water for irrigation. Other projects, such as the lower Snake River projects, provide the incidental benefit of pumping by maintaining elevations for other purposes, such as navigation.
- Hydroelectric Power Generation. The Federal dams in the Northwest supply about 27 percent of the region's power under average water conditions (Bonville 2019a).
- Navigation. The four lower Columbia River dams and four lower Snake River dams have navigation locks that allow passage for boats and barges to facilitate the transport of goods to and from the Pacific Ocean and inland ports as far upstream as Lewiston, Idaho.
- Recreation. The reservoir and adjacent public (or park) lands provide recreational opportunities for boaters, anglers, swimmers, wind and kite surfers, hunters, hikers, and campers throughout the year.
- Fish and Wildlife. The Corps and Reclamation operate the system to support the protection and conservation of fish and wildlife species in the Columbia River Basin. Bonville supports efforts to mitigate for the effects of development and operation of the FCRPS. This includes the impacts of the CRS on fish and wildlife in the mainstem Columbia River and its tributaries, pursuant to the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Northwest Power Act),¹ in a manner consistent with the Northwest Power and Conservation Council's Fish and Wildlife Program.

An overview of the CRS is provided in Section 1.9, *Introduction to Columbia River System Operations*.

In the 1990s, the co-lead agencies analyzed the environmental impacts of operating the system in the Columbia River System Operation Review (SOR) EIS, and issued respective Records of Decision (RODs) in 1997 that adopted a system operation strategy. This strategy included operations supporting fish listed under the Endangered Species Act (ESA), while fulfilling all other congressionally authorized purposes. Operational changes have been adopted under subsequent ESA consultations and project-specific NEPA documents. Changed environmental conditions in the Columbia River Basin, and new scientific information since the release of the SOR EIS, have triggered a reevaluation of the coordinated Columbia River System Operations (CRSO). In preparing this EIS, the co-lead agencies are also responding to the Opinion and Order issued by the U.S. District Court for the District of Oregon³ (see Section 1.2 for more information).

¹ 16 U.S.C § 839b (h)(10)(A).

³ *National Wildlife Federation, et al. v. National Marine Fisheries Service, et al.*, 184 F. Supp. 3d 861 (D. Or. 2016).

1.2 PURPOSE AND NEED FOR ACTION

The ongoing action that requires evaluation under NEPA is the long-term coordinated operation and management of the CRS projects for the multiple purposes identified above. An underlying need to which the co-lead agencies are responding, is to review and update the management of the CRS, including evaluating measures to avoid, offset, or minimize impacts to resources affected by managing the CRS in the context of new information and changed conditions in the Columbia River Basin since the SOR EIS was released. In addition, the co-lead agencies are responding to the Opinion and Order issued by the U.S. District Court for the District of Oregon which states that the EIS should evaluate how to ensure that the prospective management of the CRS is not likely to jeopardize the continued existence of any endangered or threatened species, or result in the destruction or adverse modification of designated critical habitat. This includes evaluating mitigation measures to address impacts to listed species from CRS operations. The EIS evaluates actions within the current authorities of the co-lead agencies, as well as certain actions that are not within their authorities, based on the District Court for the District of Oregon's observations about alternatives that could be considered and comments received during the scoping process. The EIS also allows the co-lead agencies and the region to evaluate the costs, benefits, and tradeoffs of various alternatives as part of reviewing and updating the management of the CRS.

The co-lead agencies will use the information garnered through this process to guide future decisions, and allow for a flexible approach to meeting multiple responsibilities including resource, legal, and institutional purposes of the action.

- Resource Purposes:
 - Provide for a reliable level of FRM by operating the CRS to afford safeguards for public safety, infrastructure, and property
 - Provide an adequate, efficient, economical, and reliable power supply that supports the integrated Columbia River Power System
 - Provide water supply for irrigation, municipal, and industrial uses
 - Provide for waterway transportation capability
 - Provide for the conservation of fish and wildlife resources, including threatened, endangered, and sensitive species throughout the environment affected by CRS operations
 - Consider and plan for climate change impacts on resources, and on the management of the CRS
 - Provide opportunities for recreation at CRS lakes and reservoirs
 - Protect and preserve cultural resources

- Legal and Institutional Purposes:
 - Act within the authorities granted to the agencies under existing statutes, and when applicable, identify where new statutory authority may be needed
 - Comply with environmental laws and regulations and all other applicable Federal statutory and regulatory requirements, including those specifically addressing the CRS such as requirements under the Northwest Power Act “to adequately protect, mitigate, and enhance fish and wildlife, including related spawning grounds and habitat, affected by such projects or facilities in a manner that provides equitable treatment for such fish and wildlife with the other purposes for which such system and facilities are managed and operated.” (16 United States Code [U.S.C.] § 839b(11)(A))
 - Protect Native American treaty and reserved rights and fulfill trust obligations for natural and cultural resources throughout the environment affected by CRS operations
 - Continue to use a collaborative Regional Forum framework to allow for flexibility and adaptive management of the CRS
 - Ensure project Water Control Manuals adequately reflect the management of the CRS

1.3 SCOPE OF THE PROJECT

1.3.1 Geographic and Temporal Scope

The Columbia River is one of the largest rivers in North America. With its tributaries, it forms the dominant water system in the Northwest Region. It is the fourth largest river in the United States, as measured by average annual flow. The Columbia River originates in British Columbia, at Columbia Lake on the west slope of the Rocky Mountains. The river enters the United States in the northeastern corner of the state of Washington. It then flows south and west, then southeasterly to its confluence with the Snake River near Pasco, Washington. It turns westward, forming the Washington-Oregon border before flowing into the Pacific Ocean near Astoria, Oregon. Four of the major tributaries to the Columbia River in the United States are the Kootenai, Clark Fork, Pend Oreille, and Snake rivers.

The specific geographic scope of the CRS proposed alternatives encompasses the 14 Federal projects on the Columbia River and its major tributaries (Figure 1-1). The other Federal projects in the Columbia River Basin (e.g., the Willamette Valley projects, the Yakima Valley projects, and other Federal projects on the Snake River) and non-Federal projects in the basin, are not included in the specific geographic scope for the effects analysis because operation of those other projects are separate actions carried out under different legal authorities.⁴ In addition, three Canadian projects in the Canadian portion of the basin are partially coordinated with the CRS under the Columbia River Treaty (CRT). These other projects may be included in the

⁴ For example, the Willamette Basin System, operated by the Corps, is authorized in part by several of the same Flood Control Acts as some of the CRS projects. However, as outlined in these authorizations, the Willamette System was designed as a comprehensive plan of development specific to the Willamette Basin, which would be operated as a separate system from the CRS.

cumulative effects analysis, as appropriate (refer to Chapter 6, *Cumulative Effects*). The potential for any significant effects of the alternatives that could arise in Canadian portions of the basin were reviewed in general as a matter of policy.

The temporal scope of this analysis is assumed to be 25 years from the signing of the RODs, with the exception of the socioeconomic-related resource analysis. For the socioeconomic analysis, a 50-year period of analysis is used to better capture the full array of costs, benefits, and tradeoffs being evaluated in the alternatives. The 50-year period of analysis provides a long-term perspective, and enables the socioeconomic analysis to distinguish between short-term impacts that may occur during the implementation of alternatives and long-term effects that would occur after implementation is completed. The assumption for analysis in the draft EIS is that any alternative would be implemented immediately after the ROD is signed. Recognizing the uncertainty around particular structural and mitigation measures and the time required for implementation, a sensitivity analysis was completed to determine the effect of construction timing on costs and is provided in the cost analysis.

1.4 COLUMBIA RIVER SYSTEM OPERATIONS INTERAGENCY TEAM

1.4.1 Co-Lead Agencies

The co-lead agencies (the Corps, Reclamation, and Bonneville) share responsibility and legal authority for managing the Federal elements of the CRS. These three co-lead agencies coordinate the operation of the CRS and have worked together to develop this EIS.

The Corps and Reclamation develop operating requirements for their projects. These are the limits within which a reservoir or dam must be operated. Some requirements are established by Congress when a project is authorized, while others are established by the agencies based on operating experience. Within these operating limits, Bonneville schedules and dispatches power. This process requires continuous communication and coordination among the three agencies.

1.4.1.1 *The U.S. Army Corps of Engineers*

The Corps operates and maintains 12 of the 14 projects being evaluated as part of the CRSO EIS. Nine of these projects are operated on the lower Snake and Columbia rivers, while three provide storage in the upper reaches of the Columbia River Basin. The Corps has a major role in coordinating multiple uses in the system. It is responsible for system FRM in the basin, maintaining navigation locks and channels to accommodate river passage, producing hydropower, maintaining recreation facilities, and operating fish passage facilities.

1.4.1.2 *The U.S. Bureau of Reclamation*

Reclamation operates two CRS storage projects: Grand Coulee and Hungry Horse. Grand Coulee Dam Project plays a prominent role in the coordinated CRS because of its size (approximately 5.4 million acre-feet [Maf] of storage in Lake Roosevelt) and key location. Grand Coulee is the

largest CRS project used for FRM and is a key generator and regulator for hydropower. Additionally, Grand Coulee Dam serves as the primary water diversion facility for the Columbia Basin Project and its irrigation system. Storage at Hungry Horse is very valuable because of its headwaters location. The water released from Hungry Horse passes through many downstream dam and reservoir projects—both Federal and non-Federal. Hungry Horse provides local and system FRM and hydropower. Additionally, flow augmentation delivered from Hungry Horse benefits both resident and anadromous fish as it passes downstream.

1.4.1.3 Bonneville Power Administration

Bonneville markets and distributes power generated at the Federal dams on the Columbia River and its tributaries. The not-for-profit agency sells power from the dams and other generating plants to public and private utilities and large industries. The agency also owns and operates over 15,000 miles of high voltage transmission lines to deliver the electricity. Federal law requires Bonneville, when providing electricity produced at the Federal dams, to give preference to publicly owned utilities and entities in the Northwest.

1.4.2 Co-Lead Agency Framework

The co-lead agencies established a project organizational structure to analyze the broad range of alternatives for this EIS. Multiple interagency technical teams, consisting of co-lead agency staff and cooperating agencies, represented the resources analyzed. The technical teams provided subject matter expertise in the preparation of the draft EIS and interacted with the other technical teams.

1.4.3 Cooperating Agency Involvement

The co-lead agencies asked tribes and Federal, state, and local agencies to participate as cooperating agencies based on their jurisdiction by law, or their special expertise with respect to any environmental issue evaluated in this EIS. The agencies and tribes listed in Table 1-1 accepted the request and are cooperating agencies for this project. These cooperating agencies contributed to the draft EIS by providing information, participating on technical teams, and reviewing draft documents. A more in-depth discussion is located in Chapter 9, *Coordination and Public Involvement Process*.

Table 1-1. Columbia River System Operations Environmental Impact Statement Cooperating Agencies

Cooperating Agencies
Federal Agencies
U.S. Environmental Protection Agency, Region 10
U.S. Coast Guard, 13th Coast Guard District
U.S. Department of the Interior, Bureau of Indian Affairs

*Columbia River System Operations Environmental Impact Statement
Chapter 1, Introduction*

Cooperating Agencies
State Agencies
<i>Idaho</i>
Governor's Office of Species Conservation ^{1/}
Governor's Office of Energy and Mineral Resources
Department of Fish and Game
Department of Agriculture
Department of Lands
Department of Environmental Quality
Historic Preservation Office
Department of Parks and Recreation
Department of Water Resources
Idaho Department of Transportation
<i>Oregon</i>
Department of Fish and Wildlife ^{1/}
Department of Energy
Water Resources Department
Department of Agriculture
Department of Environmental Quality
<i>Montana</i>
Montana Office of the Governor ^{1/}
Montana Fish, Wildlife and Parks
<i>Washington</i>
Department of Ecology
Department of Fish and Wildlife ^{1/}
Department of Agriculture
County Agencies
Lake County, Montana
Tribes
Confederated Salish and Kootenai Tribes of the Flathead Reservation
Confederated Tribes of the Colville Reservation
Confederated Tribes of the Grand Ronde
Confederated Tribes of the Umatilla Indian Reservation
Confederated Tribes and Bands of the Yakama Nation
Cowlitz Indian Tribe
Kootenai Tribe of Idaho
Nez Perce Tribe
Shoshone-Bannock Tribes of the Fort Hall Reservation
Intertribal Organization
Upper Snake River Tribes Foundation on behalf of Burns Paiute Tribe, Fort McDermitt Paiute-Shoshone Tribe, and Shoshone-Paiute Tribes of the Duck Valley Reservation.

1/ Lead for that state's Memorandum of Understanding.

1.5 NATIONAL ENVIRONMENTAL POLICY ACT PROCESS AND PUBLIC INVOLVEMENT

1.5.1 Overview of the National Environmental Policy Act Process

Two major purposes of the NEPA process are better-informed decisions and public involvement. This EIS provides information necessary for decision-makers to fully evaluate a range of alternatives and adopt a long-term operation strategy for the CRS. It fully addresses the potential impacts of alternatives, as required under the NEPA of 1969, as amended (42 U.S.C. § 4321 et seq.); Council on Environmental Quality (CEQ) regulations (40 Code of Federal Regulations [C.F.R.] §§ 1500–1508); Corps Engineer Regulation (ER) 200-2-2 (33 C.F.R. § 230); Department of Energy's NEPA Implementing Procedures (10 C.F.R. § 1021); Department of the Interior (DOI) NEPA Regulations (43 C.F.R. § 46); and the DOI Departmental Manual Chapter 516. A brief description of public involvement can be seen in Section 1.5.2, while a more in-depth discussion is located in Chapter 9, *Coordination and Public Involvement Process*. Figure 1-2 illustrates the EIS NEPA Overview Process and where the co-lead agencies are in the process.

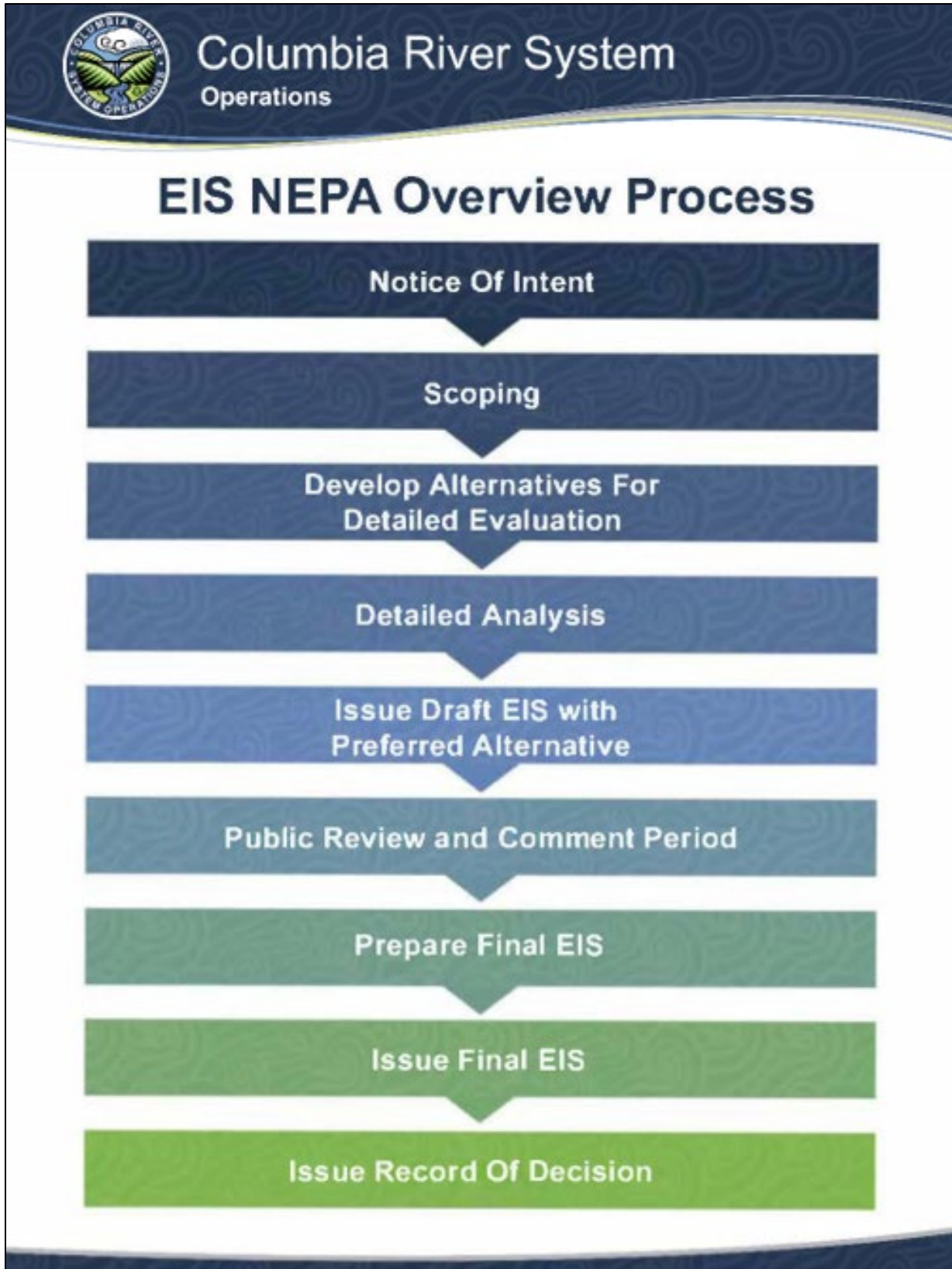


Figure 1-2. The Environmental Impact Statement National Environmental Policy Act Overview Process

1.5.2 Public Involvement

Public involvement is required by NEPA before a Federal agency undertakes an action affecting the environment. The purpose of public involvement is to support informed decision-making. This section gives an overview of the public involvement process for this project, including public scoping and tribal coordination. Chapter 9, *Coordination and Public Involvement Process*, provides a more in-depth discussion.

1.5.2.1 Public Scoping

One of the first steps in the NEPA process is to establish the scope of the project, and one component of accomplishing this step is the public scoping process. The co-lead agencies implemented a robust public scoping process intended to provide ample opportunity for the public to engage. The public was invited to provide assistance in defining the issues, concerns, and scope of alternatives to be addressed. The Notice of Intent (NOI) was published in the *Federal Register* on September 30, 2016 (81 Federal Register [FR] 67382). The public comment period was scheduled to end January 17, 2017, and a schedule was announced for 15 public meetings and two webinars. In addition, a public scoping letter was sent to interested parties on September 30, 2016. On November 4, 2016, the co-lead agencies issued a *Federal Register* notice of an additional public meeting to be held in Pasco, Washington (81 FR 76962). On January 3, 2017, the comment period was extended to February 7, 2017 (82 FR 137).

In addition, the co-lead agencies issued a series of press releases and newspaper advertisements announcing the public meetings. A public website (www.crsso.info) was established at the time of the NOI to communicate and share information about the CRSO EIS. The 16 open-house public meetings were held across the region (Figure 1-3). Two webinars were held on December 13, 2016.

The co-lead agencies received more than 400,000 comments during the scoping period and these were summarized into the *Public Scoping Report for the Columbia River System Operations Environmental Impact Statement*, October 2017, which can be found at www.crsso.info and is incorporated by reference herein. Members of the public, tribes, local and state governmental agencies, non-governmental organizations, and other stakeholders provided these comments.

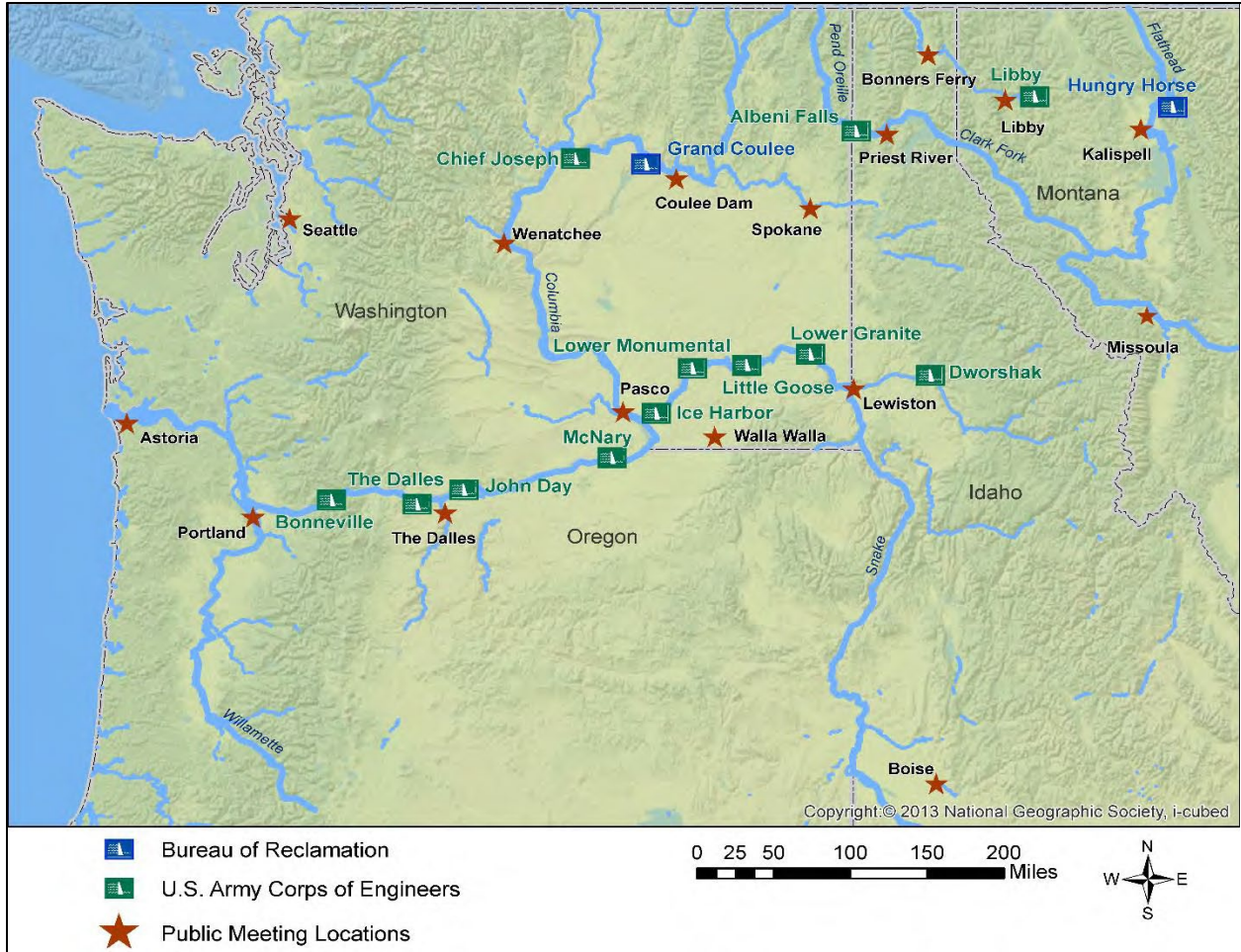


Figure 1-3. Map of Public Scoping Meeting Locations

1.5.2.2 Public Involvement on the Draft Environmental Impact Statement

The draft EIS was reviewed during a public comment period which opened on February 28, 2020, when the Notice of Availability was published in the *Federal Register* (85 FR 11986), and ended April 13, 2020. Public announcements of the availability of the draft EIS were posted on the CRSO EIS project website, sent to the mailing list via e-mail and postal mail, and made available to public news outlets and 26 public libraries. These communications included dates, times, and venues for public comment meetings and outlined the various ways to submit comments. Ultimately, due to health and safety concerns associated with the outbreak and spread of the COVID-19 pandemic, the six scheduled public meetings were replaced with phone-in public comment meetings held on the original meeting dates and times. Meetings were held on March 17, March 18, March 19, March 25, March 26, and March 31, 2020. The meetings were recorded and transcribed, and the transcripts posted to the CRSO EIS project website. All comments from the public meetings were provided as public comments for the agencies to consider for the final EIS. The public was also invited to submit comments online to a public comment database via the CRSO EIS website or via postal mail.

Approximately 59,000 comment letters were submitted. Of these, approximately 55,000 were form letters. The co-lead agencies responded to all substantive comments. The comments reflected diverse stakeholders and opinions, and ranged from comments on the alternatives to the methods of analysis. Appendix T provides the public comments and co-lead agency responses. The public comment and review process resulted in minor corrections and clarifications in the Final EIS, but did not result in any substantial changes to the alternatives or conclusions provided in the Draft EIS. The Notice of Availability of the Final EIS was published on July 31, 2020. A Record of Decision is expected September 2020.

1.5.2.3 Tribal Coordination and Government-to-Government Consultation

Since time immemorial, Native American tribes have inhabited the Columbia River Basin. These tribes successfully subsisted on the abundant natural resources of the area, and built thriving communities that relied on the lands to sustain their way of life. Through treaties, executive orders, judicial decisions, and legislation, tribes ceded most of their aboriginal territory to the United States. Tribes retained smaller portions of land for their reservations. Many tribes, through treaties, retained the right to hunt, fish, and gather in their usual and accustomed locations, including areas outside of their reservations. The potentially affected area of the CRS includes portions of tribal reservations, trust lands, and ceded lands of 19 federally recognized tribes. Reservoirs that are part of the CRS system inundate parts of three existing Indian reservations: the Colville and Spokane reservations, which are partially inundated by Lake Roosevelt, and the Nez Perce Reservation, which is partially inundated by Dworshak Reservoir. In fact, half of Grand Coulee Dam's reservoir, Lake Roosevelt, lies within the Colville Reservation. In some cases, the U.S. Government has entered into special agreements with these tribes regarding management of the reservoirs because of their location within reservations.

The co-lead agencies have a unique legal and political relationship with tribal governments as sovereigns. This Federal trust responsibility is established through, and confirmed by, the U.S. Constitution, treaties, statutes, executive orders, and judicial decisions. The co-lead agencies have regulations and tribal policies regarding the trust responsibility (refer to Chapters 8 and 9). In recognition of the Federal government's trust responsibility, the co-lead agencies engage in regular and meaningful government-to-government consultation and collaboration with tribal governments when a proposed action may affect a tribe or its resources. In an effort to ensure regular engagement and participation in the CRSO EIS, multiple avenues were identified for tribal engagement:

- Participation in the NEPA process as a Cooperating Agency (see Section 1.4.3, *Cooperating Agency Involvement*).
- Tribal engagement and consultation on a government-to-government level.
- Through existing processes developed under the Columbia Basin Fish Accords.

Before the public scoping notice was published in the *Federal Register* on September 30, 2016, the co-lead agencies initiated an engagement and consultation process with the 19 federally

recognized Native American tribes and three tribal organizations in the Columbia River Basin that are potentially impacted by proposed actions being evaluated in the EIS. The co-lead agencies took a three-tiered approach to ensure successful tribal engagement and consultation throughout the development of the CRSO EIS. The co-lead agencies also indicated that, upon request, one-on-one, government-to-government consultation with any individual tribe was available at any time throughout the CRSO EIS process.

The three-tiered strategic approach to tribal engagement and government-to-government consultation was intended to emphasize information sharing and communication with tribal technical staff to ensure policy staff and leadership were regularly and sufficiently informed throughout the CRSO EIS process. At the first tier, technical issues were raised by technical or policy tribal staff and resolved, whenever possible. Unresolved issues were then raised to the second tier—Deputy Level Meetings. The third tier, Executive Level Meetings, was intended to ensure tribal leadership were informed of the EIS development and to address any issues not resolved at the Technical or Deputy level, as well as to consult on major decision points in the CRSO EIS process directly with the co-lead agency Executives.

Tier 1 – Technical Level Meetings: Attended by the technical staff of the three co-lead agencies and key subject matter experts. These meetings were held quarterly at a staff level throughout the NEPA process or more frequently to meet the needs of tribal participants. These meetings provided tribal staff with information critical to preparing tribal leadership for Deputy and Executive level meetings. The co-lead agencies conducted technical level meetings in person and via webinars and conference calls.

Tier 2 – Deputy Level Meetings: Attended by deputies and appropriate support staff from the three co-lead agencies. A morning session was held to provide meaningful dialog and updates on the project, with time set aside in the afternoon for consultation sessions with individual tribes. The co-lead agencies held the Deputy level meetings in various locations around the region to make it as convenient as possible to tribal participants to attend; the locations usually included Boise, Idaho; Spokane, Washington; and Portland, Oregon. These regional meetings were held in person at appropriate intervals, prior to Executive level meetings, or as requested by tribal leaders.

Tier 3 – Executive Level Meetings: These sessions were attended by executives and appropriate support staff from the three co-lead agencies. Time was set aside in the afternoon for consultation sessions with individual tribes. As with the Deputy level meetings, the co-lead agencies held Executive level meetings in multiple locations around the region to make it as convenient as possible for tribal leaders to participate. These regional meetings were held in person when significant project milestones were achieved. Executive level meetings occurred once a year, or as requested by tribal leaders.

Individual tribes were also afforded consultation meetings with appropriate co-lead agency staff or Executives when requested. Additionally, co-lead agency staff and tribal liaisons contacted each tribe's designated points of contact.

1.5.2.4 Tribal Perspectives

The co-lead agencies have included a “Tribal Perspectives” section in the CRSO EIS to provide an opportunity for tribes to offer their unique perspective on the impacts of the CRS specific to their respective tribe. This section can be found in Section 3.17, *Indian Trust Assets, Tribal Perspectives, and Tribal Interests*. This Tribal Perspectives narrative is intended to convey impacts to non-property based cultural resources. Each of the 19 tribes had an opportunity to provide their narrative to address the Tribal Perspectives section in a holistic manner. Eleven tribes provided tribal perspectives.

The evaluation of CRSO EIS alternatives and impacts on many of the resources important to tribes throughout the Columbia River Basin (e.g., salmon, resident fish, and lamprey, as well as cultural resources) were analyzed in the alternatives of the CRSO EIS. For example, many tribes share overlapping interests in the Columbia River Basin. However, potential CRS impacts may be unique to individual tribes based on many factors, including where they were historically located, where they are currently located, and which resources are impacted in those locations. In most instances, the CRSO EIS analysis focused on impacts to specific resources affected by a proposed alternative.

1.6 KEY ISSUES AND RESOURCE CONCERNS

During the NEPA public scoping process, the cooperating agencies, tribes, the public, and stakeholders identified issues and concerns to the co-lead agencies. Section 1.6.1, *Issues Identified during Scoping*, points out three issues that repeatedly were brought up during the scoping process. Section 1.6.2, *Resource Concerns*, provides an overview of various public concerns, presented by resource, which arose in the scoping process.

1.6.1 Issues Identified During Scoping

During scoping, much of the discussion focused on the specific needs of individual river issues or resources. For a more in-depth discussion, refer to Chapter 9, *Coordination and Public Involvement Process*. Several key issues identified were ESA-listed fish, climate change, and socioeconomics.

Many comments regarding ESA-listed fish were received. These comments were specifically directed at the relationship between ESA-listed fish species (e.g., salmon, steelhead, bull trout, and white sturgeon) and dam configuration and operations. The effects of the CRS on both anadromous and resident ESA-listed fish, as well as non-ESA-listed fish, have been debated in the region over the last several decades. The implementation of fish improvement technologies and structures, and ways to optimize the system for fish is an ongoing discussion for Federal, state, local, and tribal entities in the Columbia River Basin. In addition to ESA-listed fish, many scoping comments were received regarding ESA-listed Southern resident killer whales and how they will be addressed through this process when assessing impacts to salmon populations.

Another key issue expressed in scoping comments was the need for climate change to be addressed in the EIS, particularly with respect to how the system would be affected by a changing environment, as well as water quantity and quality (particularly stream and reservoir temperatures), salmonid survival and recovery, hydropower production, and groundwater recharge. Increasing temperatures, reduced snowpack, altered amounts and timing of runoff, drought, and low water conditions were of specific concern, as were how factors contributing to climate change (e.g., greenhouse gas emissions) could potentially be affected by actions in the Columbia River Basin.

Socioeconomic scoping comments were directed primarily at the positive and negative effects of the proposed action to tourism, recreation, fisheries, hydropower generation, flood control, industry, transportation, and agriculture. Potential impacts to the existing Columbia and Snake river navigation system are of concern to many in the Columbia River Basin. In addition, the scoping comments expressed concerns regarding potential effects to recreation (boating, fishing, etc.) as a result of actions impacting fish and wildlife.

1.6.1.1 Tribal Issues Identified During Scoping

During scoping for the CRSO EIS, tribes expressed concerns about the impacts the system has had on natural resources, cultural resources, and ways of life. The tribes in the Basin expressed concerns about impacts on tribal economics with regards to fishing, hunting, and their culture, such as preserving their language and tribal way of life. In addition, some tribes had comments about how they cope with levels of poverty, ill health, and unemployment at significantly higher proportional rates than any other ethnic group in the country, which in turn leads to significantly higher mortality rates in comparison to non-native communities. Throughout the document, the co-lead agencies have considered effects to tribal interests that were provided in their Tribal Perspectives.

1.6.2 Resource Concerns

A variety of interests are represented throughout the Columbia River Basin, and not all of those interests are compatible; thus, tradeoffs between resources must occur. The following is a short description of each major resource and a summary of concerns about each expressed during scoping.

1.6.2.1 Navigation

The key navigation interests on the CRS are those people and businesses with economic ties to ships, barges, and port facilities that rely on Federal facilities in the CRS to provide the waterway infrastructure. People concerned about the ability to navigate the waters of the CRS emphasized the importance of waterborne commerce as an element of the regional economy and the need to maintain adequate channel depths for navigation.

1.6.2.2 Flood Risk Management

People in flood-prone areas have an interest in FRM in the Northwest. Maintaining existing FRM levels is important to those interests, as are accurate flood forecasting efforts for efficient reservoir storage and water releases. Some have expressed concerns regarding impacts experienced in the upper Columbia River Basin from reservoir FRM operations aimed at protecting flood-prone areas along the lower Columbia River.

1.6.2.3 Water Supply and Irrigation

The primary irrigation customers of the system are those farmers who divert or pump water from rivers and reservoir pools to irrigate their crops. These customers emphasize the economic benefits of agriculture to the region, and are concerned with maintaining adequate reservoir elevations to accommodate irrigation pumps and ensure the continued availability of stored water for irrigation.

1.6.2.4 Power Generation

Hydropower provides low cost electricity, helps meet state and local carbon emission goals, provides resiliency to the interconnected power system and, when available, is a low-cost flexible resource that can be used to integrate alternative energy resources into the power grid. At times both Federal CRS dams and non-Federal dams produce large quantities of excess electricity that is surplus to meeting regional firm power load demands. Such surplus power is regularly offered for sale to purchasers throughout the western United States and Canada. Many parties stressed how vitally important hydropower is to the regional economy. Numerous commenters expressed concern that clean, historically affordable hydropower might be replaced with other energy resources like fossil-fuel powered generation such as natural gas power or small modular nuclear reactors. These other types of energy may be more expensive, unproven, or more ecologically damaging. Commenters expressed concern that this EIS process may result in decisions that would compromise the region's historic hydropower resource base. Other power-related concerns included energy conservation, increased generating efficiency, and keeping electricity rates low.

1.6.2.5 Anadromous Fish

Tribes, states, the public, commercial and sport fishing groups, and Federal fishery management agencies are concerned about how the projects affect, and will continue to affect, anadromous fish survival and recovery. Many expressed the importance of the salmon and lamprey contribution to the environment, regional economy, and ecosystem of the Pacific Northwest.

1.6.2.6 Resident Fish and Resident Fish Habitat

The primary interests related to resident fish and their habitat includes the tribes, state and Federal fishery management agencies, anglers, and businesses that serve the anglers. These

interests believe resident fish should be considered just as important as anadromous fish in CRS operations. They would like to see storage reservoirs operated to benefit resident fish or limit the effects of storage operations on resident fish.

1.6.2.7 Wildlife and Wildlife Habitat

Tribes, resource managers, hunters, and sightseers are important interest groups for wildlife and wildlife habitat. For the tribes, wildlife is important to cultural and ecological integrity. They seek to place more emphasis on wildlife in system operations by preserving and restoring habitat and wetlands, improving water quality, and changing river flows to benefit wildlife. During scoping, many people expressed how much they value orcas, including ESA-listed Southern resident killer whales.

1.6.2.8 Recreation

CRS projects provide recreational opportunities for the public in a variety of ways. Outfitters, guides, boaters, marina owners, and tribal, local, state, and Federal agencies providing recreation-related services, represent these interests. They emphasize the economic and social impacts reservoir operations have on regions and communities dependent on recreation and tourism. Some river recreational interests would like more opportunities for whitewater recreation. In addition, recreational fishing groups have concerns about effects on fish and what improvements have been or could be made.

1.6.2.9 Cultural Resources

The Columbia River Basin has been home to humans for over 12,000 years. Many of the tribes trace the history of the region back to time immemorial. Many, if not all, of the region's tribes have oral traditions telling of their creation in the places where they were and are along the Columbia River. The pre-contact and historic-period artifacts and sites along the river are an important source of information about the past, and they supplement other sources of information, such as written records and oral history. Traditional cultural properties (defined in Section 3.16), highly valued by Native Americans, include fishing sites at usual and accustomed places, hunting and traditional hunting sites, and natural resources important to contemporary tribal life. Native Americans, archaeologists, historians, members of the general public, and state and Federal agencies are interested in protecting the cultural resources of the region. These interests would like to minimize damage to cultural resources from the effects of reservoir operations, which include but are not limited to water level fluctuations, wave and wind action, inundation, irrigation, transportation, and recreation, among others. In addition, there is a concern about losses caused by vandalism and looting.

1.6.2.10 Water Quality

The primary water quality issues related to reservoir operations are total dissolved gas (TDG), water temperature, and sediment. TDG is a concern at dams that provide juvenile fish passage spill at many locations in the Columbia River Basin. Elevated water temperature, above state

water quality criteria of 20°C (68°F) exist within much of the Columbia River Basin. Sediment transport through many of the reservoirs is also a concern; dams disrupt the longitudinal continuity of the river system, which often results in armoring riverbeds, which are less suitable for spawning. These concerns are represented through actions brought by environmental groups, regulations, and policy actions by Federal, state, and local agencies, and tribes.

1.6.2.11 Economics

Virtually everyone in the Northwest has an economic stake in the CRS. Low-cost, affordable hydropower is an important element in the economic life of the region. Comments expressed concern about the economic effects of changes to recreation, navigation, irrigation, and water supply as a result of changes to river operations.

1.6.3 Climate Change Consideration for the Columbia River System Operations

Based on recent research, increasing temperatures due to climate change will likely lead to declining snowpack and earlier peak seasonal snowmelt. Though less certain, there is also potential for decreased fall and summer streamflows and longer periods of low summer flows (RMJOC 2018). Many comments received during the scoping process reflected concerns about how these changes may impact individual resources, air quality and greenhouse gasses. The basis for the climate assessment in this EIS includes findings on projected regional temperature, precipitation, snowpack, and streamflow changes resulting from a 4-year research project completed by the University of Washington and Oregon State University for the River Management Joint Operating Committee, and in collaboration with regional stakeholders. The discussion in Chapter 3 of the environmental consequences to resources from the measures and alternatives reflect modeling and analysis based on observed climate in the region over the 80-year period of 1929 to 2008. Chapter 4 builds on that analysis by providing a discussion of how the projected changes in regional climate through 2050 may impact the resources and effectiveness of alternatives for the CRS.

1.7 RELATIONSHIP TO OTHER FEDERAL NATIONAL ENVIRONMENTAL POLICY ACT EFFORTS, AND OTHER FEDERAL STUDIES, DOCUMENTS, AND REPORTS

The following projects and programs occur within the Columbia River Basin and are interrelated with, but independent from, this EIS.

- Final Environmental Impact Statement to Inform Columbia River Basin Hatchery Operations and the Funding of Mitchell Act Hatchery Programs, September 2014, National Marine Fisheries Service (NMFS). This EIS examines alternatives designed to reduce or minimize the adverse effects, or increase the benefits, of hatchery operations on natural-origin salmon and steelhead populations. Hatchery operators would continue to pursue not only the conservation or harvest goals that currently apply to each hatchery program, but also different or additional conservation and harvest goals.
- Lower Snake River Programmatic Sediment Management Plan (PSMP) Final EIS, August 2014, Corps. The PSMP provides a programmatic framework to evaluate and implement

sediment management measures to address the accumulation of sediment that interferes with existing authorized project purposes in the lower Snake River projects. The PSMP process includes triggers, actions for long-term and short-term planning, actions to address sediment, as well as monitoring and regional engagement.

- The Double-Crested Cormorant Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary, Final Environmental Impact Statement, 2015. This plan had two phases: Phase 1: Reduce colony size to baseline population (as identified in NMFS Biological Opinion [BiOp] Reasonable and Prudent Action 46) to between 5,380 and 5,939 breeding pairs on East Sand Island. Phase 2: Modify terrain at East Sand Island to limit breeding habitat to maintain colony size in the long term; support with hazing and egg take as needed to ensure colony does not exceed 5,380 to 5,939 breeding pairs. The Corps reduced the colony below the 5,380 to 5,939 threshold, and then moved into early implementation of Phase 2 in 2018. The Corps has implemented the terrain modification at East Sand Island during winter of 2018 and will monitor population at East Sand Island for 3 years (2019 was Year 1) to determine success of the project. The Corps will use hazing as needed to maintain population size.
- Caspian Tern Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary, Final Environmental Impact Statement, 2005, U.S. Fish and Wildlife Service (USFWS). Management has reduced habitat on East Sand Island to a minimum of 1 acre, while enhancing or creating habitat out of the Columbia River Basin (southern Oregon/northern California) to support breeding pairs, creating 2 acres for every 1 acre reduced on East Sand Island. It was assumed that reducing habitat at East Sand Island to 1 acre would support 3,125 to 4,375 breeding pairs, which would support a population growth rate. The Corps created approximately 8 acres of alternative nesting habitat and reduced the breeding habitat at East Sand Island to 1 acre. However, there are still a greater number of birds because they nested in densities higher than anticipated. The Corps will continue to maintain 1 acre of habitat at East Sand Island and use hazing to prevent birds from establishing satellite colonies on the beaches.
- Columbia Basin Project (CBP). Grand Coulee, operated by Reclamation, stores water for the CBP. The water is pumped approximately 300 feet from Lake Roosevelt to Banks Lake where it is distributed by canal to irrigators within the CBP. The CBP currently has water rights and previous NEPA compliance to deliver 3.318 Maf of water for irrigation of 720,000 acres and for M&I purposes. Water for the Odessa Subarea and Lake Roosevelt Incremental Storage agreement are included in the 3.318 Maf.
- Lower Columbia River Dredged Material Maintenance Plan. The most recent dredged material management plan (DMMP) is from 1998 for the continued operation and maintenance of the federally authorized Lower Columbia River Federal Navigation Channel (43 feet deep with 5 feet of advanced maintenance dredging, by 600 feet wide with 100 feet advanced maintenance dredging) with minimized draft restriction days. Currently, an integrated DMMP EIS is being developed for a 20-year DMMP for the lower Columbia River from river mile 105.5 to 3 for the continued maintenance of the congressionally authorized

Federal navigation channel (Water Resources Development Act of 1999, Consolidated Appropriations Act of 2004).

- **John Day Mitigation Program.** The John Day Mitigation program was originally authorized to offset mainstem fall Chinook salmon production losses that resulted from construction of The Dalles and John Day Dams and is implemented by the Corps. Mitigation for these losses is particularly important to regional tribes that historically depended on these salmon for ceremonial, subsistence and economic support. The scope of this mitigation program consists of a combination of adult (broodstock) collection, adult egg take (spawning), egg incubation, juvenile rearing and acclimation, and release of hatchery fall Chinook salmon using a combination of hatchery facilities on the middle Columbia River. The purpose of this mitigation program is to identify facilities for the production and release of hatchery smolts in numbers sufficient to achieve in-kind mitigation: that is, a total adult production of 107,000 adult fall Chinook salmon at a ratio of 25 percent tule fall Chinook salmon and 75 percent upper river fall Chinook salmon. Upriver brights should be released from sites above the Bonneville Project to achieve in-place mitigation.
- **Bonneville's Fish and Wildlife Program.** Bonneville provides funding to multiple local, state, tribal and Federal entities as part of its Fish and Wildlife Program to implement offsite mitigation actions listed in various biological opinions for ESA-listed species. The Bonneville Fish and Wildlife Program also funds efforts to protect, mitigate, and enhance fish and wildlife, including non-listed species, affected by the development and operation of the FCRPS, which includes the CRS under the Northwest Power Act. These efforts are consistent with the recommendations developed through the Northwest Power and Conservation Council's Fish and Wildlife Program. These projects would continue to undergo site-specific environmental compliance prior to implementation. This analysis includes review under applicable laws and regulations, such as NEPA.
- **Odessa Subarea Special Study Project.** The need to address declining groundwater supply in the Odessa Subarea and avoid economic loss to the region's agricultural sector led Reclamation and Washington State Department of Ecology (Ecology) to conduct the Odessa Subarea Special Study. The purpose identified by Reclamation and Ecology to guide the proposed action is: ". . . to maintain economic viability by providing surface water from the CBP to replace groundwater from declining wells currently used for irrigation in the Odessa Subarea." This purpose is consistent with the intent of the CBP act by encouraging "settlement and development of the project, and for other purposes." Surface water would be provided as part of the continued, phased development of the CBP, and would come from existing CBP diversion and storage water rights from the Columbia River. The Odessa Subarea Special Study was completed in 2012 and the ROD signed in 2013 (Reclamation 2012b, 2013).
- **2019 to 2021 Flexible Spill Operation Agreement.** The 2019 to 2021 Flexible Spill Operation Agreement outlines implementation of the spring flexible spill operations in 2019 and 2020 at the lower Snake River projects and lower Columbia River projects. Spill operations in 2019 included spill up to the 120 percent TDG cap under the applicable state water quality standards. The Spill Operation Agreement also identified a spring flexible spill scenario for

implementation in 2020 to 2021 up to the 125 percent TDG cap at most of the dams, which the parties later collaboratively worked to finalize. The state processes necessary to modify the state water quality standards are ongoing. Flexible spill refers to a 24-hour variable spill operation for juvenile fish passage at the four lower Snake River and four lower Columbia River projects. The flexible spill operation takes advantage of peak and off-peak load hours throughout the day to vary juvenile fish passage spill to complement periods of power demand. During peak load hours, spill for juvenile fish passage is provided at Performance Standard spill levels for up to 8 hours per day. Performance Standard spill is juvenile fish passage spill at the eight fish passage dams (initially developed under the National Oceanic and Atmospheric Administration [NOAA] 2008 BiOp and implemented under the NOAA 2008, 2010, and 2014 BiOps to achieve 96 percent juvenile dam passage survival for spring migrants and 93 percent juvenile dam passage survival for summer migrants. During the remaining 16 hours throughout the day, spill for juvenile fish passage is provided up to the TDG cap, defined as spill to the maximum level that meets, but does not exceed, the TDG criteria allowed under the applicable state water quality standard. The 2019 flexible spill operation was implemented.

- ESA Section 7(a)(2) 2019 BiOp, Consultation for Continued Operation and Maintenance of the CRS, conducted by NMFS for the Corps, Bonneville, and Reclamation, March 29, 2019. This BiOp addresses the continued operation and maintenance of the CRS with the inclusion of the 2019 to 2021 Flexible Spill Operation Agreement for spill and hydropower operations.
- Lower Snake River Fish and Wildlife Compensation Program. This program was initiated to provide fish and wildlife compensation for construction of the four lower Snake River projects (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite). The program was first described in a 1975 report, *Special Report, Lower Snake River Fish and Wildlife Compensation Plan, Lower Snake River, Washington and Idaho*. This report was developed by the Corps, in consultation with the USFWS, to assure compliance with the Fish and Wildlife Coordination Act. With the exception of riparian habitat development, the Lower Snake River Fish and Wildlife Compensation Program mitigation requirements for both fisheries and terrestrial wildlife, as laid out in the authorizations and subsequent clarifying reports, are complete. The construction of fish hatcheries and hatchery facility transfers are complete, but operating and maintaining a number of hatcheries continues. The terrestrial wildlife mitigation program, including the development of lands along the lower Snake River, acquisition of new lands for hunting opportunity, and the game farm alternative, is also complete. The Corps will continue to maintain and enhance wildlife habitat developed under the Lower Snake Compensation Plan into the foreseeable future through the Natural Resource Management program.
- Sovereign Review Process during the Treaty Review. *While the following process is not related to the CRSO process and has been officially concluded, it is noted here for historical informational purposes only.* The purpose of the Columbia River Treaty 2014/2024 Review (Treaty Review) was to enable the United States Entity, working in collaboration with regional sovereigns and stakeholders, to make an informed recommendation to the U.S. Department of State as to whether it is in the best interest of the U.S. to continue the

Treaty, terminate the Treaty, or seek to negotiate with Canada to amend or modify the Treaty. The Treaty Review included extensive engagement within the region. Regional sovereigns participated through the Sovereign Review Team and included representatives from four northwestern states (Oregon, Washington, Montana, and Idaho), 15 Native American tribes, and representatives from 10 Federal agencies with responsibilities related to the Columbia River. The Sovereign Review Team's primary responsibility was in the policy and recommendation development arena. The Sovereign Technical Team, composed of technical experts representing the sovereigns, provided expertise to design the analytical work with Sovereign Technical Team workgroups providing more specialized technical expertise in specific areas. Non-sovereign stakeholders in the region participated through listening sessions, workshops, and other public meetings. Non-sovereigns included electric utilities, irrigators, commercial navigation interests, recreation interests, and others. Government-to-government level sessions were also held with regional tribal leadership and congressional and national leaders and committees. The Sovereign Review process resulted in a Regional Recommendation that was delivered to the U.S. Department of State in December 2013.

1.8 RELEVANT NATIONAL ENVIRONMENTAL POLICY ACT AND ENDANGERED SPECIES ACT DOCUMENTS AND REPORTS

Key relevant documents used in this EIS are listed below:

- Columbia River System Operations Review Final EIS, November 1995. Preparations for this EIS began to take shape as soon as the first petition was made for Columbia River salmonids to be listed under the ESA. It was a joint project between Reclamation, the Corps, and Bonneville to consider changes in the operation of the FCRPS to benefit salmon runs.
- Biological Opinion: Effects to Listed Species from Operation of the Federal Columbia River Power System, consultation conducted by USFWS, December 20, 2000. The BiOp came in response to a draft feasibility report/environmental impact statement on operation of the FCRPS by Bonneville, Reclamation, and the Corps. It essentially addressed three non-breaching alternatives: major system improvements, existing conditions, and maximum transport of juvenile salmon. A fourth alternative, breaching the lower Snake River dams or natural river drawdown, was not analyzed in the BiOp, but would be addressed if the implementation of this alternative came to fruition.
- Lower Snake River Juvenile Salmon Migration Feasibility Report and Final EIS, Corps, Walla Walla District, February 2002. This feasibility report/environmental impact statement examines only the four dams on the lower Snake River: Lower Granite, Little Goose, Lower Monumental, and Ice Harbor. It comes in response to the 2000 NOAA NMFS BiOp on operation of the FCRPS. It addresses four alternatives: major system improvements, existing conditions, maximum transport of juvenile salmon, and natural river drawdown. Major system improvements, with adaptive management, were the preferred alternative of the study.

- Endangered Species Act Section 7(a)(2) 2008 Biological Opinion, Consultation for Operation of the Federal Columbia River Power System, conducted by NMFS for the Corps, Bonneville, and Reclamation, May 5, 2008. This BiOp was later supplemented, May 20, 2010, to incorporate the Adaptive Management Implementation Plan and January 17, 2014 to: (1) address specific issues raised by the District Court for the District of Oregon; (2) consider effects to newly designated critical habitat for eulachon and green sturgeon, and to proposed critical habitat for lower Columbia River coho salmon; and (3) address updated scientific information in 2010 and 2014.
- Upper Columbia Alternative Flood Control and Fish Operations Final EIS, April 2006 and Corps and Reclamation Records of Decisions, June 2008, and September 2009, respectively; the Corps as lead and Reclamation as cooperating agency. This EIS examined the implementation of alternative flood operations at Libby Dam on the Kootenai River and Hungry Horse Dam on the South Fork Flathead River, with an operation known as “variable discharge storage regulation procedure,” or VarQ, and flow augmentation for ESA-listed fish populations in the Kootenai River, the Flathead River, and mainstem Columbia River. Flow augmentation (i.e., fish flows) includes release of water for bull trout, salmon, and, at Libby Dam, white sturgeon. The actions addressed in this EIS are in direct response to reasonable and prudent actions contained in the 2000 USFWS FCRPS BiOp; the 2006 USFWS BiOp regarding the Effects of Libby Dam Operations on the Kootenai River White Sturgeon, Bull Trout and Kootenai Sturgeon Critical Habitat, and in the 2004 Updated Proposed Action; and the 2004 NMFS FCRPS BiOp.
- Biological Opinion regarding the Effects of Libby Dam Operations on the Kootenai River White Sturgeon, Bull Trout, and Kootenai Sturgeon Critical Habitat. Consultation conducted by USFWS, February 18, 2006, with a 2008 clarified reasonable and prudent alternative. This BiOp addressed implementation of VarQ, ramping rates and daily shaping, minimum flows, and flow augmentation for fish.
- Albeni Falls Flexible Winter Power Operations Final Environmental Assessment October 2011, and Finding of No Significant Impact, November 2011, Corps and Bonneville. This is a winter management operation at Albeni Falls Dam that more actively uses storage behind Albeni Falls Dam for power generation.

1.9 INTRODUCTION TO COLUMBIA RIVER SYSTEM OPERATIONS

Dam development in the Columbia River Basin began in the 1800s. Mainstem dam development began with Rock Island Dam (a non-Federal project) on the Columbia River in 1933, and continued through 1975 with the completion of Lower Granite Dam on the Snake River. Most of the dams were constructed from the 1950s through the 1970s. This section provides brief descriptions of Federal projects and non-Federal projects, and an overview of how the CRS is operated.

1.9.1 Federal Dams and Reservoirs

Federal agencies operate a series of 31 multipurpose dams known as the Federal Columbia River Power System on the Columbia River and its tributaries, 14 of which are operated as a coordinated system, referred to as the CRS. The 14 CRS projects are described below. The other FCRPS projects, such as those in the Willamette subbasin, the Yakima subbasin, or the Boise River Basin, operate more independently. The output at the projects with hydropower facilities is used in meeting the region's electricity demand. However, the multi-purpose operation of these other FCRPS projects is generally not factored into the coordinated planning scenarios of the CRS.

Project features of the CRS include dams and reservoirs, navigation channels and locks, hydroelectric powerhouses, associated transmission infrastructure, spillways, sluiceways, fish ladders and bypass facilities, irrigation diversions and pumps, parks and recreation facilities, boat launches, lands dedicated to the projects, and areas set aside for mitigation of wildlife habitat losses.

Bonneville, the Corps, and Reclamation each have a role in coordinating the CRS. The Corps operates 12 of the 14 projects, and has responsibilities for FRM, recreation, fish and wildlife conservation, navigation, power production, irrigation and M&I water supply at these 12 reservoirs (although responsibilities for several resources, such as fish and wildlife conservation and power generation, are shared with other agencies). The Corps also maintains navigation channels and has FRM responsibilities throughout the Columbia River Basin. Reclamation operates Grand Coulee and Hungry Horse projects, and has responsibility for federally financed water development and irrigation programs, hydropower, and water quality at these two projects. Bonneville Power Administration markets and distributes the power generated at all Federal projects in the Columbia River Basin, and builds and operates transmission lines to deliver the electricity. Bonneville also mitigates the impacts on fish and wildlife from the federally owned hydroelectric projects from which Bonneville markets power. The Corps and Reclamation develop multiple purpose operating requirements for their projects and, within these limits, Bonneville schedules and dispatches power. The CRS alternatives (referred to in this EIS as No Action Alternative and Multiple Objective Alternatives 1 through 4 and the Preferred Alternative) only include specific actions at these 14 Federal projects, and do not include any actions at the other FCRPS or non-Federal projects.

The general characteristics of each of these 14 Federal projects are summarized in Table 1-2, and more detailed descriptions of these projects can be found at www.CRSO.info.

Table 1-2. General Characteristics of the Columbia River System Projects

Project	Reservoir / Lake	Project Type	Approximate Normal Operating Range NGVD29	Number of Turbine Units (Nameplate Capacity-MW) ^{3/}	Number of Spillbays and Other Tubes	Navigation Locks	Fish Passage
Libby	Koocanusa	Storage	2,287–2,459 feet ^{1/}	5 (605)	2 spillbays	N/A	N/A
Hungry Horse	Hungry Horse	Storage	3,336–3,560 feet ^{1/}	4 (428)	1 ring gate (spillbay) 3 outlet tubes	N/A	N/A
Albeni Falls	Pend Oreille	Storage	2,051–2,062.5 feet ^{1/}	3 (49)	10 spillbays	N/A	N/A
Grand Coulee	Roosevelt	Storage	1,208–1,290 feet ^{1/}	33 (6,735 + pumped storage)	11 spillbays 40 outlet tubes	N/A	N/A
Chief Joseph	Rufus Woods	Run-of-river	950–956 feet	27 (2,614)	19 spillbays	N/A	N/A
Dworshak	Dworshak	Storage	1,445–1,600 feet ^{1/}	3 (465)	2 spillbays	N/A	N/A
Lower Granite	Lower Granite	Run-of-river	733–738 feet	6 (930)	8 spillbays	Yes	Yes
Little Goose	Bryan	Run-of-river	633–638 feet	6 (930)	8 spillbays	Yes	Yes
Lower Monumental	Herbert G. West	Run-of-river	537–540 feet	6 (930)	8 spillbays	Yes	Yes
Ice Harbor	Sacajawea	Run-of-river	437–440 feet	6 (693)	10 spillbays	Yes	Yes
McNary	Wallula	Run-of-river	337–340 feet	14 (1,120)	22 spillbays	Yes	Yes
John Day ^{2/}	Umatilla	Storage	January 1–March 14: 262.0–265.0 feet March 15–April 9: 262.5–265.0 feet April 10–September 30: 262.5–264.0 feet October 1–31: 262.5–265.0 feet November 1–December 31: 262.0–266.5 feet	16 (2,480)	20 spillbays	Yes	Yes

*Columbia River System Operations Environmental Impact Statement
Chapter 1, Introduction*

Project	Reservoir / Lake	Project Type	Approximate Normal Operating Range NGVD29	Number of Turbine Units (Nameplate Capacity-MW)^{3/}	Number of Spillbays and Other Tubes	Navigation Locks	Fish Passage
The Dalles	Celilo	Run-of-river	155–160 feet	22 (2,052), plus 2 fish units	23 spillbays	Yes	Yes
Bonneville	Bonneville	Run-of-river	71.5–76.5 feet	PH1: 10 PH2: 8 (1,195) plus 2 fish units	18 spillbays	Yes	Yes

Note: N/A = not applicable; NGVD29 = National Geodetic Vertical Datum of 1929.

1/ For storage reservoirs, the minimum possible elevation is based on location of the project intakes. Actual reservoir levels may reach these elevations only rarely.

2/ The normal operating range for John Day varies seasonally to support multiple objectives including irrigation, navigation, ESA-listed fish recovery, hydropower, and FRM.

3/ Bonneville (2019a).

1.9.2 Storage and Run-of-River Projects

The 14 Federal projects examined in detail in the CRS fall into two major categories: storage and run-of-river projects. It is important to understand the difference between the two, which is graphically illustrated in Figure 1-4, and explained in the following paragraphs. The six Federal projects classified as storage projects in the CRS are Libby, Hungry Horse, Albeni Falls, Grand Coulee, Dworshak, and John Day. The eight Federal projects considered to be run-of-river projects in the CRS are Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, The Dalles, and Bonneville. While John Day may be characterized as a storage project and is authorized for FRM, it has limited storage capacity and is operated more like a run-of-river project where the project does not store incoming flow.

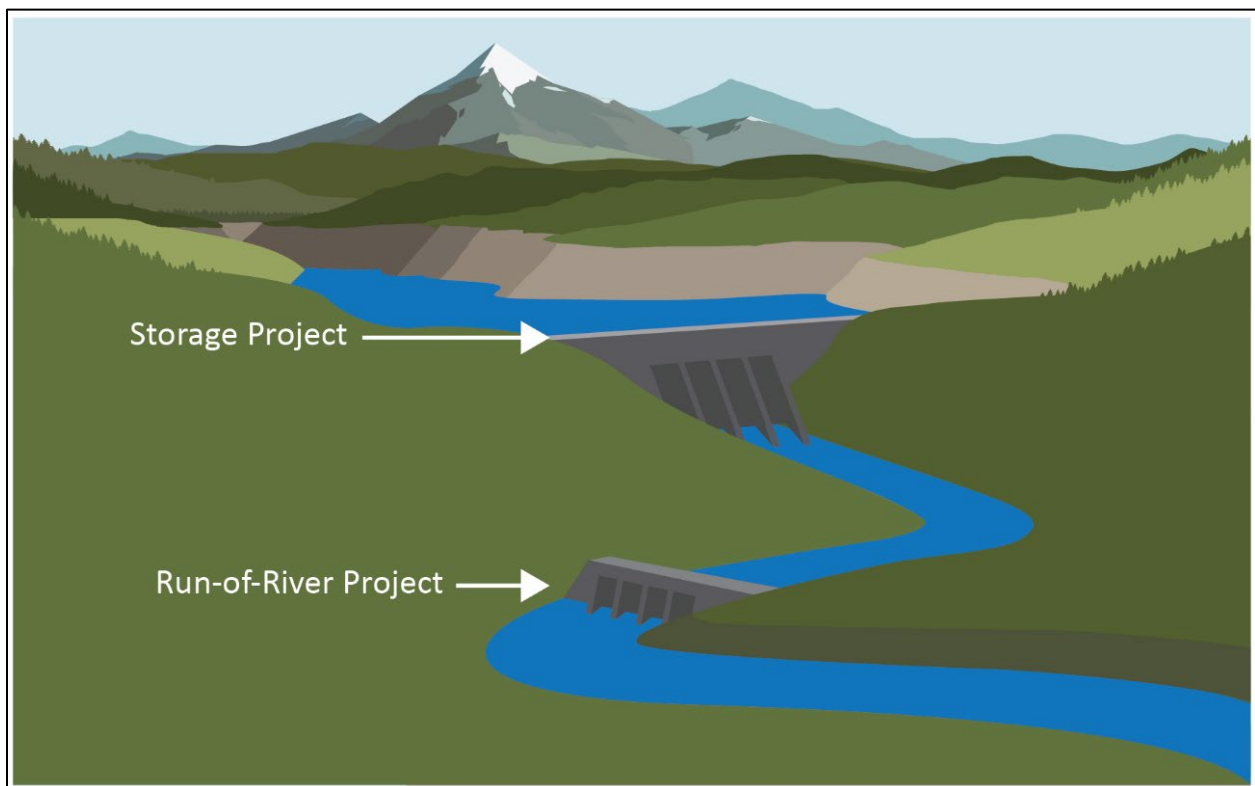


Figure 1-4. Graphic Representation of Storage and Run-of-River Projects

1.9.2.1 Storage Projects

Storage is the key to operation of the multiple-use river system. The storage reservoirs adjust the river's natural flow patterns to conform more closely to water use patterns, storing water from rain and snowmelt to reduce flood risk and generate power when needed. Water in storage reservoirs is also called upon throughout the year to support flows for fish. More water enters the river system during the spring snowmelt than is required at the time for power production, irrigation, and other uses. Reservoirs capture some of this runoff and store it until the late summer, fall, and winter, when it is released.

The system storage capacity represents the system’s capability to “shape” flows for a variety of purposes. Shaping refers to the operating agencies’ ability to control river flow by timing the storage and release of water from the storage reservoirs to meet specific purposes. Water is held in storage and released for multiple authorized purposes, including hydropower and for fish. In addition, shaping helps reduce downstream flows during the flooding season. Balancing the various uses of system storage can be challenging as demands increase because only a finite amount of water and storage space is available in the system to meet competing needs.

The total system storage capacity in the Columbia Basin is approximately 55 Maf of which approximately 20 Maf is in Canada, approximately 17 Maf in the CRS, and approximately 18 Maf in other Federal and non-Federal reservoirs. Of the total storage capacity, approximately 40 Maf is available for system FRM. This is an enormous amount of water, but it is only about 30 percent of an average year's runoff, as measured at The Dalles. While there is a large amount of storage on the Columbia River, there is a relatively low degree of control on the Columbia compared to other large river systems in the United States (e.g., the Missouri and Colorado River systems). Figure 1-5 illustrates the average annual and usable reservoir storage in the Columbia, Colorado, and Missouri River basins.

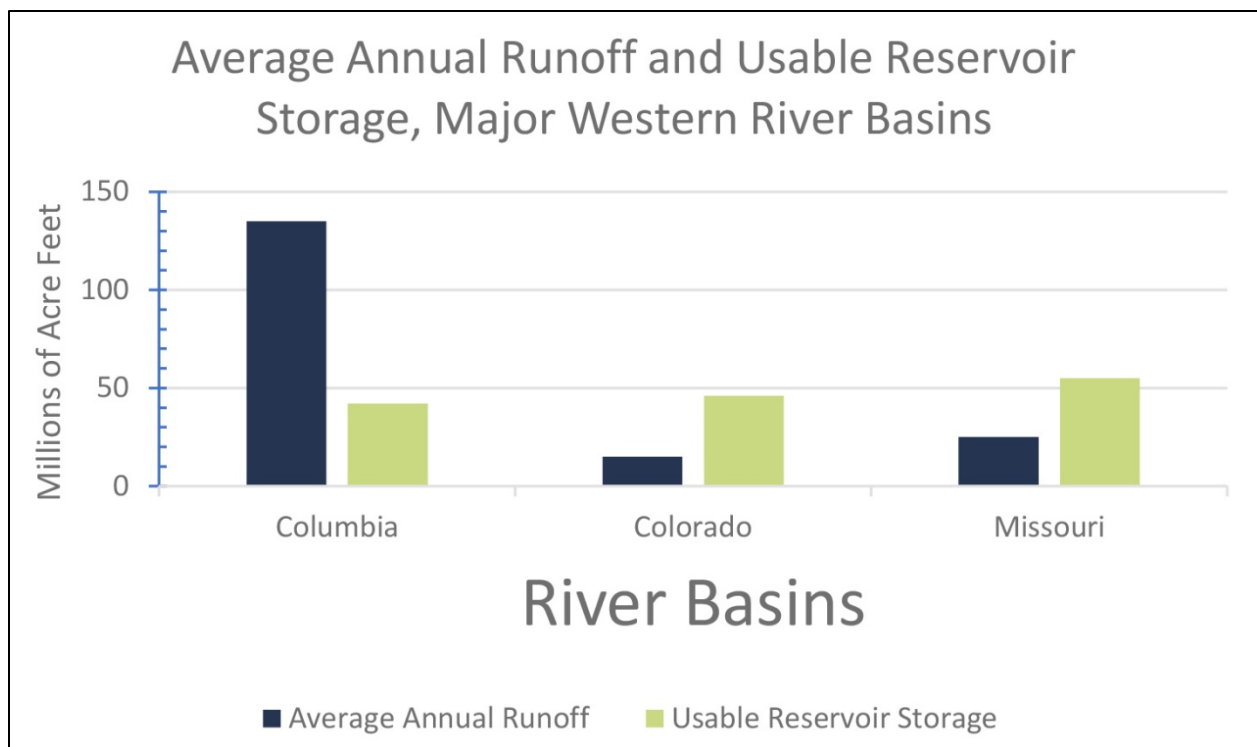


Figure 1-5. Comparison of Major Western River Basins

The combined storage in the reservoirs of the five Federal storage projects considered in the CRSO EIS is approximately 17 Maf. Active storage capacity of the five storage projects ranges from about 1.2 Maf at Albeni Falls to nearly 5.4 Maf at Grand Coulee (Table 1-3). While John Day is authorized for FRM, it has limited storage capacity and is operated primarily like a run-of-river project where the project does not store incoming flow. Three Canadian dams, Mica,

Duncan, and Arrow, add up to another 20.5 Maf of storage. These eight projects are strategically located in the throughout the Columbia River Basin to capture runoff for later release.

Table 1-3. Active Storage Capacity at Columbia River System Storage Projects

Project	River	Operator	Active Storage Approximate (Maf)	Authorized System FRM (Maf)
Projects Authorized and Operated for System Flood Control			17.0	16.5
Libby	Kootenai	Corps	5.0	5.0
Hungry Horse	South Fork Flathead	Reclamation	3.0	3.0
Albeni Falls	Pend Oreille	Corps	1.2	0.6
Dworshak	North Fork Clearwater	Corps	2.0	2.0
Grand Coulee	Columbia	Reclamation	5.4	5.4
John Day	Columbia	Corps	0.5	0.5

Note: Maf = the volume of water that would cover 1 million acres to a depth of 1 foot.

Reservoir levels at storage projects typically vary greatly during normal operations and with changes in year-to-year water conditions. Libby operates over a range of 172 feet; Hungry Horse, 224 feet; Albeni Falls, 11.5 feet; Grand Coulee, 82 feet; and Dworshak, 155 feet.

Although Albeni Falls operates over a relatively small range, it controls a large volume of stored water because of the large surface area of Lake Pend Oreille. Variations between full pools and lowered pools tend to occur seasonally. Just prior to the spring snowmelt, pools are generally kept low to provide enough space for increasing flows and FRM. When possible, operators try to operate pools near full during the summer, when recreation demand is the highest.

Figure 1-6 illustrates elevation patterns for Libby under median hydrographs of dry, average, and wet years. The figure groups years into “dry,” “average,” and “wet” years based on the May water supply forecast for the April to August runoff period into Libby, and then calculates the median elevation for each day within the group. The dry grouping represents the lowest 20 percent of forecasted years, the average grouping represents years in the middle 60 percent of forecasted years, and wet grouping represents the highest 20 percent of forecasted years. This type of figure is explained further in Chapter 3, but is shown here to demonstrate how reservoir levels at storage projects can vary depending on water year type.

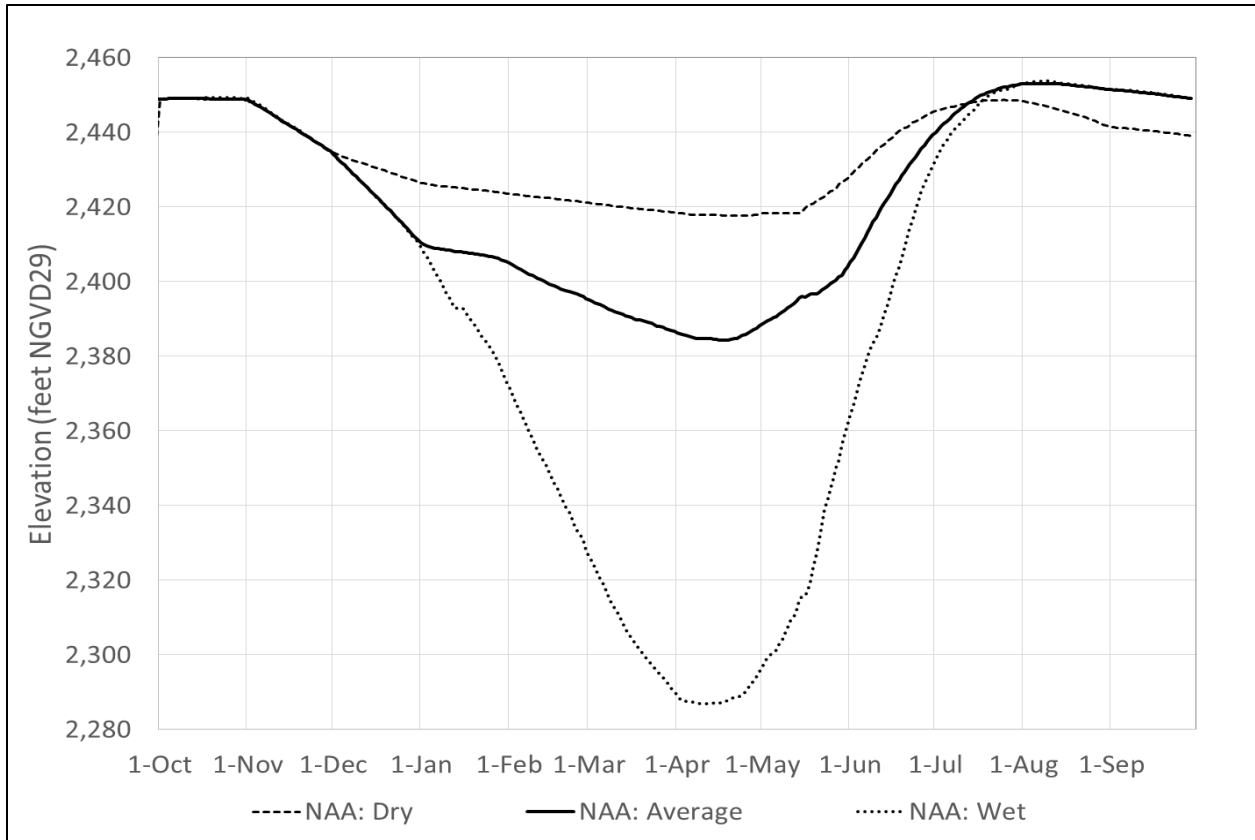


Figure 1-6. Median Hydrographs of Dry, Average, and Wet Years at Libby Project

Note: NAA = No Action Alternative.

1.9.2.2 Run-of-River Projects

The Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, The Dalles, and Bonneville projects are run-of-river projects with limited storage capacity. They were developed primarily for navigation and/or hydropower generation. All run-of-river projects provide hydraulic head for power generation. The eight Federal projects on the lower Snake and Columbia rivers also form enough channel depth to permit barge navigation. Run-of-river projects pass water at the dam at nearly the same rate it enters. The water that backs up behind run-of-river projects is referred to as pondage. The pondage at these projects is sufficient to control flows on only a daily or weekly basis, and use of the pondage causes frequent, small fluctuations in water levels. Reservoir levels behind these projects typically vary only 3 to 5 feet in normal operations (see Table 1-2). Maintaining the reservoir within the normal operating range in the pool allows the facilities at the dams (e.g., navigation locks, hydropower turbines, fish ladders, and juvenile fish bypass facilities) to function properly, in accordance with the engineering design. Irrigation has developed in the run-of-river projects using the pool elevations that exist due to hydropower and navigation operations.

1.9.3 Non-Federal Dams and Reservoirs

In addition to the 14 Federal projects described above, there are numerous other dam and reservoir projects in the Columbia River and its tributaries that are operated by Federal and non-Federal entities in the United States and Canada. Major dams in the Columbia Basin are shown in Figure 1-7. A brief description of these non-Federal facilities and how they relate to the CRS is contained in the following paragraphs.

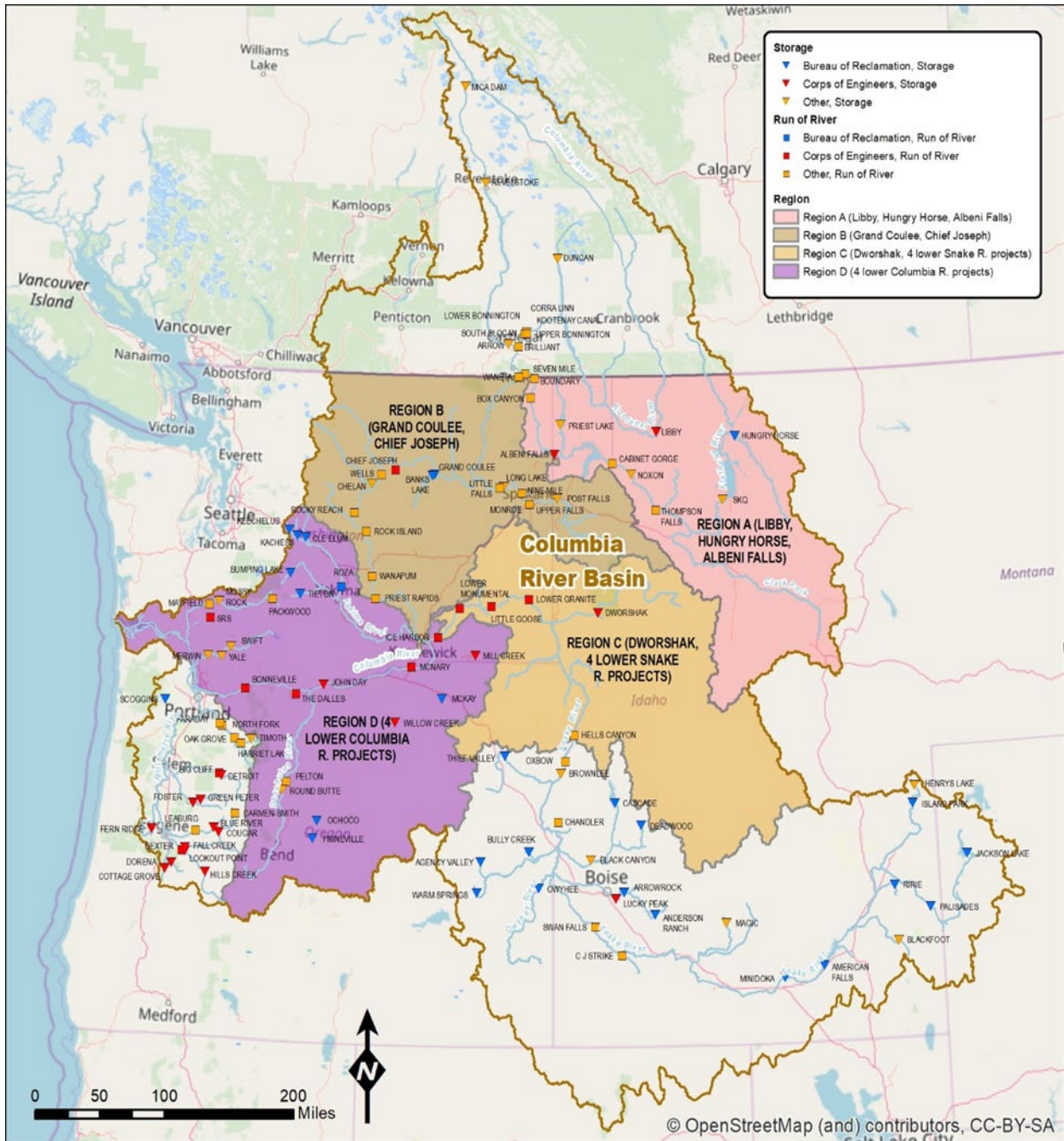


Figure 1-7. Columbia River Watershed System

1.9.3.1 Canadian Projects

Projects located in the Canadian portion of the Columbia River watershed play a key role in overall system operation and coordination, although the co-lead agencies do not operate these Canadian projects. There is a total of 11 major dams in the Canadian portion of the basin, shown in Figure 1-7. Of the 11 dams, 7 are downstream of CRS projects, including Libby or Hungry Horse and Albeni Falls; the Kootenai River below Libby and the Pend Oreille River below Albeni Falls and two non-Federal U.S. dams both flow north into Canada. Three Canadian projects (Mica, Duncan, and Arrow Lakes) are CRT storage projects located in the headwaters of the Columbia and Kootenay River system and are particularly important to overall system storage coordination. The CRT, ratified in 1964, cleared the way for the construction of storage capacity at these three Canadian storage projects and at Libby Dam. This more than doubled the storage capacity of the CRS. The CRT provides for coordination of operations of the three CRT Canadian storage projects with U.S. projects for power production, FRM, and other purposes as mutually agreed upon.

In evaluating CRSO alternatives, the CRT projects in Canada (Mica, Duncan, and Arrow Lakes) are assumed to operate consistent with practices in effect at the time the CRSO NOI was published in the *Federal Register* on September 30, 2016 (81 FR 67382). Assumptions about CRT storage are necessary to analyze CRS operations, and the best available information is the current operations. This assumption, and any other assumptions, procedures, or methodologies in this EIS regarding the Canadian projects or the effect of Canadian projects and their operations are for EIS analytical purposes only and does not establish, create, or imply any position or interpretation of the CRT. This EIS evaluated the effects in the four NEPA sub regions in the United States, while recognizing the CRS projects operate within a transboundary basin. The potential for any significant effects of the alternatives that could arise in Canadian portions of the basin were reviewed in general as a matter of policy.

1.9.3.2 Mid-Columbia River Projects

After Rock Island Dam was completed in 1933, four more run-of-river dams were constructed on the middle Columbia River (Region B in Figure 1-7) in Washington during the 1950s and 1960s by three different Public Utility Districts (PUDs). These projects are operated under licenses from the Federal Energy Regulatory Commission (FERC). They include:

- Wells, operated by Douglas County PUD
- Rocky Reach and Rock Island, operated by Chelan County PUD
- Wanapum and Priest Rapids, operated by Grant County PUD

Flow patterns at the mid-Columbia River projects are influenced by operations at the Canadian and Federal projects upstream, particularly Grand Coulee Dam. While releases from Grand Coulee Dam are regulated by Chief Joseph Dam, the Federal project located upstream from Wells Dam, Federal storage project operations still affect the size and timing of flows at the five

PUD dams. The CRSO alternatives do not include any specific actions that would require the mid-Columbia River projects to operate outside their normal ranges.

1.9.3.3 Middle Snake River Dams

Idaho Power Company operates three FERC-licensed dams, collectively known as the Hells Canyon Complex, located on the middle Snake River between Oregon and Idaho. The Hells Canyon, Oxbow, and Brownlee Projects are hydropower facilities that affect flows into the lower Snake River. Hells Canyon and Oxbow are run-of-river projects downstream of Brownlee Dam. Brownlee Dam is the most significant project for FRM in the Hells Canyon Complex with an active storage capacity of 980,000 acre-feet that is used jointly for FRM and power production. Operations at Brownlee Dam control inflows to Oxbow and Hells Canyon, which operate as run-of-river dams passing flows through to the lower Snake River projects. The Hells Canyon Complex has a significant effect on flows in the lower Snake River, especially in the vicinity of Lewiston, Idaho, with Brownlee Reservoir helping to reduce flooding in the lower Columbia River Basin. The CRS alternatives do not include any specific actions that would require the Hells Canyon Complex to operate outside its normal ranges.

1.9.3.4 Pend Oreille, Clark Fork, and Flathead River Dams

Major non-Federal projects in the U.S. on the Pend Oreille and Clark Fork River systems are shown on Figure 1-7 in Region A. All of these dams are downstream of Hungry Horse Dam, and two are downstream of Albeni Falls Dam. The CRSO EIS alternatives do not include any specific actions that would require these non-Federal projects to operate outside their normal ranges. These projects are operated under licenses from FERC.

- Pend Oreille River Dams:
 - Box Canyon, operated by Pend Oreille County PUD
 - Boundary, operated by Seattle City Light
- Clark Fork River Dams:
 - Thompson Falls, operated by Northwestern Corporation
 - Noxon Rapids and Cabinet Gorge, operated by Avista Corporation
- Flathead River Dams:
 - Seli's Ksanka Qlispel, operated by Energy Keepers, Inc.

1.9.3.5 Other Tributary Dams

There are many other dams located on tributaries of the Columbia River and upstream of CRS projects and outside of the study area. Major dams are shown in Figure 1-7 and include dams in the following sub-basins.

- The Middle Snake River includes 3 non-Federal dams.
- The Upper Snake River Basin includes 23 Federal and non-Federal dams.
- The Yakima River Basin includes 6 Federal dams.
- The Spokane River Basin includes 5 non-Federal dams.
- The Wenatchee River Basin includes Chelan Dam, a non-Federal dam.
- The Priest River Basin includes Priest Lake Dam, a non-Federal dam.
- Tributaries of the Lower Columbia River include 34 Federal and non-Federal dams.

1.9.4 System Planning and Operations

Each Federal project within the scope of the CRSO EIS was constructed under specific congressionally authorized legislation identifying the major intended uses. All of the projects were specifically authorized for hydropower production, most were authorized for navigation, and some were also authorized for FRM and irrigation. The seasonal abundance of water, and the predictability of its use, allows a project to support other uses as well, but only incidentally. General congressional authorization allows for such uses as fish and wildlife conservation, recreation, and M&I water supply.

While the authorizing legislation stipulated intended use, it seldom contained explicit provisions for operating the individual projects or for their coordinated operation within the total system. The Corps and Reclamation are largely responsible for deciding how to operate their projects based on the principles of multiple-use operation, agency statutes, operations experience, and public input. Project operations are guided by water control manuals prepared for most projects.

Congressional authorization, multiple-use operating principles, water control manuals, and public interest provide overall guidance for system planning and management. Within this overall framework, planning is needed to guide system operations in response to actual hydrologic conditions. As a result, several annual planning processes guide system operations from year to year.

1.9.5 Annual Planning

The Corps, Reclamation and non-Federal utilities update their operating plans throughout the year to optimize power operations within the constraints for FRM, fish operations, navigation, and other constraints (specified in their FERC licenses for non-Federal utilities; specified by the Corps and Reclamation for Bonneville power operations).

The annual planning process starts each February and incorporates non-power considerations. Each reservoir owner submits multiple-use operating requirements (e.g., required minimum outflows) that must be accommodated in the resulting plan. Utility parties also submit forecasts of their electricity loads, the output of their non-hydro generating resources, and planned

maintenance outages for their resources. Studies are conducted to determine how much power can be produced from the whole system and by each Pacific Northwest Coordination Agreement (PNCA) party. The PNCA is an agreement involving 16 entities in the Northwest, including Federal water and power agencies and electric utilities. Through the PNCA, major hydroelectric generating plants and electric systems that serve the Pacific Northwest, including dams on the Columbia River in the United States, operations are planned as if they are controlled by a single entity. This is important because the power generation benefits of the Columbia River Treaty are based on an assumption that the operation of the Columbia River dams will be coordinated between the United States and Canada. The PNCA studies are updated throughout the operating year and guide reservoir operations that produce the planned power capability while meeting numerous other operating requirements. Although reservoirs are not required to operate in accordance with the plan, rights and obligations under the PNCA provide for exchanges of power between utilities to assure each utility can achieve the benefits of a coordinated plan.

Annual planning processes are also developed for purposes other than power. The Technical Management Team (TMT) is an inter-agency technical group comprised of sovereign representatives responsible for making in-season recommendations to the co-lead agencies (Corps, Bonneville, and Reclamation) on dam and reservoir operations in an effort to meet the expectations of the applicable BiOps and accommodate changing conditions, such as water supply, fish migration, water quality, new information, and maintenance issues. The TMT consists of representatives from the co-lead agencies, NMFS, USFWS, the states of Oregon, Washington, Idaho, and Montana, and tribal sovereigns.

Each fall, the co-lead agencies prepare an annual water management plan (WMP) consistent with applicable BiOps that describes the planned operations of the CRS dams and reservoirs for the water year (October 1 through September 30). The WMP is designed by the co-lead agencies to meet specific purposes:

- Implement water management measures consistent with actions considered in their respective BiOps.
- Assist in meeting the biological performance standards specified in the BiOps in combination with other actions or operations identified in the BiOps.
- Meet other CRS project requirements and purposes such as FRM, hydropower generation, irrigation, navigation, recreation, and conservation of fish and wildlife.
- Take into account recommendations contained in the applicable Northwest Power and Conservation Council's Fish and Wildlife Program and amendments.

The WMP also includes special operations planned for the year (e.g., special tests, maintenance, construction activities, etc.) known at the time the WMP is developed. Throughout the season, the co-lead agencies use the TMT forum to provide the region with seasonal updates on water supply forecasts and specific project operations.

The Corps coordinates with regional agencies to prepare an annual fish passage plan (FPP) that provides detailed operating criteria for project fish passage facilities, powerhouses, and spillways to facilitate the safe and efficient passage of migratory fish. The FPP contains appendices that describe special operations for fish research studies, the juvenile fish transportation program, operation of turbine units within operational constraints, spill for fish passage, TDG monitoring, and dewatering procedures. The FPP is coordinated through the inter-agency Fish Passage Operations and Maintenance Coordination Team.

1.9.6 Annual and Short-Term Operation

Current operation of the Federal system throughout the year is based on meeting several related, but sometimes conflicting, objectives. These include providing adequate flood storage space for controlling spring runoff; providing sufficient water levels for navigation, recreation, and fish and wildlife; maintaining an acceptable probability that reservoirs will refill to provide water for next year's operation; providing adequate water supply for irrigation; providing flows to aid the downstream migration of anadromous juvenile fish; and maximizing power generation, within the requirements imposed by other objectives.

Annual operation of the Federal system follows a three-season cycle (fall/winter, spring, and summer) graphically represented in Figure 1-8.

- For the fall/winter season, approximately October to mid-March, the general hydrologic condition is the start of the new water year, and the building of a snowpack and future water supply. In the fall and winter months, storage projects in the Columbia River Basin are preparing for the following spring's runoff (snowmelt and rain). Storage projects are operated to reduce flooding downstream. As snow accumulates in the mountains, reservoirs are lowered (drawn down) so high flows in the spring can be captured. During this fall/winter season, operators must also provide a safe navigation corridor, generate power, and protect wildlife habitat.

In the fall and winter, rivers are flowing at low, base-flow levels. Little is known at this time of year about how much snow will accumulate throughout the winter and how much water will come down the river in the upcoming spring. Winter storms may also bring rises in the river during this season.

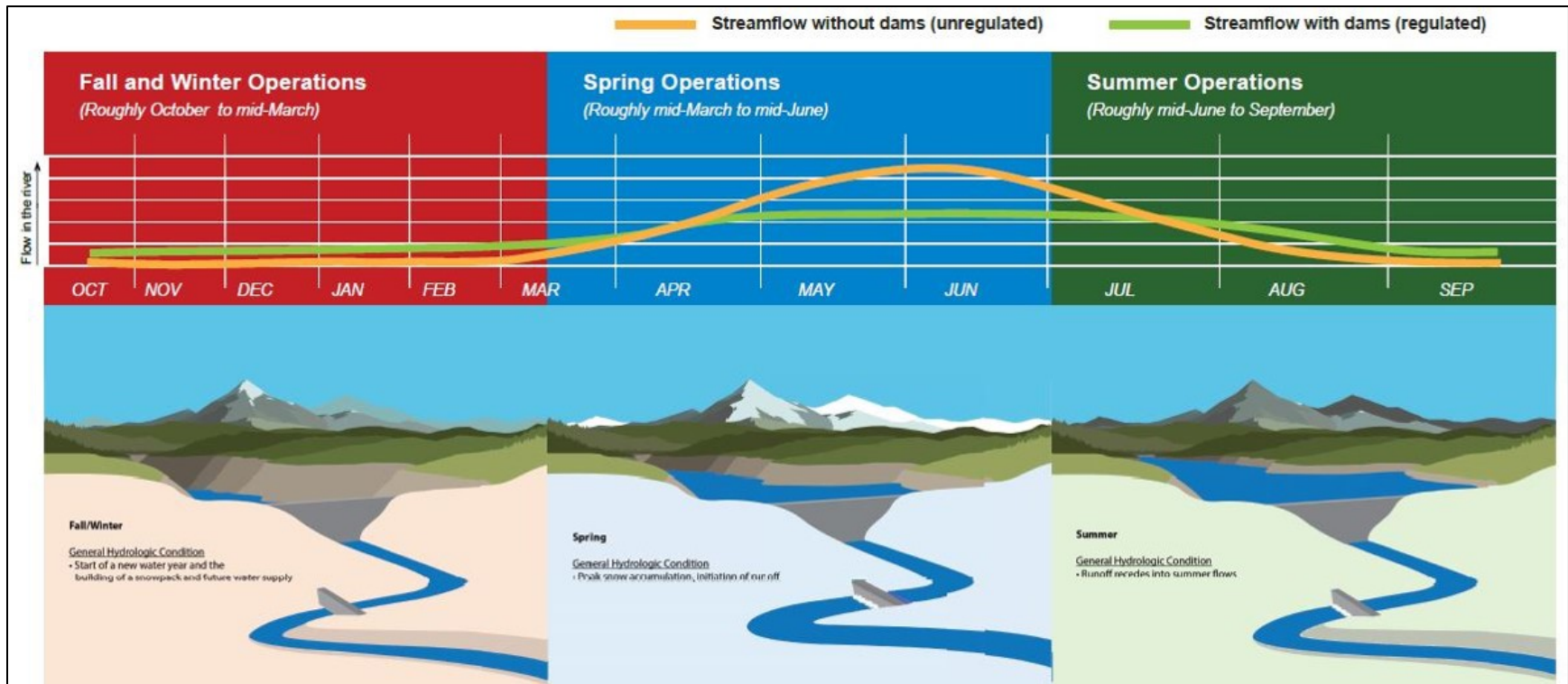


Figure 1-8. Seasonal Operations of Columbia River System

- During the spring season, the general hydrologic condition is peak snow accumulation sometime between mid-March and mid-May, depending on location in the Columbia River Basin and elevation. Water supply forecasts provide context to the type of runoff anticipated in the spring and provide information about the space required for FRM operations. Runoff can occur earlier in lower elevation subbasins because of earlier snowmelt and low elevation rains. Once runoff begins, the storage projects reduce outflow and begin refilling the reservoirs. The co-lead agencies balance FRM requirements and refill by attempting to operate no lower than the FRM elevation as of April 10.

The CRS is operated in the spring primarily to manage spring runoff for FRM to the extent possible, store water for irrigation use later in the season, and provide conditions to aid juvenile and adult fish migration. During this time, operators must also provide a safe navigation corridor, generate power, and protect wildlife habitat.

- For the summer season, which runs from approximately mid-June through September, spring runoff recedes into lower summer flows. Storage reservoirs reach their highest elevation in the summer months, often reaching full pool. Water stored during the spring is then released to augment flows for fish in the lower Columbia and lower Snake Rivers. Flows also provide water for irrigation, recreation, and power production. By summer, the peak flows from spring runoff transition to lower summer flows.

In the summer months, the system is operated to balance additional flow for augmentation downstream to aid juvenile and adult fish migration, provide water for irrigation use, and generate power. During this time, operators must also provide a safe navigation corridor, support recreation interests, and protect wildlife habitat.

The co-lead agencies have some flexibility in CRS operations as they attempt to meet the diverse and changing needs of the region based on information that becomes available over the course of the operating year. Many factors cause short-term operational adjustments. For example, sometimes periods of heavy rain cause higher flows in the fall. This water can be used to produce additional or surplus energy, which can be offered and sold into the wholesale electricity market. Alternatively, depending on conditions at the dams, water can be stored for future use if storage space is available. In a poor snowpack year, minimum fish flows, navigation, and other constraints dictate how much water the projects must discharge, allowing as much water as possible to be used to fill the reservoir. In a poor snowpack year, there may not be enough water to provide power to meet firm energy demand in the region, and Bonneville might need to purchase power on the wholesale market to meet its obligations.

The actual operations take place in what is described as “real time,” that is, decisions must be made in a few minutes, days, or at most, a few weeks. Operators regulate the system in an effort to satisfy all the various purposes contained in the annual operating plan. They may need to respond to in-stream conditions for fish or navigation, or take advantage of an opportunity to generate extra power to sell as surplus when economically beneficial. Boating accidents, generator outages, the weather, and even the timing of recreational events can influence operational decisions. From time to time, there are also periodic maintenance activities that

drive reservoir levels. For example, Reclamation has established a periodic maintenance schedule for the drum gates that regulate flow into the spillway at Grand Coulee Dam, and this requires the reservoir to be drawn down to elevation 1,255 feet NGVD29.⁵ Please see Chapter 2 for more details on maintenance-driven elevation changes.

1.9.7 Operational Strategies to Meet Other System Uses, Planning and Operations

Preceding sections summarized key operational strategies to effectively manage and plan CRS operations, including but not limited to water supply, hydropower generation, and FRM. The following sections summarize key operational strategies to effectively manage other resources including navigation, water quality, and fish resources.

1.9.7.1 Navigation

Navigation in the Columbia River Basin is both commercial and recreational. Section 3.10 provides detailed information on navigation. Commercial use takes place primarily along the Columbia-Snake Navigation System (CSNS). The CSNS covers the entire 470-mile-long water highway formed by the eight mainstem dams and lock facilities on the lower Columbia and Snake rivers. The CSNS follows the navigable reaches of the lower Snake River beginning near Lewiston, Idaho, and Clarkston, Washington, to its confluence with the Columbia River near Pasco, Washington, and then down another 330 miles on the Columbia River to its junction with the Pacific Ocean near Astoria, Oregon. The CSNS consists of three primary segments: (1) a 43-foot-deep draft segment between the Pacific Ocean and Portland, Oregon, and Vancouver, Washington (River Mile [RM] 106); (2) a 28-foot segment (maintained at 17 feet) of the Columbia River between Vancouver, Washington and The Dalles, Oregon; and (3) a 14-foot shallow draft section of the Columbia River, which stretches from The Dalles to Pasco, Washington to the Snake River RM 140 at Lewiston, Idaho, and Clarkston, Washington. Traditionally, locks are taken out of service for approximately two weeks each year for maintenance, which generally occurs in the spring. The shallow draft channel accommodates Corps and U.S. Coast Guard vessels, shallow-draft tugs, barges, and recreational boats; and connects the interior of the Columbia River Basin with deep-water ports on the lower Columbia River.

Commercial barges and other river traffic need minimum water depths to navigate successfully. Unlike other river uses, navigation has depth requirements that do not vary seasonally. Dam operators must regulate water releases and maintain reservoir levels to provide minimum navigation depths throughout the year. Operating requirements for navigation differ between the waterway's deep draft and shallow draft segments.

From the Pacific Ocean to The Dalles, Oregon, navigation requirements can usually be met by natural river flows, without any special releases of water from the CRS projects. Periodic dredging maintains this channel's depth to support navigation even at normal low flows, most

⁵ More information on NGVD29 can be found in Chapter 3, *Hydrology and Hydraulics*, Section 3.2.4.1.

notably near Pillar Rock, which is located in the middle of the channel at Columbia RM 27 near Brookfield, Washington.

In the portion of the shallow-draft channel from Pasco, Washington, to Lewiston, Idaho, maximum and minimum reservoir elevations have been established to maintain an authorized 14-foot channel depth. The authorized channel depth can be maintained physically, by dredging, most notably in Lower Granite Reservoir at the confluence of the Snake and Clearwater Rivers, or operationally by raising reservoir levels. At times, the navigation channel is controlled operationally for specific purposes. For example, the McNary Reservoir needs to be above a minimum of 338 feet and held within a half-foot range and Priest Rapids Dam discharges need to be held within a specified range to facilitate periodic shipments of nuclear reactor compartment disposal packages to the Port of Benton by the U.S. Navy. Thus, navigation requirements are fully met within the flexibility provided under normal CRS operations.

Between 1996 and 2016, an average of 54.1 million tons of freight per year was moved on the CSNS, of which 4.8 million tons of freight was moved on the lower Snake River (Corps 2018e). The top ten commodities transported are wheat, soybeans, corn, wood, sodium carbonate, pebbles and gravel, potassium chloride fertilizers, gasoline, other light oils, and scrap metal (Corps 2018e).

Many types of recreational motorized and non-motorized pleasure crafts are used throughout the Columbia River Basin. Commercial tour guide and transportation services also exist in some locations. Several cruise companies offer cruises along the lower Columbia River and on the lower Snake River to Clarkston, Washington.

Two ferries operate on Lake Roosevelt, the reservoir behind Grand Coulee Dam. The Keller Ferry is operated by the Washington Department of Transportation as a link on rural State Route 21 and provides access to the Colville Indian Reservation. It can run throughout the entire operating range of the reservoir, from elevation 1,208 to 1,290 feet. The Inchelium-Gifford Ferry provides access to the Colville Indian Reservation from Washington State Highway 25. This ferry cannot operate below elevation 1,229 feet. Both ferries carry normal highway traffic.

1.9.7.2 Fish

Prior to dam construction, some populations of salmon, steelhead, lamprey, and other anadromous species migrated as far as 1,200 miles up the Columbia River to Lake Windermere, Canada, and 600 miles up the Snake River to Shoshone Falls, near Twin Falls, Idaho. As part of the Independent Science Advisory Board (ISAB) review of density dependence, the ISAB estimated that a range of 5 to 9 million salmon and steelhead once returned to the Columbia River Basin in the pre-development era (prior to 1850) with the primary evidence (i.e., probable harvest rates) supporting an estimate of around 6 million fish per year (ISAB 2015). Other published estimates of pre-development abundance range from 7.5 to 8.9 million fish (Chapman 1986) or 10 to 16 million fish (NW Council 1986), assuming that all species could

reach maximum abundance in the same year. Broad and significant declines in salmon had occurred by 1895. (Gilbert and Evermann 1895). Current returns of salmon and steelhead are well below the pre-development estimates of abundance. NMFS' 2016 5-year status review notes that:

Many West Coast salmon and steelhead (*Oncorhynchus* spp.) stocks have declined substantially from their historical numbers and now are at a fraction of their historical abundance. Several factors contribute to these declines, including: overfishing, loss and degradation of freshwater and estuarine habitat, hydropower development, poor ocean conditions, and hatchery practices. These factors collectively led to the National Marine Fisheries Service's (NMFS) listing of 28 salmon and steelhead stocks in California, Idaho, Oregon, and Washington under the Federal Endangered Species Act (ESA). (NMFS 2016e)

Dams without fish passage block anadromous fish access to much of the upstream portions of the Columbia and Snake rivers and their tributaries. As juveniles, anadromous fish migrate from fresh water to marine environments and then return to fresh water as adults to spawn. Over 550 miles of mainstem Columbia River habitat (and many more miles of tributaries) have no returning anadromous fish above Chief Joseph Dam, which is the current upstream limit of salmon and steelhead in the Columbia River. Over 50 percent of the originally inhabited mainstem of the Snake River is no longer accessible to anadromous fish, as the Hells Canyon Complex limits access to the upper 247 miles of this river, plus access to tributaries. Dworshak Dam blocks upstream migration on the North Fork of the Clearwater River. Additional historical background information is included in Section 3.5.

The kinds and numbers of resident fish vary considerably across the Columbia River Basin. Many species interact with each other and their habitats to form local/regional fish communities. Some of these species are important for cultural, recreational, and commercial harvest. Some resident fish populations, including bull trout and Kootenai River white sturgeon are listed under the ESA. Others, such as burbot, westslope cutthroat trout, and kokanee, are not listed. Many habitats in the Columbia River Basin are fragmented by Federal and non-Federal dams for native resident fish. Dams and associated reservoirs have created more opportunities for the expansion of non-native game fish introduced into the basin.

Within the Columbia River Basin, various actions, plans, agreements, and programs have been implemented by Federal, state, local, and tribal entities to contribute to the survival and recovery of ESA-listed species and to the maintenance of other stocks. These actions, plans, and programs aim to improve water quality, habitat, up- and down-stream migrations, and address predation, among other goals.

Water quality improvements include the installation of flow deflectors to reduce the amount of TDG at Chief Joseph, all four lower Snake projects (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams), McNary, John Day, and Bonneville dams, and multilevel outlets to release water at certain temperatures at some projects, including Libby, Hungry Horse, and Dworshak Dams.

Throughout the Columbia River Basin, fish and wildlife habitat protection, mitigation, and enhancement projects have been constructed with funding from a wide variety of programs, including programs implemented through by the state agencies like the Washington Salmon Recovery Funding Board and the Oregon Watershed Enhancement Board as well as Federal programs such as Bonneville's Fish and Wildlife Program, Corps' authorities like the Section 536 program, BOR's ESA Recovery Program, NOAA's Pacific Coastal Salmon Recovery Fund, USFWS Partners for Fish and Wildlife Program, NRCS Conservation Easement Recovery Program, North American Wetlands Conservation Act. These interagency groups work collaboratively to better integrate, organize, and coordinate fish recovery and water quality efforts in support of protecting and restoring the Columbia River Basin aquatic ecosystem.

HABITAT ACTIONS

Bonneville works with states, tribes, and watershed groups to protect, mitigate, and enhance spawning and rearing habitat, targeting factors that limit fish survival throughout the Columbia River Basin. Bonneville has funded hundreds of actions across the basin to restore natural stream channels, reconnect estuarine tidal channels, enhance flow volume and timing, expand cold water refuges and open access to habitat (www.cbfish.org). These habitat improvement actions provide both near-term and long-term benefits, including those that will help address the effects of climate change. Actions that improve connectivity and stream flow will provide a buffer against the effects of climate change.

In addition to habitat improvement actions, Bonneville works with willing landowners to protect land and water by putting it under permanent conservation easement to further support habitat and fish conservation in the short and long term.

All eight Federal projects on the lower Columbia and lower Snake Rivers provide fish passage to accommodate anadromous fish migration. Some fish facilities were included in the initial design of the projects, while others were added at a later date. Facilities and operations designed to benefit fish include ladders for adults and diversion screens for juveniles; a transportation program consisting of collection facilities, barges, and trucks for juvenile migration; hatcheries to supplement harvest and wild stocks; and in-stream flow management for both juveniles and adults. Actions to address predation on salmon and steelhead have ranged from lethal removal to non-lethal dissuasion and hazing. Avian wires at the CRS projects and higher water levels during nesting seasons are techniques to deter birds from using a particular area. For seals and sea lions (pinnipeds), exclusion devices have been installed at the projects as a dissuasion method. Hazing has been carried out to deter both birds and pinnipeds from preying on migrating salmonids.

UPSTREAM FISH PASSAGE

Fish ladders, which allow adult salmon and other fish species including lamprey to migrate upstream, were built during the original construction of all eight Federal run-of-river projects on the lower Columbia and Snake rivers. (The five PUD dams on the middle Columbia River also have fish ladders to maintain anadromous fish access to the Wenatchee, Methow, Entiat, and

Okanogan rivers.) Each of these projects has one to three ladders operating continuously, except during winter maintenance outages. Even though the fish ladders were not originally designed for lamprey passage, several ladder modifications have been made since the early 2000s and more are expected in the future to improve lamprey passage. Resident fish passage is blocked by Libby, Hungry Horse, and Albeni Falls dams. The Grand Coulee, Chief Joseph, and Dworshak dams effectively block the upstream migration of anadromous fish. All six of these projects were not designed with fish passage facilities and so effectively block the upstream access for both resident and anadromous fish.

The Bonneville Dam has three fish ladders; The Dalles, John Day, McNary, Ice Harbor, and Lower Monumental Dams each have two fish ladders; and the Little Goose and Lower Granite Dams each have one fish ladder. Adult fish enter a ladder through collection systems that run along the entire front of a dam's powerhouse, as well as at other key locations. Specific flow conditions near the ladder entrances are needed to attract adult fish into the ladders. The attraction water is provided by pumps, small turbines, or gravity flow from the reservoir behind the dam, depending on the design of the individual system. The fish swim upstream to the base of the fish ladder, where they migrate up the ladder and exit into the reservoir above the dam. Each ladder contains a fish-counting station where the fish pass an underwater viewing window, allowing them to be counted and identified by species.

DOWNSTREAM FISH PASSAGE

Currently, juvenile fish can migrate past the dams via several routes: over the spillway, through the turbines, or through the juvenile fish bypass systems, sluiceways or corner collector (Table 1-4). In addition, some fish are transported past the dams by barge or truck.

Table 1-4. Types of Downstream Fish Passage

Project	Type of Downstream Fish Passage
Lower Granite	spillway, spillway weir, juvenile bypass system, turbines, barges, and trucks
Little Goose	spillway, spillway weir, juvenile bypass system, turbines, barges, and trucks
Lower Monumental	spillway, spillway weir, juvenile bypass system, turbines, barges, and trucks
Ice Harbor	spillway, spillway weir, juvenile bypass system, and turbines
McNary	spillway, two spillway weirs, juvenile bypass system, turbines, and improved fish passage turbines
John Day	spillway, two spillway weirs, juvenile bypass system, and turbines
The Dalles	spillway, sluiceway, and turbines
Bonneville	corner collector, spillway, sluiceway, juvenile bypass system, turbines, and improved fish passage turbines

Spillway passage occurs through either conventional spill or spillway weirs (Figure 1-9). Conventional spill requires juvenile fish, which generally travel near the surface of the river, to dive to find passage at the bottom of the spill gates, while spillway weirs provide conditions that are more favorable and more effective surface passage. Spillway weirs are mounted onto the face of a dam and use surface flows to draw fish toward the structure. This route allows

juvenile salmon and steelhead to pass the dam near the water surface under lower accelerations and lower pressures, providing a more efficient and faster dam passage route.

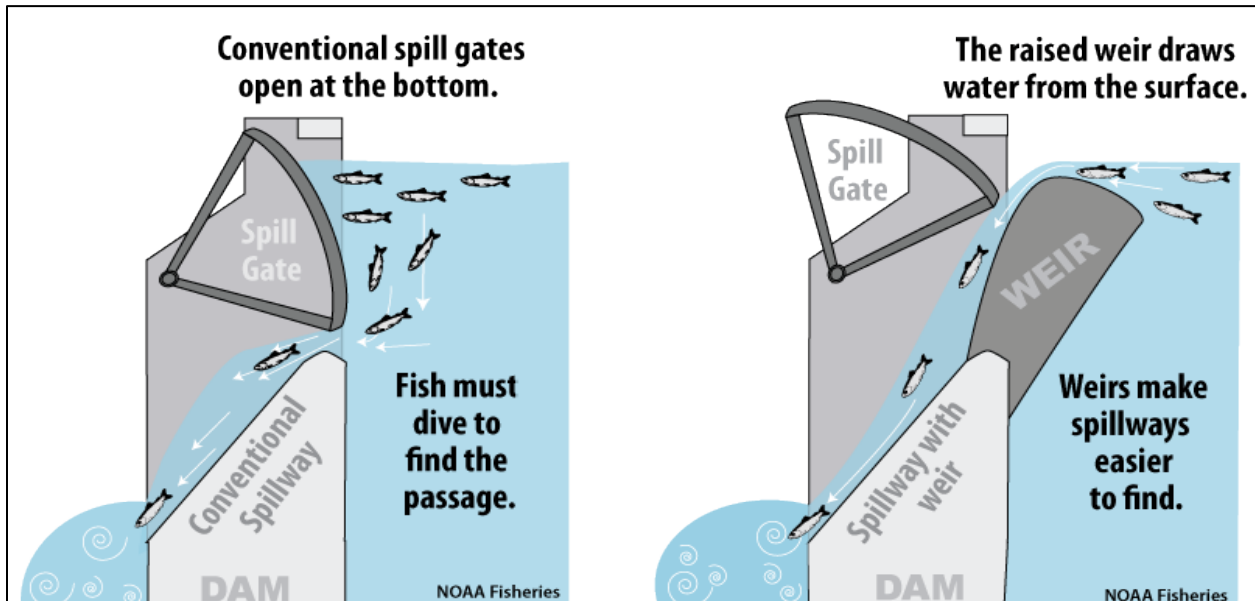


Figure 1-9. Passage Routes of Juvenile Salmon for Conventional Spill and Spillway Weir Routes

Powerhouse passage for juvenile salmonids is also broken into multiple routes, including turbines, juvenile bypass, sluiceways, and corner collector passage. Juvenile bypass systems divert juvenile anadromous fish away from the turbine intakes and through a bypass system to raceways, where they are collected for transport or bypassed directly back into the river. The juvenile bypass system guides 60 to 90 percent of juvenile salmon and steelhead that enter the powerhouse away from the turbines and into the bypass. Fish collected for transport are placed in either barges or trucks and transported around multiple dams and released downstream of Bonneville Dam.

At The Dalles Dam, turbine units are not screened. As a result, powerhouse fish passage consists of turbines or the ice-and-trash sluiceway, a rectangular channel extending along the upstream side of the powerhouse. When the sluiceway gates are open, water and juvenile migrants are skimmed from the forebay into the sluiceway, and bypassed to the tailrace.

At Bonneville Dam, turbine units are only screened at the second powerhouse because juvenile fish turbine passage was found to be better without screens at the first powerhouse. The first powerhouse also has an ice-and-trash sluiceway. The corner collector at Bonneville Dam was the ice and trash sluiceway at the second powerhouse that was transformed into a juvenile bypass route that was extended to release the fish back into the river further downstream.

1.9.7.3 Water Quality

State water quality standards are developed to ensure the protection of the water's beneficial uses. Minimum outflow requirements, which generally vary by season, are specified for each

project to help maintain desired downstream conditions. The co-lead agencies recognize Federal, state, and U.S. Environmental Protection Agency–approved tribal water quality standards, and manage a variety of programs and facilities intended to maintain water quality throughout the Columbia River Basin. Two main water quality parameters affected by CRS operations are water temperature and TDG. See Section 3.4 for detailed water quality information.

TEMPERATURE

It is understood that the creation of reservoirs can cause a change in the natural thermal regime of a river. Reservoirs tend to create thermal responses that lag behind that found in unregulated rivers, creating outflow temperatures that are cooler in the spring and warmer in the fall compared to natural or pre-dam thermal conditions. Dams and reservoirs tend to reduce the within-day warming and cooling processes typically observed in free-flowing rivers. For more information, refer to Section 3.4, *Water Quality*.

The CRS storage projects, which include Hungry Horse, Libby, and Dworshak dams are deep storage reservoirs that retain water for several months, allowing for temperature stratification (water arranged in layers that vary in temperature). This stratification provides the ability to operate these dams, through selective withdrawal, to meet downstream water temperature objectives. Cold-water releases from Dworshak Dam have been used successfully to reduce water temperatures at Lower Granite Dam. However, the cooling effects of the Dworshak releases are attenuated, as the Snake River flows toward the confluence with the Columbia River. Water temperatures in the lower Snake River are primarily determined by a combination of the temperature of the water originating from the middle Snake River and the Clearwater River. Lower and middle Snake River maximum summer temperatures exceeded the current 68°F (20°C) Washington standard before the dams were constructed (Corps 2002b; Peery, Bjornn, and Stuehrenberg 2003). Grand Coulee is also considered a storage project, but it is unique in the fact that it has relatively low retention times due to the large amount of flow through the project. This short retention time results in very weak thermal stratification, and homogenous temperatures at penstock intake depths. The lack of strong thermal stratification results in Grand Coulee Dam releasing the coolest water possible during hot summer months. The other CRS dams are run-of-river projects with short retention times (only a few days or weeks) with more uniform water temperatures from the surface to the bottom (not stratified); selective withdrawal is not possible at these dams.

TOTAL DISSOLVED GAS

Spilling water at a dam results in increased TDG levels in downstream waters when aerated water plunges to depths where pressure increases the solubility of atmospheric gases. Water that contains high levels of dissolved gases (e.g., nitrogen and oxygen) can be harmful to fish. The TDG saturation in water below CRS dams often exceed state and tribal water quality standards of 110 percent during the juvenile fish passage season, generally April to August; however, this criterion does not apply to flows above the 7-day, 10-year frequency flow (7Q10) flood flow. In addition, special waiver or rule modifications from Oregon Department of

Environmental Quality and a criteria adjustment from Ecology have been established as a special condition during the juvenile fish passage periods of spill for downstream fish migration (April 1 to August 31), allowing for the exceedance of the 110 percent TDG water quality standard at the lower Columbia River and lower Snake River dams up to a specified tailwater or forebay percent TDG maximum. The co-lead agencies have made major efforts to reduce TDG generation during the juvenile fish passage season by regulating flow and installing structures such as flow deflectors to reduce the plunge of water that reduces the amount of entrained air. Although the co-lead agencies have made major efforts to reduce TDG generation during high-flow years, there are situations where TDG water quality criteria are exceeded. For example, TDG can be in excess of 120 percent in the Columbia River at the International Boundary. Spillway releases can improve downstream juvenile fish migration, so balancing these releases and TDG production is important.

TDG and water temperature data are monitored in real time through a network of fixed monitoring stations operated by the Corps, Reclamation, and Grant and Douglas County PUD to provide information about dam operations during the juvenile fish passage and migration season. These monitors are used to measure compliance with state and tribal water quality standards.⁶ The data collected through this monitoring network provides information used to adjust spill on a real-time basis through the system.

⁶ Tribal water quality standards exist for the mainstem Columbia River and tributaries per each tribe's jurisdiction. Certain tribes in the basin have water quality standards that have been approved by U.S. Environmental Protection Agency.

CHAPTER 2 - ALTERNATIVES

2.1 INTRODUCTION

This chapter describes the No Action Alternative and the four Multiple Objective Alternatives (MOs) which make up the initial range of alternatives considered in the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS). A sixth alternative, the Preferred Alternative, includes many of the measures described in this chapter. The Preferred Alternative is described and evaluated in Chapter 7.

The U.S. Army Corps of Engineers (Corps), U.S. Bureau of Reclamation (Reclamation), and Bonneville Power Administration (Bonneville), co-lead agencies for the EIS, developed a range of alternatives for the future physical configuration, operation, and maintenance of the 14 projects of the Columbia River System (CRS) to achieve a reasonable balance of competing resource demands for the available water and meet the purpose and need for this EIS.

The co-lead agencies defined eight objectives (Section 2.2.1) to meet the purpose and need statement for the EIS and to direct the development of the alternatives. A suite of eight preliminary draft alternatives were developed to focus on individual resources. These Single Objective Alternatives provided information regarding how well measures might perform when combined, and helped identify any conflicts between resources, actions, or locations. These Single Objective Alternatives informed the next iteration of alternatives development. The resulting range of alternatives consists of the No Action Alternative and four MOs. The No Action Alternative is a description of continuing current practices, whereas the MOs modify one or more aspects of the operation, maintenance, and configuration of the projects.

The MOs include a range of spill levels for juvenile fish passage, varying levels of hydropower production, and differing actions to support the needs of Endangered Species Act (ESA)-listed anadromous and resident fish. The MOs also include proposed means to support future delivery of water for irrigation and municipal and industrial (M&I) purposes as well as increased water management flexibility to react to unanticipated changes in river flow and increase the likelihood of achieving refill of storage reservoirs. After evaluating the potential effects of the alternatives on flood risk management (FRM), irrigation, hydropower generation, navigation, fish and wildlife conservation, cultural resources, recreation and other environmental and socioeconomic resources, the Preferred Alternative was developed to achieve a reasonable balance of competing resource needs (Chapter 7, *Preferred Alternative*) while meeting the purpose and need statement (Section 1.2). This chapter describes the five alternatives and the process used to develop and evaluate them.

2.2 OVERVIEW OF ALTERNATIVES DEVELOPMENT PROCESS

The three co-lead agencies developed alternatives for the CRSO EIS to focus on changes to operations, maintenance, and configuration of the 14 identified projects in the CRS. Several other scopes that include regional efforts for consideration were suggested for the EIS which the co-lead agencies did not develop alternatives to address. These are identified in Section 2.4.

Alternatives were developed to meet the purpose and need statement, identified objectives, and congressionally authorized purposes of the projects within the CRS. The process used to develop the No Action Alternative and MOs is summarized in this chapter, and fully detailed in Appendix A, *Alternatives Development*.

The co-lead agencies used an iterative process to build alternatives. They began by identifying objectives for future management of the CRS. Actions that could be taken to meet those objectives, called measures, were then identified. Finally, the measures were combined into alternatives and refined over time to produce a reasonable range of alternatives for analysis. In support of the alternatives development process, technical subject matter experts were convened from the three co-lead agencies, cooperating agency staffs, and multiple Native American tribes. These subject matter experts were assigned to technical teams based on their respective area of expertise. Many in-person workshops and web-based meetings were conducted by the technical teams to ensure a collaborative alternatives development process. Reviews of early draft alternatives, comment resolution, and refinement of alternatives were also conducted via web-based meetings to include large numbers of team members across the geographic region. The co-lead agencies used the input from the scoping process, technical teams, cooperating agencies, and tribes as the alternatives were developed. They also considered the Purpose and Need Statement and objectives. While there were broad efforts to collaboratively build and evaluate the alternatives, the co-lead agencies are ultimately responsible for the decisions made in the EIS process, including decisions on scope of the analysis. The co-lead agencies retain final responsibility for the analysis in the draft and final EISs and the decision made in each agency's respective Records of Decision (RODs). The participation of the cooperating agencies and their collaboration with the lead agencies does not infer that they agree with the conclusions in the analysis or that they are waiving any rights to review and comment on the draft and final EIS during the public comment period.

Multiple Objective Alternatives Terminology

Objectives are what the Federal agencies are trying to accomplish (the "why"). They are statements of the desired outcome of the EIS, as identified by the Federal agencies and scoping comments. An example of an objective is to improve ESA-listed anadromous salmonid adult fish migration within the project area.

A **measure** is the action the agencies would take to achieve an objective (the "how"). It describes an action, usually in a precise location, that meets an objective, in whole or in part. Using the objective mentioned above, a measure could be to provide structural enhancements for fish passage, such as improving fish ladders.

An **alternative** is a combination of one or more measures that, together, would address one or more of the objectives. In this EIS, the co-lead agencies designed the action alternatives to address several objectives and are therefore calling them MOs.

2.2.1 Objectives

Objectives are statements of the desired outcome of various resource conditions that are expected to result by taking Federal action(s). The eight objectives presented below, along with

the EIS Purpose and Need statement (Section 1.2), guided the development of a reasonable range of alternatives:

- Objective 1: Improve ESA-listed anadromous salmonid juvenile fish rearing, passage, and survival within the CRSO project area through actions including but not limited to project configuration, flow management, spill operations, and water quality management.
- Objective 2: Improve ESA-listed anadromous salmonid adult fish migration within the CRSO project area through actions including but not limited to project configuration, flow management, spill operations, and water quality management.
- Objective 3: Improve ESA-listed resident fish survival and spawning success at CRSO projects through actions including but not limited to project configuration, flow management, improving connectivity, project operations, and water quality management.
- Objective 4: Provide an adequate, efficient, economical, and reliable power supply that supports the integrated Columbia River Power System.
- Objective 5: Minimize greenhouse gas emissions from power production in the Northwest by generating carbon-free power through a combination of hydropower and integration of other renewable energy sources.
- Objective 6: Maximize operating flexibility by implementing updated, adaptable water management strategies to be responsive to changing conditions, including hydrology, climate, and the environment.
- Objective 7: Meet existing contractual water supply obligations and provide for authorized additional regional water supply.
- Objective 8: Improve conditions for lamprey within the CRSO project area through actions potentially including but not limited to project configurations, flow management, spill operations, and water quality management.

2.2.2 Measures

As stated previously, a measure describes an action that could be taken to meet one or more objectives. Measures are typically specific to a discrete action in a precise location. For example, a measure could be to improve adult ladder passage through modification of the adult trap at the Lower Granite Project. An alternative is usually constructed of a number of measures that are combined to meet the objectives.

Many measures were considered to address objectives and build a reasonable range of alternatives during the development of this EIS. Potential measures were submitted by the public, stakeholders, and tribes during the scoping process. Additional measures were developed by technical team members from co-lead and cooperating agencies. Before combining measures into alternatives, they were evaluated to determine if they met the EIS purpose and need statement and at least one objective. Those measures that did not meet at least one objective were eliminated from further consideration. Remaining measures were

further evaluated to determine whether the measures were technically feasible, or whether they constituted a risk to human life and safety (including increasing flood risk). Additional detail of this process can be found in Appendix A, *Alternatives Development*.

Measures remaining after screening fall under two categories: structural or operational. Structural measures are those involving a physical change to the project such as installation of a feature in the spillway or modifying fish ladders. Operational measures are those involving a change in how water is stored or released at the projects or how juvenile fish are transported around the projects. Examples of operational measures include a change in timing of drawdown or refill of a water storage reservoir and a change in how much water is released through the spillway versus the powerhouse. Further, the operational measures of each alternative are categorized as follows:

- **Fish Passage Spill** – Fish passage spill refers to the use of flow released through spillway gates to allow juvenile fish to migrate downstream from the forebay of a reservoir to the tailrace of the dam.
- **Juvenile Fish Transportation** – Juvenile fish transportation refers to the collection of ESA-listed juvenile fish at collector projects for relocation downstream of the Bonneville project via barges or trucks.
- **Water Management** – Water management refers to the planned release of flow from the projects to either draft or refill reservoirs. Water management also refers to operations to meet project purposes such as FRM, hydropower production, and irrigation as well as fish and wildlife purposes.
- **Water Supply** – Water supply refers to the withdrawal of water for the purpose of irrigation and M&I use.
- **Other Operational** – Other operational measures include actions taken to support fish and wildlife. For example, the drawdown of reservoirs to reduce juvenile salmon outmigration time.

2.3 ALTERNATIVE SCREENING

To achieve a broad range of alternatives, the co-lead agencies collaborated with cooperating agencies in teams of technical experts through several iterations to create 12 alternatives that could meet the CRSO EIS purpose and need statement: first, eight Single Objective Alternatives, and then four MOs. After completing the effort to develop the Single Objective Alternatives and MOs, the co-lead agencies evaluated all 12 alternatives against screening criteria of completeness and efficiency.

- **Completeness** was used to evaluate the extent to which a given alternative provides and accounts for all actions to meet most or all objectives, and thereby satisfying the purpose and need statement.

- **Efficiency** was considered as how well (without duplication of effort) an alternative would meet objectives. Usually, cost effectiveness is part of this consideration, but costs were not available at the early screening of alternatives. In this case, efficiency was based on efficiency of analysis of measures and the elimination of duplication of effort.

The evaluation of the 12 alternatives against these two criteria found that the MOs were more complete than the single objective alternatives. The MOs were also determined to be more efficient, as MOs were composed of combinations of measures from the single objective alternatives. Retaining the single objective alternatives would have resulted in duplication of analyses which otherwise are included in the MOs. This resulted in the finding that the four MOs presented the most complete and efficient way to achieve identified objectives, and these represented a reasonable range of alternatives that included the suites of measures the technical teams identified. The single objective alternatives were eliminated from further consideration. The complete detailed descriptions of the single objective alternatives and their measures are located in Appendix A, *Alternatives Development*. A brief description of the alternatives removed from further consideration is in Section 2.5.

2.4 RANGE OF ALTERNATIVES

2.4.1 Introduction

The analysis in this chapter focuses on five alternatives, which include the No Action Alternative, Multiple Objective Alternative 1 (MO1), Multiple Objective Alternative 2 (MO2), Multiple Objective Alternative 3 (MO3), and Multiple Objective Alternative 4 (MO4). An important note is that the descriptions of the MOs only include how they differ from the No Action Alternative. For example, under the No Action Alternative, Libby and Hungry Horse Dams operate to daily and hourly ramping up and down restrictions as per the 2006 USFWS biological opinion (BiOp). Two MOs include ramping rate measures that would allow project operators to increase or decrease the rate of flow released from the dam more quickly than under the No Action Alternative. The other two MOs would continue to adhere to the No Action Alternative ramping rates and their descriptions do not restate the No Action Alternative operation for the sake of brevity.

MOs are so named in that they attempt to incorporate measures that would address more than one of the eight CRSO objectives. However, these alternatives do not attempt to balance all of the objectives equally. Rather, the MOs explore a range of structural and operational changes in order to determine impacts of potential new solutions and analyze the trade-offs of combining ideas under one alternative.

The sections below provide summarized descriptions of the five alternatives, which include an explanation of the measures within the alternative. The descriptions begin with an overall summary of the alternative and include the distinction amongst the four MOs. The structural measures of each alternative are characterized first, followed by the operational measures. The complete detailed descriptions of the alternatives and their measures are located in Appendix A, *Alternatives Development*.

2.4.2 No Action Alternative

For this EIS, the No Action Alternative describes the operation, maintenance, and configuration of the CRS, from September 30, 2016, the date the Notice of Intent to complete the CRSO EIS was published in the Federal Register. The No Action Alternative is required by the National Environmental Policy Act (NEPA), in accordance with the Council on Environmental Quality regulations (40 Code of Federal Regulations [C.F.R.] 1502.14). The No Action Alternative considers what would happen if the CRS continued to be operated, maintained, and configured with no change. The EIS assumes that, to the extent possible, all ongoing, scheduled, and routine maintenance activities for the Federal infrastructure and all structural features, including those recently constructed or reasonably foreseeable, are included in the No Action Alternative.

The No Action Alternative provides a baseline condition for comparing environmental effects of the MOs. The No Action Alternative assumes the CRS will continue to be operated for all congressionally authorized purposes, requiring a balancing of operations across the 14 projects within the CRS. Current operations include actions agreed to in previous ESA consultations among the co-lead agencies, National Marine Fisheries Service (NMFS), and U.S. Fish and Wildlife Service (USFWS).

The No Action Alternative also assumes structural measures already budgeted and scheduled would be implemented. The majority of these structural/construction projects are modifications to the dams intended to improve conditions for ESA-listed fish or improve safety for operators and the public. A general description of the No Action Alternative is located in Section 2.4.2. Additional discussion of the No Action Alternative is contained in Appendix A, *Alternatives Development*.

As described in Chapter 1, *Introduction*, the CRS is operated to meet multiple authorized purposes, and consider other regional priorities. The volume of water in the CRS in any given year is variable and finite, and not all operations to benefit various resources may be achieved in a given year. In coordinating system water management, the co-lead agencies generally prioritize FRM and environmental responsibilities, such as conservation actions for ESA-listed fish species and other species of concern, before Bonneville shapes any remaining flexibility to manage water flow for hydropower generation to meet daily and seasonal power demands.

Information described in the No Action Alternative is drawn from a number of documents, including the Fish Operations Plan (FOP) (Corps 2016a), the Fish Passage Plan (Corps 2016b), BiOps from NMFS and USFWS (USFWS 2006; NMFS 2008a), water management plans (Corps 1992), and other sources.

2.4.2.1 No Action Alternative Description of Measures

This section provides a brief description of the way the CRS is operated, and would be expected to operate, if no other changes are implemented. A more comprehensive description of current system operations is contained in Appendix A, *Alternatives Development*.

STRUCTURAL MEASURES

In addition to investments that meet the structural measures criteria described in Section 2.4.2, the co-lead agencies will continue to invest in power-related capital improvements, additions, replacements, and non-routine extraordinary maintenance/expense as needed to meet reliability standards, availability requirements, regional adequacy guidelines, efficiency needs, environmental requirements, safety and security standards, and other requirements.

Hungry Horse Project Power Plant Modernization

The power plant at Hungry Horse Project began an extensive modernization effort in Fiscal Year (FY) 2018. This work will bring the facilities to current industry standards. It will include the full overhaul or replacement of governors, exciters, fixed-wheel gates, and turbines; a generator rewind; overhaul of the selective withdrawal system; and recoating the penstocks. In addition, cranes that service the power plant will be refurbished or replaced, and the power plant will be brought up to modern fire protection standards. For one of the years of the project, the power plant overhaul would limit the number of turbines available to generate power during the overhaul. This would not affect the amount of water released from the dam because outlets will be used. The full effort is expected to take 10 years to complete.

Third Powerplant Overhaul Project

Third Powerplant Overhaul Project includes work on the six generating units, turbines, shafts, and auxiliary equipment at the Grand Coulee Dam Third Powerplant. The main portion of the overhaul work is being completed within the confines of the third powerplant.

John W. Keys III Pump-Generating Plant Modernization Project

John W. Keys III Pump-Generating Plant Modernization Project at Grand Coulee Dam includes pump-generating and auxiliary equipment. Work will be within the confines of the plant and completed in 2034.

Lower Granite Project Juvenile Facility Bypass Improvements

This action modified the existing bypass system to construct an open channel with increased orifice size, intended to move fish from the collection channel to the existing juvenile fish collection facility. The work is intended to reduce the time fish spend in the system, moving them more quickly and reducing stress and delays. The project includes an enlarged collection channel, flow reduction through the transport channel, improved water supply to the location downstream of the collection channel, and a relocation of the primary outfall to reduce predation. Construction was complete and the system became fully operational in FY 2019.

Lower Granite Project Spillway Passive Integrated Transponder Monitoring System

A passive integrated transponder (PIT)-tag monitoring system was installed over spillbay 1, the location of the removable spillway weir. The system includes a set of antennas mounted in the

surface of the spillway and connected to an electrical transceiver located on the tailrace deck. These antennas support collection of data so numbers of juvenile fish migrating over the spillway can be compared with using the bypass system or other routes. This system was installed in FY 2020.

Little Goose Project Adjustable Spillway Weir Closure

An adjustable spillway weir (ASW) was fabricated and installed in spillbay 1 at Little Goose Dam. The project included a mechanical system to adjust the crest elevation of the spillway to allow juvenile salmon and steelhead to pass the dam near the water surface. This allows operators to adjust quickly to changing conditions, thus increasing the likelihood of juvenile salmon and steelhead survival under the No Action Alternative spill operation.

Little Goose Project Adult Ladder Temperature Improvements

This structural measure includes a 90-foot-deep chimney attached to the face of the dam to pull cool water from lower reservoir elevations and release it into the fish ladder. In the ladder, the cold water mixes with surface water from the forebay to lower water temperatures. The cold water is also sprayed onto the surface water in the forebay to cool water at the ladder exit. This project is intended to keep ladder water temperatures within an acceptable range and prevent delays in fish passage during periods of high water and air temperatures. Construction was completed in FY 2018.

Little Goose Project Boat Barrier

This structure is composed of a set of anchors and lines holding a string of booms and cables in the forebay of the Little Goose Project. It is a safety measure intended to keep boats from approaching the spillway. The cables have bird spikes to keep fish-eating birds off the structure in an attempt to reduce predation in the forebay. Construction was completed in FY 2018.

Little Goose Project Trash Shear Boom Repair

This is a repair of an existing boom. The action included replacement of longitudinal cable to reconnect 20 concrete floats. The floats are 40 feet long and 8 inches wide. This boom is intended to direct debris away from the powerhouse to protect powerhouse infrastructure.

Ice Harbor Project Turbines 1 to 3 Replacement and Generator Rewind¹

The Ice Harbor turbine replacement and rewind will replace existing turbine runner blades on units 1, 2, and 3, with state-of-the-art improved fish passage runners. The project will also rewind the electrical components and replace the distributors. Collectively, these changes will improve hydraulic conditions for fish and increase hydropower generating efficiency. Units 1 and 3 will be replaced with adjustable blades for increased operating flexibility to adjust to changing river conditions. Unit 2 will remain a fixed-blade unit. The turbine replacement is scheduled to be completed in FY 2021, with some turbines being installed sooner than FY 2021.

McNary Project Turbine Replacement

This action includes full replacement of all 14 turbines at McNary with new turbines. This includes replacement of runners, discharge rings, windings, wicket gates, and potential draft tube modifications, pending final design. The replacement will increase reliability, increase generating efficiency, increase hydraulic capacity, and improve hydraulic conditions for fish. The turbine replacement project is presently in its design phase. Construction is expected to be completed within FY 2033.

Adult Passive Integrated Transponder Tag Monitoring System at John Day Project

PIT antennas were installed in both the north and south adult fish ladders during the 2016/2017 winter maintenance period. A PIT detection system at John Day Project will allow biologists to track and monitor adult upstream migration and assist in development of more accurate estimates of adult salmon survival through the CRS.

Bonneville Project Gatewell Orifice Modifications

Biological testing in 2008, 2009, and 2013 showed elevated mortality for juvenile salmon in the gatewells when the units are operating at the upper end of the peak efficiency range (>15

¹ As part of ongoing litigation on the Columbia River System, the Corps, in coordination with Bonneville, is providing information to National Wildlife Federation on certain planned projects at the four lower Snake River dam and reservoir projects through the end of the CRSO EIS process. The four lower Snake River dam and reservoir projects are Ice Harbor, Lower Monumental, Little Goose and Lower Granite. The Corps, in coordination with Bonneville, is providing information on three categories: (1) Capital Hydropower Improvement Projects; (2) Columbia River Fish Mitigation Projects; and (3) Other Non-Power Capital Projects (e.g., navigation). The Capital Hydropower Improvement Project information provided to National Wildlife Federation is available here:

<https://www.bpa.gov/Finance/AssetMgmt/lsrdp/Pages/Lower-Snake-River-Dam-Projects.aspx>.

The Corps' Engineering Regulations provide that the evaluation of alternatives does not include past costs (or benefits) (Engineering Regulation 1105-2-100 Section 2-4). The Corps considers any expenditures, including capital, at any of its dam and reservoir projects that occur prior to completion of the EIS as "sunk" costs, and therefore, these expenditures would not be relevant to a recommendation on whether the dam and reservoir projects should be breached or not. Sunk costs have already been expended and are not material in the evaluation of alternatives that will be implemented after those expenditures have been made. Rather, in evaluating alternatives for the CRSO EIS, the co-lead agencies are evaluating future benefits and costs.

thousand cubic feet per second [kcfs]). This project is to improve juvenile salmon survival in the gatewells at the Bonneville Project's second powerhouse.

OPERATIONS

The CRS is operated for a number of purposes: to reduce flood risk, generate hydropower, provide water for irrigation and water supply, to provide navigation, for recreation, and to meet fish and wildlife purposes. The current operations are described below.

Operations for Flood Risk Management

The CRS is authorized to provide FRM in the Columbia River Basin. It is the responsibility of the Corps and Reclamation to protect the general safety and welfare of the public by managing risks and consequences associated with flooding. The CRS operates storage dams and reservoirs to balance inflow and outflow and meet the authorized purposes. All CRS storage projects generally operate in a coordinated manner to minimize flood consequences in local areas and in the lower Columbia River below Bonneville Project. Operations are developed collaboratively by co-lead agency water managers and are described in the Water Control Manual for each project. Operations may vary from year to year based on forecasted water conditions and are adjusted throughout the year to meet changing conditions caused by weather. A gage located at The Dalles, Oregon, is the reference gage for the Columbia River Basin.

Water managers from the co-lead agencies operate the system to make the best use of flood space (capacity in the reservoirs to store inflows) and flood storage (the actual volume of water stored in a reservoir for future use) across the FRM season. The FRM season includes three operational regimes developed to provide flood protections throughout the Columbia River Basin. These regimes are described in the following paragraphs:

- **Fall Operations: September through December.** Minimal system FRM operations occur during this period, although specific projects have maximum reservoir elevations to meet FRM objectives or other goals and agreements. For example, Albeni Falls meets maximum reservoir elevation in mid-November to provide power generation flexibility, manage winter floods and to protect kokanee spawning incubation. Maximum reservoir elevations are set for the Libby, Hungry Horse, and Dworshak Projects for December.
- **Storage Evacuation Operations: January through April.** During storage evacuation operations, the storage projects are drafted based on precipitation and snow accumulation in the basin in order to prepare for high spring flows and reduce the potential for flooding. The projects operate to a storage reservoir diagram (SRD) that is specific to each reservoir. The SRD describes the minimum flood space requirement for each project and is adjusted monthly based on current water supply conditions.
- **Refill Operations: May through August.** Although CRS reservoir operations generally achieve refill by June 30, the actual refill date may vary depending on the timing and shape of the spring runoff. For example, a late snowmelt runoff may result in a later refill in order to avoid excessive spill. During the refill period, outflow from the reservoir is kept lower

than inflow, allowing the water level in the reservoir to increase and refill. In this manner, the reservoir eventually reaches its refill elevation when flood risk has significantly decreased. FRM refill at Hungry Horse and Libby dams are operated based on variable flow operating criteria. This criterion provides a more normal spring flow regime that benefits listed species and increases the likelihood of full reservoirs and water supplies for summer flow needs.

Fall Operations at the Libby Project

Libby Project typically releases the minimum outflow (4 kcfs) through the month of October in order to maintain the reservoir elevation prior to the start of the FRM draft in November. The maximum elevation requirement for November 30 is elevation 2,448 feet National Geodetic Vertical Datum of 1929 (NGVD29), which allows 0.5 million acre-feet (Maf) of space. However, Libby is often drafted as low as 2,435 feet NGVD29 in November to ensure that the December 31 flood space elevation requirements can be achieved without exceeding the powerhouse capacity at Libby Project.

Downstream Control Points at the Hungry Horse Project

Columbia Falls, Montana, serves as the control point for local FRM operations at the Hungry Horse Project. In 2014, the official flood stage for the Flathead River at Columbia Falls was modified to 13 feet (an approximate flow of 44 kcfs) when the Flathead Lake elevation is in the top 1 foot (elevation 2,892 to 2,893 feet NGVD29). The flood stage is 14 feet (approximately 51 kcfs) when the elevation of Flathead Lake is more than 1 foot below full pool (elevation 2,892 feet NGVD29 or lower).

When the Flathead River at Columbia Falls is at or above flood stage or forecasted to be at or above flood stage, outflows from the Hungry Horse Project will be adjusted as necessary (to a minimum discharge of 300 cubic feet per second) as long as enough space exists in the reservoir to manage remaining runoff. The Hungry Horse Project generally starts reducing discharges when flood stage at Columbia Falls begins to exceed 12.5 feet when flood stage criteria is 13 feet, and 13 feet when flood stage criteria is 14 feet. Depending on the remaining runoff volume and available reservoir space, however, the project may not begin reducing discharges until Columbia Falls reaches levels higher than these criteria.

Allowable Rate of Change of Release at the John Day Project

Safety precautions prohibit sudden changes in flow from the John Day Reservoir during normal operating conditions. However, unusual or emergency conditions may require rapid evacuation of stored water to achieve maximum flood storage space (between 257.0 and 268.0 feet NGVD29). The maximum permissible rate of change in tailwater elevation is 3 feet per hour, which corresponds to a change of approximately 200 kcfs per hour. This restriction is necessary to provide navigation safety at the downstream approach to the navigation lock. The maximum rate of change will not be used on a routine basis due to potentially severe effects on navigation, recreation, and fish, including ESA-listed salmonids.

Operations to Benefit Anadromous Fish

Fish and Wildlife Operations

The CRS is authorized to operate in a manner that provides benefits to fish and wildlife. The co-lead agencies coordinate fish and wildlife management with a number of other Federal, State, and tribal entities. In addition to operations intended to benefit ESA-listed anadromous fish and their designated critical habitat, the co-lead agencies operate the CRS projects to benefit ESA-listed resident fish (e.g., bull trout [*Salvelinus confluentus*] and Kootenai River White Sturgeon [*Acipenser transmontanus*]) and their designated critical habitat. The co-lead agencies, in coordination with NMFS and USFWS, make adjustments in CRS operations based on the best available science, knowledge about current conditions in the system, and any effects from management actions. Under the No Action Alternative, the analysis assumes that the system will continue to be operated for fish and wildlife purposes per the terms of the 2016 Fish Passage Plan and the FOP, both of which are developed annually by the Corps, in coordination with Bonneville, regional Federal, State, and tribal fish agencies, and other partners from the Fish Passage Operations and Maintenance work group. Operations to benefit ESA-listed resident fish are also described. Specific operations for fish and wildlife are designated in the following paragraphs and would continue as described under the No Action Alternative.

Total Dissolved Gas Management

The co-lead agencies use several different methods to manage total dissolved gas (TDG) across the basin, including monitoring, structures, and operations, which are described here. Specific actions are further described in future sections related to operations for fish benefits.

The co-lead agencies implement a TDG monitoring program, with monitoring locations at all 14 CRS projects, as well as the middle Columbia River dams (Wells Dam, Rocky Reach, Rock Island, and Priest Rapids), and other locations on the Snake and Columbia Rivers. The monitoring stations are operated by the Corps, Reclamation, and the Grant and Douglas County Public Utility Districts. Data collected at these locations is used to inform project operations and adjust spill on a real-time basis during fish migration season, and to monitor compliance with state and tribal water quality standards.

Spillway flow deflectors have been installed at all of the 14 CRS projects except at The Dalles and Grand Coulee (see Chapter 3, *Affected Environment and Environmental Consequences*, for further discussion). Flow deflectors are structures that are installed at the base of the spillway. They deflect spillway flows horizontally at the water surface, away from the dam, rather than allowing the water discharged over the spillway to plunge vertically in the stilling basin and increase concentrations of TDG. In addition to flow deflectors, the Corps has installed a training wall at The Dalles to increase survival of juvenile fish that pass over the spillways and limit TDG.

The Corps develops and implements specific spill patterns for each of the lower Snake and lower Columbia projects. These patterns dictate how much water is discharged through each spillway during fish passage season, and are defined in the Fish Passage Plan, developed

annually. The spill patterns are developed to respond to the unique configuration of fish passage facilities, spillways, flow deflectors, and downstream bathymetry at each project. Spill patterns are managed to adapt to changing conditions, such as flow volumes, in the river (see Spill Operations section below).

Flow Augmentation

The Libby, Hungry Horse, Dworshak, and Grand Coulee Projects are managed to provide water for downstream flow augmentation to benefit ESA-listed fish in spring and summer. Spring flow augmentation generally begins in April, after the storage reservoirs have filled to the spring elevation objectives per the annual Water Management Plan for that year² (FRM refill generally runs from December through April). Specific operations and elevations for are outlined in the Water Control Manual for each project. Dworshak operations are described below. These operations would continue under the No Action Alternative.

Storage projects provide summer flow augmentation after refilling to their maximum elevation, usually around the end of June or July. Libby and Hungry Horse summer flow augmentation draft benefits anadromous fish but is also shaped to benefit ESA-listed resident bull trout and other sensitive, native fish species downstream of the projects. The intent is to maintain steady or gradually declining flows until they reach the end of September elevation objectives. Grand Coulee is also drafted to provide summer flow augmentation to benefit ESA-listed salmonids in the Columbia River. Drafts for flow augmentation from Grand Coulee typically begin in July, while summer flow augmentation at the other projects generally begins in either June or July, depending on water supply and stream flow conditions.

Spring and Summer Flow Objectives

The co-lead agencies, in collaboration with NMFS, USFWS, and state and tribal fish and wildlife agencies across the Columbia River Basin, have developed flow objectives for the spring and summer fish passage seasons on the lower Snake and lower Columbia Rivers. These flow objectives are intended to benefit ESA-listed fish. In some years, the flow objectives may not be met throughout the entire migration season because flows in the lower Snake and Columbia Rivers depend on the volume and shape of natural runoff, combined with the flow augmentation volumes. Due to annual water year variability, these volumes may not meet the flow objectives in spite of water managers' efforts to meet them as much as possible.

For the lower Snake River, the spring flow objective is determined by the final April water forecast for Lower Granite Dam; the summer flow objective is determined by the June water forecast. In the lower Columbia River, the flow objectives are determined by the April and June forecasts at The Dalles.

² The water management plan for each year is available at <https://pweb.crohms.org/tmt/>.

Spring and Summer Operations at Dworshak Project

Dworshak Project is operated in the spring to maximize the probability of refilling the reservoir to support summer flow augmentation, and also to provide the flows needed to meet spring objectives in the lower Snake River during the downstream migration of juvenile salmon and steelhead. If both these objectives cannot be achieved, the Technical Management Team (TMT) will make an in-season recommendation, weighing considerations unique to each particular year. During the spring, Dworshak releases approximately 4 to 6 kcfs, if necessary, to help move fish from the Dworshak and Clearwater fish hatcheries, located directly downstream, into the mainstem of the Clearwater River.

Summer flow augmentation provided from Dworshak increases the survival of ESA-listed fish by moderating river temperatures and increasing water velocities in the lower Snake River. During the summer (July and August), the co-lead agencies operate Dworshak to help meet the flow/temperature objectives identified, in coordination with the TMT. The co-lead agencies plan to draft to elevation 1,535 feet NGVD29 by the end of August and elevation 1,520 feet NGVD29 by the end of September each year, unless modified per the agreement between the United States government and the Nez Perce Tribe for water use in the Dworshak Reservoir. Portions of Dworshak Reservoir lie within the exterior boundaries of the Nez Perce Reservation. The extension of the draft limit into September assures water will be released consistent with the Snake River Basin Adjudication Agreement.

Flood Risk Management Shift

Periodically, the co-lead agencies look for opportunities to shift system FRM space requirements from Brownlee Reservoir (owned by Idaho Power) and Dworshak to Grand Coulee from January through April in order to provide more water for flow augmentation in the lower Snake River during spring migration of anadromous fish. The shift allows operators to draft Grand Coulee deeper in the winter in order to keep the Brownlee and Dworshak reservoirs at higher levels. The reservoirs must be back to their specific upper rule curve (URC) by April 30. These shifts are implemented only after coordination with the TMT and are intended to increase the probability for increased spring flows in the lower Snake River. Consideration of these FRM shifts by the Corps and Reclamation will include an analysis of impacts to FRM, and the shift would not occur if FRM would be compromised.

Spill Operations

Planned annual spring and summer spill operations at the lower Snake and lower Columbia River projects are designed to improve downstream fish passage for juvenile salmonids. Spill levels and patterns of spill across the spillways are defined by regional fish managers and agencies in the annual FOP. State agencies, such as Oregon Department of Environmental Quality and Washington State Department of Ecology, each set TDG water quality standards for their respective areas of jurisdiction. The co-lead agencies are required to comply with state water quality standards. In 2016, the co-lead agencies implemented performance standard spill levels for fish passage that did not exceed 120 percent TDG in project tailraces, and 115 percent

TDG in the forebay of the next project downstream. At the lower Snake River projects, spring spill is implemented from April 3 to June 20, and summer spill occurs from June 21 to August 31. At the lower Columbia River projects, spring spill is implemented from April 10 to June 15, and summer spill occurs from June 16 to August 31. Spill would continue at the same levels and timing under the No Action Alternative.

Under certain circumstances, such as during high flow events, the CRS projects may need to release water using the spillways to maintain sufficient storage capacity in the reservoirs for FRM. When this occurs, it is referred to as involuntary spill. When an involuntary spill operation is implemented, the co-lead agencies use the Spill Priority List that establishes the order and amount of spill to be released by the CRS projects. The Spill Priority List is developed in a regional forum and published in each year’s water management plan. Table 2-1 provides the order and cap for spill above the FOP spill levels. The Spill Priority List defines the project priority order for lack-of-load spill in order to manage TDG on a system-wide basis. If necessary, to spill above FOP rates due to lack-of-load, spill will be allocated to projects in the following priority order.

Table 2-1. Spill Priority List

Priority Order	Project	TDG Cap (%)	Example Spill Caps (kcfs)
Level 1 (State TDG Standards^{1/})			
1	LWG	120% / 115%	41
2	LGS	120% / 115%	40
3	LMN (bulk)	120% / 115%	28
4	LMN (uniform)	120% / 115%	36
5	IHR (night)	120% ^{2/}	95 ^{3/}
6	IHR (day)	120% ^{2/}	75 ^{3/}
7	MCN	120% / 115%	146
8	JDA	120% / 115%	90
9	TDA	120% / 115%	135
10	BON	120% ^{2/}	130
11	CHJ	110%	20
12	GCL ^{4/}	110%	OT = 0; DG = 5
13	DWR	110%	30%
Level 2			
14	LWG	120%	45
15	LGS	120%	52
16	LMN (uniform)	120%	44
17	MCN	120%	146
18	JDA	120%	146
19	TDA	120%	135
20	CHJ	120% / 115% ^{5/}	60
21	GCL ^{4/}	115%	OT = 5; DG = 15

*Columbia River System Operations Environmental Impact Statement
Chapter 2, Alternatives*

Priority Order	Project	TDG Cap (%)	Example Spill Caps (kcfs)
Level 3 (Levels 4–7: same order as Level 3)			
22	LWG	122%	52
23	LGS	122%	59
24	LMN (uniform)	122%	60
25	IHR (night)	122%	95 ^{3/}
26	IHR (day)	122%	85 ^{3/}
27	MCN	122%	152
28	JDA	122%	177
29	TDA	122%	160
30	BON	122%	160
31	CHJ	120%	100
32	GCL ^{4/}	120%	OT = 15; DG = 40

Note: This priority list was effective April 1, 2016, until further notice (no later than August 31, 2016). BON = Bonneville; CHJ = Chief Joseph; DWR = Dworshak; GCL = Grand Coulee; IHR = Ice Harbor; JDA = John Day; LGS = Little Goose; LMN = Lower Monumental; LWG = Lower Granite; MCN = McNary; TDA = The Dalles. DG = drum gate; OT = outlet tube.

1/ Apr 1-Aug 31 (FOP Spring and Summer Spill) TDG standards are in effect at LWG, LGS, LMN, IHR, MCN, JDA, TDA, BON for $\leq 120\%$ in the tailrace (Oregon, Washington) and $\leq 115\%$ in next downstream forebay (Washington), except BON which does not have a downstream forebay standard. Current spill caps are online: <http://www.nwd-wc.usace.army.mil/tmt/documents/ops/spill/caps/>.

2/ No downstream forebay standard.

3/ IHR spill caps based on: Night 1800–0500 (11 hours) = FOP spill; Day 0500–1800 (13 hours) = lack of load spill (>FOP Day 45 kcfs).

4/ GCL spill is via OTs or DGs. Transition to DG at forebay elevation 1,267–1,270 feet.

5/ Assumes spill duration ≤ 6 hrs.

Over-capacity spill is another type of involuntary spill and occurs when flows exceed the hydraulic capacity of the available power generation facilities at a specific dam. Over-capacity spill can be affected by high river flows, planned and unplanned unit outages, planned and unplanned transmission outages, and other transmission constraints. Any of these conditions physically limit the potential for hydropower production. Over-capacity spill will generally be the amount of project outflow in excess of the maximum amount that can be released through all available generators and other outlet structures (e.g., sluiceways and fish ladders). In general, when this condition occurs, the affected project will be operating at maximum generation, but within the Fish Passage Plan turbine operating criteria capability to minimize the amount of spill.

Temperature Control

Operations to improve water temperatures to benefit ESA-listed fish are conducted at 11 of the 14 CRS projects. Temperature control operations are conducted to benefit both anadromous and resident fish. Temperature control operations described here benefit anadromous fish and bull trout. Temperature operations to benefit resident fish are described later in this chapter.

During late spring and summer, water is released from lower levels of the Dworshak Reservoir using selective withdrawal gates. The water is used to help cool water temperatures in the lower Snake River downstream of the confluence of the Clearwater and Snake Rivers. These cooler waters improve thermal conditions for bull trout, salmon, and steelhead in the lower Snake River (Cook and Richmond 2004). At the Lower Granite and Little Goose Projects, the cooler water is supplied to fish ladders at the dams to allow upstream migration for adult salmonids.

At the Lower Granite and Little Goose Projects, the forebay tends to stratify, with warm water near the surface and cool water from the Dworshak Project deeper in the water column. When temperatures in the fish ladders are equal to or greater than 68 degrees Fahrenheit (°F), the Corps operates pumps to supply the fish ladders with cool water pumped from deep in the reservoir. The pumps are typically operated from mid- to late summer, depending on climatic conditions.

From June 1 to September 30, water temperature data is collected at adult ladder entrances and exits at each Corps project in the lower Snake and lower Columbia Rivers. This serves to monitor for temperature differentials in the ladder that could act to block adult fish from ascending the fish ladders to migrate upstream of each dam.

Variable Draft Limits

The variable draft limits (VDLs) are end of period draft limits at Grand Coulee and Hungry Horse in January through March. The VDL is not a mandatory draft elevation but rather provides lower limit for hydropower generation flexibility. The VDL defines the lower operating limit based on an inflow probability that would be sufficient to refill Grand Coulee and Hungry Horse to the April 10 elevation objective with 85% and 75% confidence respectively, pursuant to the 2008 NMFS BiOp (NMFS 2008d, 2010b, 2014a) and the Hanford Reach Fall Chinook Protection Program. The VDL elevation calculation does not guarantee 85% and 75% chance of refill but provides flexibility while considering the spring flow objective-based April 10 elevation. Operation above the VDL is desirable but must also not exceed the maximum elevation allowed for FRM.

Minimum Flows and Draft Limitations at Grand Coulee Project

The minimum daily average flow from the Grand Coulee Project is related to the minimum discharge below Priest Rapids Dam, which is owned by Grant County Public Utility District and located on the middle Columbia River. Generally, minimum outflow from Grand Coulee, 30 kcfs, is enough to provide the 36 kcfs minimum discharge required below Priest Rapids Dam.

The current operational draft rate limit for Lake Roosevelt is 1.5 feet per 24 hours, a rate intended to help protect against potential landslides and the erosion caused by rapidly drawing down the reservoir. Bonneville may request an exceedance to this draft rate in order to meet increased power demand (e.g., during a winter cold snap), or the Corps may make a request to

meet FRM requirements. In all cases, draft rate exceedance requests must be approved by Reclamation, and additional monitoring for erosion and landslides is required. Draft rates should not exceed 2 feet per 24 hours even if a draft rate exceedance is granted. Additional monitoring, including aerial surveillance is required when the reservoir is drafting more than 1.5 feet per 24 hours. Monitoring at more frequent intervals is required as the reservoir elevation drops. Below 1,240 feet NGVD29, no draft greater than 1.5 feet in 24 hours should be considered and all other reasonable actions should be exhausted prior to requesting approval from Reclamation for exceedance.

Lake Roosevelt Incremental Storage Release Project

The Lake Roosevelt Incremental Storage Release Project is a component of the Columbia River Water Management Program. It is intended to improve M&I water supply, provide water to replace some groundwater use in the Odessa Subarea, enhance stream flows in the Columbia River to benefit fish, and provide water to interruptible water right holders in drought years. A memorandum of understanding regarding the Lake Roosevelt Incremental Storage Release Project was signed by the State of Washington, Reclamation, and the Columbia Basin Irrigation Districts in December 2004. In December 2007, Water Resource Management Agreements supporting the incremental storage releases from Lake Roosevelt were signed by the State of Washington, the Confederated Tribes of the Colville Reservation, and the Spokane Tribe of Indians.

The Lake Roosevelt Incremental Storage Release Project does not reduce flows during the salmon flow objective period (April through August). This project provides for Lake Roosevelt to be drafted an additional 1.0 foot in non-drought years and up to 1.8 feet in drought years by the end of August. One-third of this water will go to instream flows.

Hanford Reach Fall Chinook Protection Program

Naturally spawning fall Chinook salmon in the Hanford Reach of the Columbia River, which are not listed under the ESA, spawn from October through the third week in November. Similar to the chum operations described below, a minimum flow is set during the spawning period and must be maintained to avoid dewatering redds. Though not listed under the ESA, these fish are an important resource to the region. During spawning, the Hanford Reach Fall Chinook Protection Program Agreement requires that Priest Rapid outflows be no higher than 70 kcfs and no lower than 55 kcfs for a continuous period of at least 12 hours of each day. Grand Coulee is operated to help support the minimum flow required below Priest Rapids Dam. Emergence occurs at the point where the eggs in the redds have accumulated 800 to 1,000 degree-day C temperature units after the initiation of spawning, this typically occurs over a four-week period beginning in April and ending in early May.

Chum Flows and Operations

The Grand Coulee and Bonneville Projects are operated to support chum spawning and protections at the Ives Island complex below the Bonneville Project. There are two phases of

the chum operations: spawning (typically in early November to late December) and incubation/egress (typically from late December to early April). The yearly operation is coordinated through the TMT and described in the annual Water Management Plan and seasonal updates, using the process described in Section 1.9.5, *Annual Planning*.

Grand Coulee is generally operated to refill to elevations between 1,285 and 1,288 feet NGVD29 by the end of October to provide sufficient storage to support the chum spawning operation and winter power generation.

Beginning in November, the Bonneville Project operates to maintain the tailwater elevation in the range of 11.5 feet to 13.0 feet until chum spawning ends in late December. If it becomes necessary to operate the tailwater at elevations above 13.0 feet because of precipitation events, tidal influences, etc.), chum still have the ability to spawn at higher elevations. However, as tailwater elevations increase above 13.5 feet, some habitat in the lower elevations (11.3 feet to 12.0 feet) becomes unsuitable for chum due to higher water velocities. In addition, eggs spawned at higher elevations may risk being dewatered later in the year if there is an insufficient water supply.

After chum spawning is complete in late December, the co-lead agencies coordinate with the TMT to establish the minimum tailwater elevation necessary to protect the incubating eggs until fry have emerged from the gravel, or by April 10, whichever comes first.

Priest Rapids Spring Flow Objective

The Grand Coulee Project is operated from April 10 to June 30 to help meet the spring flow objective at Priest Rapids Dam, a public utility dam in the middle Columbia River. Grand Coulee provides flow to help meet the 135 kcfs flow objective for anadromous salmon and steelhead. If water year conditions do not allow operators to meet the 135 kcfs objective, a flow lower than the objective is used and gradually increased when possible. During dry years, the initial flow typically begins at around 90 kcfs and ramps up incrementally based on the water supply forecast, the timing of the juvenile fish migration, and streamflow conditions.

Turbine Operations

To potentially improve the survival of fish that pass through the powerhouse at a project, turbines at all projects on the lower Snake and lower Columbia Rivers target an operation within ± 1 percent of peak turbine efficiency (referred to as the “1 percent range”) during the juvenile and adult migration seasons, from April 1 to October 31 (Corps 2016a, Chapters 2–9 and Appendix C). This ability to adjust unit operations for optimal performance potentially helps reduce fish injury and cavitation damage to the turbines.

Minimum Operating Pool

The four lower Snake River projects operate to minimize water travel time for juvenile fish migration by operating the forebays in the minimum operating pool (MOP) 1-foot range from

April 3 until approximately September 1. Elevations may be adjusted to meet other authorized project purposes (primarily navigation), however.

Minimum Irrigation Pool

From April 10 to September 30, John Day Project is operated to minimize water travel time for downstream-migrating juvenile salmon by operating the forebay within the minimum irrigation pool (MIP) range (262.5 to 264.0 feet). The MIP is the lowest pool elevation that allows irrigation withdrawals. Irrigation withdrawals from the John Day pool typically begin in early March and extend through mid-November.

The normal operating ranges, MOP elevation ranges, and MIP elevation ranges for the four lower Snake River and four lower Columbia River projects are included here for reference (Table 2-2).

Table 2-2. Operating Range Elevations for the Lower Snake River and Lower Columbia River Projects

Location	Normal Operating Elevation Range (NGVD29) Minimum–Maximum	MOP/MIP Elevation Range (NGVD29) Minimum–Maximum
Lower Granite	733.0–738.0	733.0–734.0
Little Goose	633.0–638.0	633.0–634.0
Lower Monumental	537.0–540.0	537.0–538.0
Ice Harbor	437.0–440.0	437.0–438.0
McNary	337.0–340.0	N/A ^{1/}
John Day	262.0–266.5	262.5–264.0 ^{2/}
The Dalles	155.0–160.0	N/A ^{1/}
Bonneville	71.5–76.5	N/A ^{1/}

Note: N/A = not applicable.

1/ McNary, The Dalles, and Bonneville Projects have no MOP or MIP restriction and operate within Normal Elevation Range.

2/ John Day is restricted by a MIP rather than a MOP.

Juvenile Fish Transportation Program

The Juvenile Fish Transportation Program is implemented by the Corps. Juvenile fish are collected at the Lower Granite, Little Goose, and Lower Monumental Projects for transport via barge or truck. They are moved downriver to a location below Bonneville Project, where they are released to continue their migration to the ocean. Juvenile fish collection starts no later than May 1, and barging begins the day after collection begins. Fish are transported daily or every other day throughout the migration season. Transportation operations may be adjusted due to research, conditions at fish collection facilities (e.g., overcrowding or temperature extremes), or through the adaptive management process with the Fish Passage Operations and Maintenance work group and/or the TMT (e.g., as a response to expected environmental conditions, or recent transport vs. in-river research results). Timing and operations are coordinated with regional fish managers.

Operations to Benefit Resident Fish

Flow Augmentation

Libby is drafted in the summer to benefit resident fish in the Kootenai River and salmonids in the Columbia River. To meet the needs of Kootenai River white sturgeon and bull trout, operations ensure minimum flows in the rivers downstream to support both species and these flows are prioritized over summer refill for recreation. The Hungry Horse Project maintains minimum flows for resident fish. To the extent possible, the intent is to maintain steady or gradually declining summer flows below the project in consideration of resident fish needs.

Temperature Control

At Libby, discharge temperatures are adjusted using a selective withdrawal system to provide thermal conditions in the Kootenai River to promote spawning, migration, and egg and larval development for Kootenai River white sturgeon and burbot, a popular game fish. To the extent possible, natural river conditions for biological productivity are provided.

At the Hungry Horse Project, per an agreement with Montana Fish, Wildlife and Parks (MFWP), selective withdrawal gates are required to be operated from June to the end of September, but are typically operated into November when the reservoir temperatures become uniform and isothermal, and the benefits of the selective withdrawal system operations are negated. The goal is to provide water temperatures to the river to improve productivity for native fish species and prevent non-native lake trout from moving upstream from Flathead Lake.

Sturgeon Operations at the Libby Project

Operations at the Libby Project include the release of flows to benefit Kootenai River white sturgeon. These operations are developed annually by regional biologists (led by USFWS), based on May water supply forecasts described in the 2006 Libby BiOp (as clarified in 2008) (USFWS 2006). Release of this water falls within FRM authorities and is equal to or greater than VarQ (variable discharge) flow.

Libby operates to release tiered Kootenai River white sturgeon flow augmentation volumes to provide for the habitat needs during spawning and recruitment in April, May, June, and July. The intent of sturgeon flow augmentation is to augment lower basin runoff from tributaries of the Kootenai River downstream of the Libby Project. Sturgeon flow augmentation operations are consistent with the current version of the *Kootenai River Ecosystem Function Restoration Flow Plan Implementation Protocol* (Bonneville 2007) and USFWS's 2006 BiOp for the Libby Project (as clarified in 2008) (USFWS 2006).

Lake Pend Oreille Elevations for Kokanee and Bull Trout

Lake elevations at the Albeni Falls Project are managed to support the survival of kokanee, a critical food source for ESA-listed bull trout. During the spring, the project is operated to fill Lake Pend Oreille in accordance with FRM criteria. During the summer, the project is operated

to maintain Lake Pend Oreille at a minimum elevation of 2,062.0 feet NGVD29 for recreation through Labor Day. In recent years, the start of drawdown has been delayed to the third Sunday in September, or September 18, whichever is later. Starting October 1, the project begins drafting to an elevation within a half-foot of 2,051.0 feet NGVD29 by mid-November, prior to when kokanee is expected to begin spawning. Flows released during the draft also support ESA-listed salmon in the Columbia River, particularly chum salmon downstream of Bonneville Project.

Operations to Limit Total Dissolved Gas Production at the Hungry Horse and Chief Joseph Projects

The Hungry Horse Project is operated to minimize spill and the resultant generation of TDG. Although the generation capacity of Hungry Horse Project is about 428 megawatts (MW), there is a transmission limit at the Hungry Horse Project of 310 MW (about 9 kcfs). Releases in excess of approximately 9 kcfs must be put through the hollow jet flow valves, which can generate TDG. Empirical data and estimates show that limiting spill to a maximum of 15 percent of total outflow will help avoid exceeding the Montana State TDG standard of 110 percent saturation. When spill is anticipated to exceed 15 percent of total outflow, Reclamation attempts, to the extent possible, to pre-draft or reshape drawdown and refill operations to minimize spill and excess TDG generation.

In 2008, the Chief Joseph Project was fitted with spillway flow deflectors to reduce levels of TDG downstream of the project when water passes over the spillway. Throughout the year, spill is allocated to the Chief Joseph Project as needed to manage TDG on a system-wide basis to reduce TDG effects to aquatic species, including ESA-listed fish species (see Table 2-1 for the Spill Priority List relative to system-wide TDG management).

HYDROPOWER GENERATION

The CRS projects are authorized to generate hydropower for electricity using large turbines at each of the projects. While the generation of hydropower does not consume water, water must be positioned to enable generation. When power is generated that water is passed from one project to the next or downstream to the ocean. The coordinated water management of the CRS therefore includes managing the amount of water used for hydropower generation. In conjunction with the Corps and Reclamation carrying out project-specific requirements, Bonneville plans system operations to meet both power and non-power objectives and shapes any remaining flexibility to manage water flow for power generation. These plans prioritize BiOp commitments over hydropower. However, in emergency situations or when managing the system to avoid an impending emergency, power system operations can be prioritized to protect human health and safety as well as the safety and reliability of the power grid.

Hydropower generation is based on a variety of factors at each project: the type of project (storage vs. run-of-river), and generator and reservoir capacity at each project. In addition, the future CRS objectives and constraints must be accounted for in determining the distribution of generation in a current period. Storage projects typically release water based on non-power

objectives, such as fish objectives or flood control. When there is flexibility for hydropower, storage projects may hold water until there is a need to generate electricity, whether for a week, a month, or even another season. The amount of electricity generated depends on available storage capacity and overall system flexibility, given other constraints.

The run-of-river projects generate electricity based on inflows, with minimal ability to store water to shape flows. Therefore, these projects also have minimal ability to control the timing of electrical generation. Some generation can be adjusted from one hour to the next, and perhaps to the subsequent day, but long-term storage for later generation is limited.

Both the lower Snake and lower Columbia River projects have minimum generation requirements to support power system reliability. The Corps has identified minimum generation powerhouse outflow values derived from actual generation records when turbines were operating within ± 1 percent of best efficiency. Varying pool elevations or system disturbances may result in minor variations.

All lower Snake and lower Columbia River powerhouses may be required to keep one or more generating units online at all times for power system reliability under low river flow conditions. Low flow operations at lower Snake and lower Columbia River projects are triggered when inflow is not sufficient to meet both minimum generation requirements and planned operations to benefit ESA-listed fish. Under low flow conditions, the lower Snake River projects will operate one turbine at minimum generation and spill the remaining outflow. Minimum generation at the lower Columbia River projects is determined by grid reliability needs and generally require more than one turbine to be operating.

Power System Operation

The amount of electricity generated at the 14 CRS projects depends on a variety of factors, including operational constraints, ESA obligations, regional load,⁴ and river flows. Seasonally, river flow determines when power is generated. For example, peak hydroelectric generation typically coincides with spring runoff, while low flows and low generation generally occur in late summer and fall. Energy supply (including generation, imports, and exports) must equal demand (load) at all times. Bonneville participates in the wholesale electricity market, where they buy and sell electricity to ensure demand and supply on the Federal system are always balanced. Bonneville is a North American Electric Reliability Corporation–registered balancing authority.⁵ As such, Bonneville is responsible for maintaining the balance between generation

⁴ *Load, or demand*, refers to electricity being consumed in the region.

⁵ A balancing authority is the entity responsible for scheduling generation on transmission paths ahead of time, maintaining a load-interchange-generation balance within a balancing authority area, and supporting interconnection frequency in real time. A balancing authority area is the collection of generation, transmission, and loads within the metered boundaries of the designated balancing authority. The balancing authority maintains load-resource balance within this area.

and load within the Bonneville Balancing Authority Area, which includes portions of the states of Washington, Oregon, Idaho, Montana, and California.

Bonneville conducts daily load shaping which means that generation is adjusted to meet load. These adjustments take place day-to-day, hour-to-hour, and even second-to-second. Bonneville uses various CRS projects (when and where there is flexibility within the FRM, environmental responsibilities, and other constraints) to increase and decrease generation to match that demand. Often, if there is not enough flexibility to meet changes in demand, Bonneville augments its generation flexibility with purchases or sales in the wholesale power market for optimized power production, while providing protection for resident fish and maintaining FRM. In some conditions, most often but not exclusively during spring runoff in high-water years, there may be more water flowing through the system than would be ideal for environmental and power needs. In these situations, even after setting some water aside for juvenile fish spill, the generation from that water supply may exceed both the regional demand and the ability to export (sell) the power to other regions like California. This excess power cannot be generated or sold, and some water is spilled for lack of market.

To ensure adequate supply to meet demand, Bonneville sets aside a certain portion of hydropower generation capability to meet its reserves obligation for unexpected increases or decreases in generation or load in the Bonneville Balancing Authority Area. These unexpected changes in generation can come from variable sources such as wind power, sudden generation outages, or transmission constraints.

Bonneville also maintains the transmission grid for safety and reliability. The ability of the transmission system to reliably accommodate generation from the projects may impact water management functions at the projects (e.g., the location and amount of power generation required to maintain system reliability, and the best location to generate to meet the need). Transmission facilities owned and operated by Bonneville interconnect and integrate electric power generated at the Federal projects to the regional transmission grid. Certain transmission system needs can impact water management functions at the projects. For example, Bonneville's management of its transmission system in response to a transmission line outage can influence the location and amount of power generation required to maintain system reliability, which impacts when, where, and through which outlets the co-lead agencies pass river flows at the dams.

At times, the combined output of generation at Libby and Hungry Horse exceeds the ability of the local transmission system to reliably deliver the output of these projects to the wider transmission system. Bonneville has implemented maximum generation limits to maintain stability and meet required standards. Bonneville sets the allowable generation from Libby and Hungry Horse to balance the amount of generation that can be used to both serve load within the Flathead Valley and transfer generation to the wider transmission system at the same time. There could be ongoing variations in allowable generation based on loads in the Flathead Valley that changes throughout the day. Currently, the combined maximum generation limit is 920

MW for heavy load hours and 860 MW for light load hours for the Libby and Hungry Horse Projects.

IRRIGATION AND WATER SUPPLY

Irrigation accounts for most surface water withdrawals in the Columbia River Basin, which is about 5 percent of total river flow.⁶ Annually, about 13 Maf of water, 7 Maf from the rivers considered in this EIS, is supplied for irrigation, drinking water, and other M&I needs. The total acreage in the United States portion of the basin irrigated by Reclamation projects (including the Columbia Basin Project, Chief Joseph Dam Project, and Yakima, Umatilla, The Dalles, Deschutes, upper Snake River, and Crooked River facilities) is about 4.3 million acres. Of this, about 680,000 acres are irrigated from river reaches potentially impacted by changes in operations evaluated in this EIS.

Of the 14 Federal projects included in this EIS, only Grand Coulee (Lake Roosevelt) and John Day have operations specific to water supply purposes. Other CRS projects do supply water for irrigation or M&I purposes, but the other projects are not operated explicitly to provide that water. The irrigation season generally extends from mid-March to November 1, but some water is also pumped through the winter months.

Grand Coulee is the largest water supply provider within the study area. Each year the John W. Keys Pumping Plant can pump up to 3,318 thousand acre-feet of water to Banks Lake for use on 720,000 acres within the Columbia Basin Project (CBP), based on water rights and completed NEPA analyses (Reclamation 2009, 2012b). Under current operations, water is pumped through six pump/generators and six pumps from Lake Roosevelt (behind the Grand Coulee Project), to Banks Lake through the John W. Keys Pumping Plant, located at the left abutment of Grand Coulee Project. Banks Lake then delivers water to the Columbia Basin Project for irrigation and M&I water use.

The Columbia Basin Project Act (57 Statute 14) authorized the Secretary of Interior to construct, operate, and maintain the CBP pursuant to the Reclamation Project Act of 1939. The Secretary subsequently directed Reclamation to construct, operate, and maintain the project in House Document 172 (October 30, 1944), according to the terms of the 1939 Reclamation Project Act. In that report, the Secretary directed Reclamation to provide water for irrigation of up to 1,029,000 acres. Grand Coulee, operated by Reclamation, stores water for the CBP. The water is pumped approximately 300 feet from Lake Roosevelt to Banks Lake where it is distributed by canal to irrigators within the CBP. The CBP currently has water rights and previous NEPA compliance to deliver 3.318 Maf of water for irrigation of 720,000 acres and for M&I purposes. Water for the Odessa Subarea and Lake Roosevelt Incremental Storage agreement are included in the 3.318 Maf.

⁶ Calculated using a 30-year average (1981 to 2010) inflow to The Dalles of 133 Maf (NWRFC 2018) and 7.1 Maf of diversion (Bonneville 2011a).

Odessa Subarea Special Study Project. The need to address declining groundwater supply in the Odessa Subarea, and avoid economic loss to the region's agricultural sector led Reclamation and Washington State Department of Ecology (Ecology) to conduct the Odessa Subarea Special Study. The purpose identified by Reclamation and Ecology to guide the proposed action is: ". . . to maintain economic viability by providing surface water from the CBP to replace groundwater from declining wells currently used for irrigation in the Odessa Subarea." This purpose is consistent with the intent of the CBP Act by encouraging "settlement and development of the project, and for other purposes." Surface water would be provided as part of the continued, phased development of the CBP, and would come from existing CBP diversion and storage water rights from the Columbia River. The Odessa Subarea Special Study was completed in 2012 and the ROD signed in (Reclamation 2012b, 2013).

The lower Snake and lower Columbia River projects also provide water to support irrigation and M&I water supply, which is delivered via a number of pumping stations. This is an incidental use and these reservoirs are not operated specifically to provide water supply of this sort. Operations at John Day on the lower Columbia River are operated specifically to maintain elevations for the operation of water supply pumps.

Maintenance Operations

Routine Maintenance

The co-lead agencies will continue to implement a maintenance program at each CRS project, consisting of routine inspection and maintenance of both power and non-power assets. The co-lead agencies conduct annual routine maintenance at all projects. Preventive and corrective maintenance coordinated and planned to occur at regular intervals is referred to as scheduled, or routine, maintenance. This type of routine maintenance would continue to be performed on all fish facilities, spillway components, navigation locks, generating units, and supporting systems to ensure project safety and reliability and to comply with North American Electric Reliability Corporation/Western Electricity Coordinating Council regulatory requirements.

Unscheduled and Non-Routine Maintenance

Unplanned maintenance is referred to as unscheduled maintenance. It may occur any time a problem, unforeseen maintenance issue, or emergency requires a project feature (e.g., a generating unit), be taken offline in order to resolve. Unscheduled maintenance, if it occurs in combination with ongoing scheduled maintenance, may significantly reduce the generating capability and hydraulic capacity of a project. The timing, duration, and extent of these events cannot be forecasted, however. The co-lead agencies inform regional water managers and fish managers when changes to regular operations are required for unscheduled and/or emergency non-routine maintenance.

Maintenance that is planned but not performed at regular intervals (e.g., turbine unit overhauls, major structural modifications, or rehabilitations) is referred to as non-routine maintenance. Non-routine maintenance is not performed at regular, pre-determined

frequency, and includes tasks more significant in nature than routine scheduled maintenance. These Federal actions would be evaluated under a separate NEPA document. Non-routine maintenance examples include power plant modernization and major rehabilitation of CRS project features. Additionally, any work conducted either by the project operator or Bonneville that takes a powerhouse line out of service will generally affect several generators at one time. These types of outages, planned and coordinated in advance where possible, would continue under the No Action Alternative.

Drum Gate Maintenance at Grand Coulee Project

Reclamation's Operations and Maintenance Program requires annual inspections and dam safety maintenance for the 11 drum gates at Grand Coulee Project. A drum gate is a hinged overflow spill gate at the top of the dam, consisting of a horizontal cylindrical section that can be raised from its compartment to increase the spillway height. Each drum gate is 135 feet long and 30 feet high. Lake Roosevelt must be at or below elevation 1,255 feet NGVD29 for a minimum of 8 weeks in order to complete drum gate maintenance. Drum gate maintenance is scheduled annually during March, April, and May to take advantage of the FRM draft. However, the water conditions in the basin (dry, average, wet), and in-season conditions may affect or delay maintenance activities. To adjust for this uncertainty, and to ensure that the drum gates are maintained, Reclamation requires that, at a minimum, drum gate maintenance must be completed at least one time in a 3-year period, two times in a 5-year period, and three times in a 7-year period. The in-season criteria for accomplishing drum gate maintenance is based on the FRM requirement for the April 30 maximum Grand Coulee elevation as determined by water supply forecasts produced in February.

The February forecast is used to allow sufficient time to draft the reservoir below 1,255 feet NGVD29 by March 15. If the February forecast sets the Grand Coulee April 30 FRM elevation at or below 1,255 feet NGVD29, Grand Coulee will be drafted to perform drum gate maintenance. When the February forecast sets the April 30 FRM requirement above 1,265 feet NGVD29, drum gate maintenance will require a "forced" draft only if needed to meet the requirements of the criteria described in the previous paragraph. If the April 30 FRM requirement is between 1,255 and 1,265 feet NGVD29, maintenance will only be done if the following year would be a "forced" drum gate maintenance year. For example, if maintenance is deferred in one year due to dry conditions and the forecasted FRM elevation is between 1,255 feet and 1,265 feet NGVD29 the next year, drum gate maintenance would be accomplished in the second year in order to avoid "forced" drum gate maintenance in the third year.

In addition to the annual drum gate maintenance, an annual inspection and maintenance activity is planned for the 57-inch butterfly drum gate intake valves. Some inspection and maintenance on these valves can occur regardless of water levels, but some maintenance requires water levels at or below 1,219 feet NGVD29. The external inspection and maintenance that requires water levels at or below 1,219 feet NGVD29, for a week's duration, is scheduled to occur once every 10 years. This inspection takes advantage of spring drafts for FRM, but in

some years may require an additional draft below FRM requirements to conduct this maintenance.

Third Powerplant Overhaul Project

On April 28, 2010, a Finding of No Significant Impact (FONSI) was signed authorizing the third powerplant overhaul and modernization, which includes work on the six generating units, turbines, shafts, and auxiliary equipment at the Grand Coulee Third Powerplant. The main portion of the overhaul work is being completed within the confines of the third powerplant. The Third Power Plant Overhaul Project was updated with a second EIS and FONSI in February 2019. Documents and information regarding the Third Powerplant Overhaul Project are available online (Reclamation 2019f).

John W. Keys III Pump-Generating Plant Modernization Project

On March 12, 2012, a FONSI was signed authorizing the overhaul and modernization of the John W. Keys III Pump-Generating Plant. The main portion of the overhaul work will be completed within the confines of the John W. Keys III Pump-Generating Plant. The overhaul and modernization are scheduled for completion in 2034. Documents and information regarding the modernization are available online (Reclamation 2017b).

Grand Coulee G1 through G18 Modernization and Overhaul Project

Reclamation is implementing this project to modernize and overhaul the power-generating units G1 through G18 in the left and right power houses at Grand Coulee Dam, by refurbishing or replacing key components. Reclamation would maintain current operations for FRM to protect communities and generate hydropower while the project is being implemented. Under the G1 through G18 Modernization and Overhaul Project, current hydrologic operations would be maintained, and, therefore, the project is not expected to have any impacts on water, or fisheries resources in the Columbia River or Lake Roosevelt. Reclamation completed an EA and FONSI in August 2018 for the Grand Coulee G1 through G18 modernization and overhaul (Reclamation 2018a).

Fish Research

Research studies may require special operations that differ from the routine operations otherwise described in the applicable and the current Fish Passage Plan. Variations in normal operations for research actions are coordinated with the TMT.

Coordination with Regional Tribes

Regional tribes participate in the development of fish-related plans such as the Fish Passage Plan and the FOP, and the co-lead agencies coordinate the operation of CRS reservoirs with these tribes. In addition to operations to support anadromous and resident fish and other resources important to the tribes, the co-lead agencies coordinate when CRS operations may directly impact resources or operations of tribally owned or operated facilities (e.g., at the

Dworshak or Grand Coulee Projects). In some cases, the co-lead agencies operate specifically to support tribal activities, such as holding the reservoirs at certain elevations to support tribal fishing in the summer and fall. This is regularly done at the John Day, The Dalles, and Bonneville Projects.

Navigation

The Corps maintains a shallow-draft navigation channel for barge transport, with a minimum depth of 14 feet, on the lower Snake and lower Columbia Rivers. For these projects, water managers in the Columbia River Basin adjust reservoir levels and spill patterns, reduce spill, or implement short-term spill curtailment, as needed to maintain safe navigation on the lower Snake River and lower Columbia River. Annual maintenance of the navigation facilities at the projects takes place in March. Major maintenance of the navigation system, including activities that may cause a temporary outage of barge traffic (e.g., gate maintenance or dredging) is conducted as needed and scheduled based on risk. These extended outages are coordinated regionally to reduce impacts to shippers and minimize economic disruption. Under the No Action Alternative, navigation operations and maintenance and operations for safety will continue.

Recreation

The co-lead agencies operate projects to support recreation in various ways. In some instances, the change in operation might involve holding a specific reservoir at a specific elevation to support a short-term activity (e.g., boat races or weekend festivals). In other locations (Albeni Falls, Dworshak, and Grand Coulee), operations may plan to achieve refill elevations and hold them to support recreation pools over a longer season. Recreation is an authorized purpose of the CRS projects, and the co-lead agencies would continue current operational adjustments to support recreation, as needed, as long as operations do not negatively impact higher priority operations (e.g., FRM or fish and wildlife purposes).

Measures Previously Committed to by the Co-lead Agencies to Benefit Endangered Species Act-Listed Fish

The co-lead agencies have coordinated with regional stakeholders to design and implement several measures to benefit ESA-listed fish species. The majority of these measures originate from USFWS or NMFS BiOp reasonable and prudent alternatives. Measures include construction of habitat projects and are often coupled with research, monitoring, and evaluation (RM&E) efforts to inform trends, successful achievement of benefits and/or next-phase project details. Operational measures include guidelines for extensive regional stakeholder coordination such as annual water management plans and fish passage plans. Measures to benefit ESA-listed fish also include hatchery programs, predator management programs, and nutrient enhancement. Table 2-3 provides specific measures to benefit ESA-listed fish implemented under the No Action Alternative and lists the source of the measure (e.g., reasonable and prudent alternative).

Table 2-3. No Action Alternative Measures to Benefit Endangered Species Act–Listed Fish Species

Measure	Measure Name	Description
Habitat Measures	Tributary Habitat Implementation 2010–2018 for both Chinook salmon and steelhead	Specified construction projects, RM&E actions, and species status and trend data collection habitat and survival improvement
	Kootenai White Sturgeon Habitat Restoration	Implementation of habitat project at a Tier 1 habitat restoration location
	Estuary Habitat Implementation 2010–2019	Specified construction projects, RM&E actions, and species status and trend data collection habitat and survival improvement
	Kootenai River White Sturgeon Nutrient Enhancement	Continued BPA support of nutrient enhancement in the Kootenai River through FY 2025
	Dworshak Reservoir Long-Term Nutrient Supplementation Program	Continued nutrient enhancement in the Dworshak Reservoir to enhance biological productivity of the reservoir for kokanee and reduction of algal blooms.
Operational Measures	Storage Project Operations (Upper Columbia Basin)	Develop Annual Water Management Plan and Fish Operations Plan for flow to aid juvenile fish passage
	Lower Columbia and Snake River Operations	Develop Annual Water Management Plan and Fish Operations Plan for flow to aid juvenile fish passage
	Sturgeon Operations at the Libby Project	Ongoing, seasonal flow augmentation from Libby Dam for Kootenai River white sturgeon, consistent with the Flow Plan Implementation Protocol; Real-Time Management
	Kootenai River Operations for Bull Trout	Libby Dam minimum flow to aid bull trout
	In-Season Water Management	Seasonal updates to the Annual Water Management Plan
	Operational Emergencies	Real-Time Management for unforeseen events
	Fish Emergencies	Real-Time Management for unforeseen events coordinated with Regional Forum
	Dry Year Operations	Real-Time Management when a dry water year is declared
	Water Quality Plan for TDG and Water Temperature	Maintain Water Quality Plan for TDG and water temperature in the mainstem Columbia and Snake Rivers
	Chum Spawning Flow	Coordination of operations via the TMT; Real-Time Management
	Turbine Unit Operations	Operate turbine units to achieve best fish passage survival (operate within 1 percent of best efficiency)
	Spill Operations to Improve Juvenile Passage	Define, and adjust within season, juvenile fish passage spill within the Annual Fish Operations Plan and Fish Passage Plan; Real-Time Management
	Juvenile Fish Transportation in the Columbia and Snake Rivers	Collect and transport juvenile fish from three Snake River dams to below Bonneville Dam per Annual Fish Operations Plan and Fish Passage Plan; Real-Time Management
	Fish Passage Plan	The Corps develops an Annual Fish Passage Plan

*Columbia River System Operations Environmental Impact Statement
Chapter 2, Alternatives*

Measure	Measure Name	Description
Hatcheries	Federal Columbia River Power System (FCRPS) Mitigation Hatcheries – Programmatic	Continue support of hatcheries and adopt programmatic criteria for funding decisions on mitigation programs for the FCRPS that incorporate best management practices
	Kootenai River White Sturgeon Conservation Aquaculture	Continued Bonneville support of hatchery-raised Kootenai River white sturgeon for supplementation of lack of wild, natural recruitment
	Implement Safety Net Programs	Continue to identify and plan for ongoing “safety net” programs to provide benefits to ESA-listed stocks at high risk of extinction
	Conservation Programs to Build Genetic Resources	Continue to fund conservation programs that assist in recovery
Predator Management Measures	Northern Pikeminnow Management Program	Ongoing base program and general increase in northern pikeminnow sport-reward fishery reward structure
	Reduce Caspian Terns on East Sand Island in the Columbia River Estuary	Annual site preparations and hazing/dissuasion to maintain 1.0 acre of suitable habitat at East Sand Island and prevent birds from establishing satellite colonies outside of 1.0-acre colony site
	Double-Crested Cormorant	Plan implementation completed March 2019. Annual hazing ongoing with limited egg-take to maintain colony size objectives, as necessary.
	Inland Avian Predation	Plan implementation concluded in 2018. Ongoing monitoring of tern colony during nesting season through 2021 breeding season.
	Other Avian Deterrent Actions	Monitor avian predator activity, continue avian deterrent programs at all lower Snake and Columbia River dams. Part of annual Fish Passage Plan .
	Marine Mammal Control Measures	Install and improve, as needed, sea lion excluder gates at all main adult fish ladder entrances at Bonneville Dam annually
Habitat Program	Lower Snake River Fish & Wildlife Compensation Plan	Congress authorized the LSRCP as part of the Water Resources Development Act of 1976 (90 Stat. 2917) to offset fish and wildlife losses caused by construction and operation of the four lower Snake River dams. A major component of the authorized plan was the design and construction of fish hatcheries and satellite facilities. Administered through the USFWS, the 26 LSRCP hatcheries and satellite facilities are operated by IDFG, Washington Department of Fish and Wildlife, Oregon Department of Fish and Wildlife, USFWS, the Nez Perce Tribe, Confederated Tribes of the Umatilla River, and Shoshone-Bannock Tribes. The LSRCP hatcheries and satellite facilities produce and release more than 19 million salmon and steelhead as part of the program's mitigation responsibility. Bonneville directly funds USFWS for the annual operation and maintenance of these LSRCP facilities. The Corps also provides annual funding to implement other components of the LSRCP such as the management units for upland and riparian habitat (woody riparian initiative), a game bird farm, and other ongoing habitat management at locations across the lower Snake River basin.

Note: IDFG = Idaho Department of Fish and Game.

Bonneville's Fish and Wildlife Program and Direct Funding Agreements with the Corps and Reclamation

Bonneville's Fish and Wildlife Program funds hundreds of projects each year to mitigate the impacts of the development and operation of the Federal hydropower system on fish and wildlife. Bonneville began this program to fulfill mandates set by Congress in the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Northwest Power Act), 16 United States Code (U.S.C.) § 839b(h)(10)(A), to protect, mitigate, and enhance fish and wildlife affected by the development and operation of the FCRPS. Bonneville's fish and wildlife program originated as a response to fulfilling the mitigation mandates established in 1980 by the Northwest Power Act. See, Section 4(h)(10)(A), 16 U.S.C. § 839b(h)(10)(A). The statute frames Bonneville's responsibilities in several specific ways. To begin, the mitigation responsibilities apply to fish and wildlife of the Columbia River Basin and the habitat that they rely on within the basin. There is no responsibility to any specific state or tribe, only to fish (not "fisheries") and wildlife. The mandate requires protection, mitigation, and enhancement; therefore, "restoration" or "recovery" is not required to comply with the Northwest Power Act.⁷ Bonneville's mitigation efforts, funded by its ratepayers, apply to fish and wildlife impacts from the Federal Columbia River Power System dams, and thus the CRS. Other hydroelectric projects, and mitigating for their impacts, are the responsibility of their owners and operators.

Under Section 4(h)(10)(A) of the Northwest Power Act, Bonneville's mitigation efforts must be "consistent with" the Council's fish and wildlife program, its power plan, and the purposes of the Act. Through the Act, Congress created a balance between Bonneville and the Council to ensure that the Council, as an interstate compact agency, "cannot bind the United States in any way, manner or form." Representative John Dingell, 126 Cong. Rec. H10682 (daily ed. Nov. 17, 1980). The Council guides but does not direct Bonneville; Bonneville has the final authority to determine how to act consistently with the program. *NW Resource Info. Ctr. v. NW Power Planning Council*, 35 F.3d. 1371, (9th Cir. 1994). The Act does not require Bonneville to implement each and every goal, objective, or measure in the Council's fish and wildlife program or any measure in particular. Rather, the Administrator must protect, mitigate, and enhance fish and wildlife in a way that is compatible with the Council's program as a whole, and with the power plan, and the Act's purposes.

The Northwest Power Act states Congress' intent that the purposes of the Act "are also intended to be construed in a manner consistent with applicable environmental laws." 16 U.S.C. § 839. Therefore, Bonneville implements many of its ESA compliance responsibilities using Northwest Power Act authorities. In this regard, it is worth noting that neither the ESA nor the Northwest Power Act sets a floor, ceiling, or baseline for the other. Such a suggestion is misplaced because, among other things, it invites circular reasoning: the fish and wildlife program developed actions in the 1980s under the Northwest Power Act, and those were

⁷ Indeed, even the Council has long recognized the difference between the mitigation required under the Act and restoration. See Council, 1982 Columbia River Basin Fish and Wildlife Program p. 2-2 <http://www.nwcouncil.org/fw/program/1982-program/>.

incorporated into biological opinions in the 1990s and 2000s, while other ESA actions were, in turn, integrated into subsequent amendments to the fish and wildlife program, and so on. It is more accurate to say that while each of these statutes has its own distinct substantive standards and objectives, sometimes actions taken to comply with one may prove helpful, if not essential, in complying with the other.

Each year Bonneville funds projects, consistent with the Northwest Power and Conservation Council's program, with many local, state, tribal, and Federal entities to fulfill its Northwest Power Act fish and wildlife responsibilities and to implement offsite mitigation actions listed in various BiOps for ESA-listed species. Offsite protection and mitigation actions typically address impacts to fish and wildlife not caused directly by the CRS, but they are actions that can improve the overall conditions for fish to help address uncertainty related to any residual adverse effects of CRS management. For example, Fish and Wildlife Program funding improves habitat in the mainstem as well as tributaries and the estuary, builds hatcheries and boosts hatchery fish production, evaluates the success of these efforts, and improves scientific knowledge through research. This work is implemented through annual contracts, many of which are associated with multi-year agreements like the Columbia River Basin Fish Accords, the Accord extensions, or wildlife settlements.

In its role under the Northwest Power Act, the Northwest Power and Conservation Council develops a program of measures to protect, mitigate, and enhance fish and wildlife, including related spawning grounds and habitat, on the Columbia River and its tributaries. Measures in the Council's program guide Bonneville's implementation of fish and wildlife mitigation projects. In their management and operation of the CRS, Bonneville, the Corps, and Reclamation have together fulfilled the other primary fish and wildlife mitigation mandate in the Northwest Power Act, providing fish and wildlife "equitable treatment" with the other congressionally authorized purposes of the FCRPS (16 U.S.C. § 839b(h)(11)(A)(i)). Since the 1990s, the Federal agencies have overhauled the system, achieving juvenile dam passage survival that meets or exceeds performance standards of 96 and 93 percent for spring and summer migrants, respectively,⁸ a marked improvement as compared to when Congress passed the Act and the estimated average juvenile mortality at each mainstem dam and reservoir project was 15 to 20 percent, with losses recorded as high as 30 percent.⁹ Travel time also improved for yearling Chinook and juvenile steelhead through the system, even in low flow years such as 2015 (NMFS 2016g, 20). And, total in-river survival has improved for migrating juvenile salmon and steelhead. Comparing two time periods, 1997–2007 and 2008–2016, reported in the National Oceanic and Atmospheric Administration's reach study (Faulkner et al. 2017), there has been a 10 percent survival increase for hatchery and wild sockeye salmon, a 2 percent increase in hatchery and wild Chinook (4 percent for wild), and a 25 percent survival increase for hatchery and wild steelhead (13 percent for wild).

⁸ See Endangered Species Act Federal Columbia River Power System 2016 Comprehensive Evaluation – Section 1, at 17, t.2 (Jan. 2017).

⁹ See *Nw. Res. Info. Ctr. v. Nw. Power Planning Council*, 35 F.3d 1371, 1374 (9th Cir. 1994) (citing the U.S. General Accounting Office, *Impacts and Implications of the Pacific Northwest Power Bill*, at 22 (Sept. 4, 1979)).

The Federal agencies achieved these results by installing turbine intake screens and bypass systems, modifying spillways (e.g., flow deflectors, surface spill weirs, and modified surface spill structures), and installing improved fish passage turbines while also experimenting with and adjusting flow and spill regimes to benefit salmon, steelhead, and sturgeon. Additional modifications to fish ladders have also been underway to increase passage of adult lamprey, including the installation of specialized lamprey passage structures at Bonneville, The Dalles, and McNary Dams. These structural and operational improvements help fulfill ESA and Clean Water Act mandates while also harkening back to one of the original purposes of the Northwest Power Act—to mitigate for fish by providing suitable environmental conditions that are substantially obtainable from the management, operation, and configuration of the system (16 U.S.C. § 839(6)).

Habitat actions

Bonneville works with states, tribes, and watershed groups to protect, mitigate, and enhance spawning and rearing habitat, targeting factors that limit fish survival throughout the Columbia River Basin. Bonneville has funded hundreds of projects across the basin to restore natural stream channels, reconnect estuarine tidal channels, enhance flow volume and timing, and expand cold water refuges and open access to habitat (www.cbfish.org). These habitat improvement actions provide both near-term and long-term benefits to anadromous and resident species, including bull trout and westslope cutthroat trout, including those that will help address the effects of climate change. Actions that improve connectivity and streamflow will provide a buffer against the effects of climate change.

In addition to habitat improvement actions, Bonneville works with willing landowners to protect land by putting it under permanent conservation easement to further support habitat and fish conservation in the short and long term.

Hatchery actions

Bonneville constructed and now funds the operation and maintenance of over 20 compensation, conservation, and supplementation hatchery programs throughout the Columbia and Snake River basins to preserve, rebuild, and reduce extinction risk for ESA-listed fish species as well as to meet Northwest Power Act objectives to protect, mitigate, and enhance fish and wildlife affected by the FCRPS. The conservation hatchery programs help rebuild and enhance the naturally reproducing ESA-listed fish in their native habitats using locally adapted broodstock, while maintaining genetic and ecologic integrity, and supporting harvest where and when consistent with conservation objectives. These hatchery programs include captive propagation for critically endangered Snake River sockeye, Snake River spring/summer Chinook supplementation, Snake River fall Chinook supplementation, reintroduction of spring Chinook in the Okanogan Basin, coho salmon reintroduction and supplementation in the middle and upper Columbia basins, reconditioning of middle and upper Columbia and Snake River steelhead kelts, Kootenai River white sturgeon, burbot, and westslope cutthroat trout.

Predation

Bonneville’s Fish and Wildlife Program funds efforts to address the mortality of ESA-listed and non-listed fish caused by predators including birds, fish, and mammals. Certain types of fish in rivers are voracious consumers of juvenile salmon and steelhead. Predation by introduced fish species in reservoirs is also a concern. Other predators are known to consume substantial numbers of adult spring Chinook salmon and winter steelhead below Bonneville Dam, and injure adult fish that migrate upstream. Bonneville funds projects to reduce the impact of these predator species on native fish.

Lamprey

Several lamprey species, both anadromous and resident, are native to the Columbia River Basin, which historically supported productive populations. Much of the research and mitigation effort in the basin is currently focused on the anadromous Pacific lamprey due to its cultural importance to tribes and vital role in the ecosystem. At present, Bonneville funds six lamprey projects to improve understanding of Pacific lamprey status and limiting factors, implement high-priority habitat restoration actions, increase populations through reintroduction and translocation efforts, and conduct artificial propagation research with plans to release hatchery juveniles in select areas pending an environmental assessment.

Wildlife Mitigation for Construction, Inundation, and Operations

When the CRS dams were built and the reservoirs behind them filled, they inundated about 308,996 acres, much of it important fish and wildlife habitat. To calculate the area affected by CRS development—dam construction and inundation by the reservoirs behind them—Bonneville relied on either the amounts agreed upon in negotiated mitigation agreements with state and tribal entities or the loss assessments prepared by Federal, state, and tribal wildlife managers.¹¹

To date, Bonneville has implemented numerous wildlife habitat projects to address the impact of the development of the FCRPS, many of which included acquisition and permanent protection of wildlife habitat. Bonneville also provides operations and maintenance funding for these projects.

The loss assessments relating to dam construction and inundation considered all habitat losses up to and including full reservoir pool levels. As such, mitigation for those losses can also serve to address the effects of reservoir operations on wildlife habitat, to the extent that such

¹¹ Bonneville funded but did not control the production of wildlife habitat loss assessments by wildlife managers in the mid-1980s and early 1990s. These documents, also called “Brown Books,” are on file with Bonneville. The Brown Books generally reflect the acres inundated by the FCRPS as determined by the surface area of the reservoirs created behind each dam (e.g., USFWS 1990).

operational impacts occur below full pool level. Bonneville continues to work with project sponsors to address any remaining, unmitigated operational impacts.

While much of the mitigation work was implemented through annual contracts, Bonneville and its partners negotiated “settlement agreements” to complete the wildlife mitigation for construction and inundation impacts, and some operational impacts, for Dworshak, Libby, Hungry Horse and part of the impacts from the Albeni Falls Dams. These settlements allowed Bonneville and the affected states or tribes to agree on an appropriate amount of mitigation to be done and the funding or other consideration Bonneville would provide.

- **Albeni Falls Dam.** In the 2018 Albeni Falls Dam Wildlife Mitigation Agreement, Bonneville and the State of Idaho established that 14,087 acres had been mitigated through the efforts of the state and three tribes to address wildlife impacts from the construction and inundation of the dam (6,617 acres were impacted as a result of the construction and inundation of Albeni Falls Dam) (State of Idaho and Bonneville 2018, Section II.C, p. 5). In addition, Bonneville agreed to fund the State of Idaho to protect and enhance 1,279 acres of wetland habitat at the Clark Fork Delta and an additional 99 acres at the Priest River Delta to address the upriver effects of Albeni Falls operations. This is in addition to the 624 acres of wetland protected and enhanced on the Clark Fork Delta by IDFG, which was funded by Bonneville through a letter agreement in 2012.
- **Dworshak Dam.** The 1992 Dworshak Wildlife Mitigation Agreement with the State of Idaho and the Nez Perce Tribe, frequently referred to as the “Dworshak Settlement,” fully mitigated the impacts to wildlife from the construction and inundation of Dworshak Dam estimated at 16,970 acres (Hansen and Meuleman 1988). To determine this acreage, Bonneville relied on the Dworshak Wildlife Agreement reports from the tribe. The tribe’s 2018 annual report indicates it has purchased 7,576 acres and still has over \$9.5 million remaining in its mitigation fund established under the agreement (Nez Perce Tribe 2018). The State of Idaho also has a \$3 million fund provided by Bonneville to manage the 60,000-acre Peter T. Johnson Unit of the Craig Mountain Wildlife Management Area (formerly known as Craig Mountain), which Bonneville purchased and transferred to the State of Idaho (IDFG 2014a). All told, Bonneville has already funded 67,576 acres of mitigation for Dworshak Dam.
- **Montana Dams.** As with Dworshak, Bonneville fully addressed the construction and inundation mitigation for wildlife occurring around Libby and Hungry Horse dams using a comprehensive long-term agreement. To determine acreage protected, Bonneville relied on reports from MFWP. Under the 1989 Montana Wildlife Mitigation Trust Agreement (MFWP 2013), Montana has protected or enhanced 272,104 acres (the Northwest Power Planning Council’s program called for a total of 55,837 acres for Libby and Hungry Horse Dams split between 29,171 acres of enhancement and 26,666 acres of protection) (Yde and Olsen 1984, cited in Wood 2009; NPCC 1987, 138–139 Table 4; MFWP 2019).

Direct Funding Agreements with the Corps and Reclamation

In addition to Bonneville's fish and wildlife mitigation described above, there are also fish and wildlife mitigation costs that are direct funded by Bonneville to the Corps and Reclamation for mitigation activities, such as hatchery operations, fish stocking, elk habitat maintenance, and others. The specifics of these programs are described below.

Lower Snake River Compensation Plan

In addition to the hatchery operations that are funded through the Fish and Wildlife Program, Bonneville directly funds the annual operations and maintenance of the LSRCP. Congress authorized the LSRCP as part of the Water Resources Development Act of 1976 (90 Stat. 2917) to offset fish and wildlife losses caused by construction and operation of the four lower Snake River dams. A major component of the authorized plan was the design and construction of fish hatcheries and satellite facilities. The LSRCP is administered through the USFWS. The LSRCP hatcheries and satellite facilities produce and release more than 19 million salmon and steelhead as part of the program's mitigation responsibility. Corps also provides annual funding to implement other components of the LSRCP such as the management units for upland and riparian habitat (woody riparian initiative), a game bird farm, and other ongoing habitat management at locations across the lower Snake River basin. LSRCP would be continued, consistent with the No Action Alternative, under all of the Multiple Objective Alternatives except for MO3.

U.S. Army Corps of Engineers' Columbia River Fish Mitigation Program

The Columbia River Fish Mitigation Program is the Corps' construction account for studying, designing, and constructing new anadromous fish passage improvements at CRS dams. Nearly all fish passage improvements required for compliance with past Biological Opinions issued by the NMFS have been constructed, and few new anadromous fish improvements requiring construction have been identified. Therefore it is assumed that for CRS dams, requirements for new construction will be completed within the next 10 years.

Examples of Columbia River Fish Mitigation Program-funded activities include installing turbine intake screens and bypass systems, modifying spillways (e.g., flow deflectors, surface spill weirs, and modified surface spill structures), and installing improved fish passage turbines. Additional modifications to fish ladders have also been underway to increase passage of adult lamprey, including the installation of specialized lamprey passage structures at Bonneville, The Dalles, and McNary dams.

Columbia River Tributary Habitat Program

Reclamation has a Columbia-Snake salmon program to help meet its ESA obligations for its two projects, Grand Coulee and Hungry Horse. The program funds, designs, and implements tributary habitat improvements for anadromous fish, including lamprey, in specified Columbia River sub-basins. This program also provides funds avian predation management.

2.4.3 Multiple Objective Alternative 1

MO1 was developed to integrate actions that would benefit both juvenile and adult life stages of ESA-listed anadromous fish, as well as measures to benefit ESA-listed resident fish. At the same time, this alternative incorporates measures for water management flexibility, hydropower production, and additional water supply.

MO1 differs from the other alternatives by carrying out a juvenile fish passage spill operation referred to as a block spill design. The block spill design alternates between a base operation that releases surface flow, where juvenile fish are most present, over the spillways using different flows at each project versus the same target at all projects. For the block that uses the same target at all projects, the operators would release flow through the spillways up to a target of no more than 120 percent TDG in the tailrace of projects and 115 percent TDG in the forebay of those projects. In addition, MO1 sets the duration of this juvenile fish passage spill to end based upon a fish count trigger rather than a predetermined date. MO1 proposes to initiate transport operations for juvenile fish approximately 2 weeks earlier than under the No Action Alternative.

After establishing the juvenile fish passage spill measure, MO1 incorporated measures to increase hydropower generation flexibility in the lower basin projects and use stored water at Dworshak for downstream water temperature control in the summer. MO1 then includes measures similar to the other action alternatives, which include increased water management flexibility, water supply, opportunities for disruption of ESA-listed fish predators, and optimize inclusion of local forecasts for upper basin projects into whole-basin planning.

All measures included in MO1 are listed in Table 2-4, and a brief description of those measures is contained in the following section.

Table 2-4. Measures of Multiple Objective Alternative 1

Measure Description	Abbreviated Measure Name
Structural Measures	
Construct additional powerhouse surface passage routes at McNary and Ice Harbor Dams	Additional Powerhouse Surface Passage
Upgrade spillway weirs to ASWs	Upgrade to Adjustable Spillway Weirs
Improve adult ladder passage through modification of adult trap at Lower Granite Dam	Lower Granite Trap Modifications
Modify the upper ladder serpentine flow control ladder sections at Bonneville Dam	Modify Bonneville Ladder Serpentine Weir
Install pumping systems to provide deeper, cooler water in adult fish ladders at Lower Monumental and Ice Harbor Dams	Lower Snake Ladder Pumps
Expand network of LPSs to bypass impediments	Lamprey Passage Structures
Modify turbine cooling water strainer systems to safely exclude Pacific lamprey	Turbine Strainer Lamprey Exclusion
Modify turbine intake bypass screens that cause juvenile lamprey impingement	Bypass Screen Modifications for Lamprey

*Columbia River System Operations Environmental Impact Statement
Chapter 2, Alternatives*

Measure Description	Abbreviated Measure Name
Modify existing fish ladders, incorporating lamprey passage features and criteria	Lamprey Passage Ladder Modifications
Install improved-fish passage turbines at John Day	Improved Fish Passage Turbines
Operational Measures	
<i>Fish Passage</i>	
Operate spill to evaluate latent mortality hypothesis; alternate base spill and spill cap 120/115 percent TDG	Block Spill Test (Base + 120/115%)
Modify summer juvenile fish passage spill operations to end based on fish collection numbers	Summer Spill Stop Trigger
Change start of juvenile fish transportation during spring juvenile fish passage spill operations	Early Start Transport
Allow contingency reserves to be carried within juvenile fish passage spill	Contingency Reserves Within Juvenile Fish Passage Spill
<i>Water Management</i>	
Modify Libby draft and refill operations when water supply forecast is 6.9 Maf or less	Modified Draft at Libby
Eliminate end-of-December variable draft at Libby and replace with single draft target	December Libby Target Elevation
Update the upstream Storage Corrections Method as applied to the Grand Coulee SRD	Update System FRM Calculation
Decrease the Grand Coulee Dam draft rate used in planning drawdown	Planned Draft Rate at Grand Coulee
Operational constraints for ongoing Grand Coulee maintenance of power plants	Grand Coulee Maintenance Operations
Develop draft requirements/assessment approach to protect against rain-induced flooding	Winter System FRM Space
<i>Water Supply</i>	
Increase volume of water pumped from Lake Roosevelt during annual irrigation season	Lake Roosevelt Additional Water Supply
Increase water managers' flexibility to store and release water from Hungry Horse Reservoir	Hungry Horse Additional Water Supply
Increase water diversion from the Columbia River for the Chief Joseph Dam Project	Chief Joseph Dam Project Additional Water Supply
<i>Hydropower</i>	
Increase forebay operating range flexibility at the lower Snake River and John Day projects for hydropower generation flexibility.	Increased Forebay Range Flexibility
<i>Other Operational</i>	
Implement modified timing of Lower Snake Basin reservoir draft for additional cooler water	Modified Dworshak Summer Draft
Implement sliding scale summer draft at Libby and Hungry Horse	Sliding Scale at Libby and Hungry Horse
Manipulate lower Columbia reservoir elevations to disrupt juvenile salmonid predator reproduction	Predator Disruption Operations

2.4.3.1 Multiple Objective Alternative 1 Description of Measures

STRUCTURAL MEASURES

Construct additional powerhouse surface passage routes at Ice Harbor and McNary Dams

This measure will be referred to as “Additional Powerhouse Surface Passage” throughout the remainder of this EIS. This measure would reestablish the operation of existing ice and trash sluiceways for fish passage, which had been ceased to accommodate updated fish collection procedures. To implement this measure, existing bulkheads would be replaced with telescoping weirs. This would also require modifications to the existing juvenile fish facility and to the floor elevation at McNary Project. Operation of these sluiceways would divert 8 kcfs from the powerhouse at McNary. The diversion at Ice Harbor would amount to 4 kcfs from the powerhouse. The surface passage would be used March 1 to August 31.

Upgrade existing spillway weirs to adjustable spillway weirs

This measure will be referred to as “Upgrade to Adjustable Spillway Weirs” throughout the remainder of this EIS. This measure would replace those existing spillway weirs that are not adjustable with adjustable spillway weirs, which will provide better operational flexibility based on river flows. Two dams, McNary and John Day, would receive the upgrades. One weir would be upgraded at McNary and two weirs would be upgraded at John Day. This measure would contribute to meeting objective 1 to improve passage for ESA-listed juvenile anadromous fish.

Improve adult ladder passage through modification of adult trap and adult trap bypass loop at Lower Granite Dam

This measure will be referred to as “Lower Granite Trap Modifications” throughout the remainder of this EIS. This measure would reconfigure the existing adult trap bypass at the Lower Granite Project to reduce the height that adult fish must ascend, reduce deployment of the main fish ladder diversion gate, and to use a vacuum tube to move adult fish that are handled for monitoring and research at the trap. This measure would contribute to meeting objective 2 to improve passage for adult ESA-listed anadromous fish.

Modify the upper ladder serpentine flow control ladder sections at Bonneville Project

This measure will be referred to as “Modify Bonneville Ladder Serpentine Weir” throughout the remainder of this EIS. This measure would modify the upper serpentine flow control fish ladder sections at the Bonneville Project, converting them to a vertical slot style fishway. The existing baffles at the project’s Bradford Island and Washington Shore fish ladders would be replaced with baffles that have vertical slot orifices for fish passage. This measure is intended to benefit adult fish passage and would contribute to meeting objective 2 for adult ESA-listed anadromous fish.

Install pumping systems to provide deeper, cooler water in adult fish ladders at Lower Monumental and Ice Harbor Projects

This measure will be referred to as “Lower Snake Ladder Pumps” throughout the remainder of this EIS. This measure would install pumping systems for the fish ladders at the Lower Monumental and Ice Harbor Projects. The pumps would pull water from elevations deep in the reservoir to provide cooling water to fish ladders and at fish ladder entrances to reduce thermal barriers to adult fish passage for adult salmon migrating upstream. This measure would contribute to meeting objective 2 to improve adult ESA-listed anadromous fish migration.

Expand network of lamprey passage structures to bypass impediments in existing fish ladders

This measure will be referred to as “Lamprey Passage Structures” throughout the remainder of this EIS. Existing fish ladders at the John Day and Bonneville Projects would be modified with additional structures to make upstream passage easier for lamprey. The structures may be an aluminum slot or tunnel that lamprey would use to travel an alternate but parallel route along the existing fish ladder. The lamprey passage structures would use an independent water source and employ flow velocities that attract lamprey to the alternative route. These structures would be constructed as follows:

At the Bonneville Project, additional lamprey passage structures would be installed in two locations: on the Bradford Island ladder (south ladder) and at the Washington Shore fish ladder (north ladder).

At the John Day Project, a lamprey passage structures would be constructed on the south fish ladder and the existing lamprey passage structures on the north ladder would be extended from the tailrace deck to the forebay.

This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Modify turbine cooling water strainer systems to safely exclude Pacific lamprey

This measure will be referred to as “Turbine Strainer Lamprey Exclusion” throughout the remainder of this EIS. This measure would install structures to prevent juvenile lamprey and all other fish from being entrained into the turbine unit cooling water source. A hood would be installed over the existing intake grating and allow sweeping flows to move fish past the opening, making entrainment unlikely, and keeping all fish out of the cooling water piping. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Modify turbine intake bypass screens that cause juvenile lamprey impingement

This measure will be referred to as “Bypass Screen Modifications for Lamprey” throughout the remainder of this EIS. This measure would replace existing fish screens used to divert fish into the collection channel of the juvenile bypass system. The co-lead agencies would replace existing extended-length bar screens with submerged traveling screens to reduce juvenile

lamprey entanglement at the McNary, Little Goose, and Lower Granite Projects. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Modify existing fish ladders, incorporating lamprey passage features and criteria

This measure will be referred to as “Lamprey Passage Ladder Modifications” throughout the remainder of this EIS. This measure would modify existing fish ladders at the lower Snake and lower Columbia River projects as follows:

- **Install ramps to salmon orifices at Bonneville Project** Install concrete or aluminum ramps in the fish ladder to make salmon orifices elevated above the fish ladder floor more accessible to lamprey. A ramp would enable adult lamprey to more easily and directly access the salmon passage openings by removing right angles at the approach.
- **Install diffuser grating plating at Bonneville Project (south and Cascade Island ladders), The Dalles (north ladder), and Lower Monumental (north and south ladders)** Install a solid stainless-steel plate over the floor diffuser grating within the existing fish ladder. The diffuser adds water to the fish ladder to increase flows in the ladder, but existing grating and water velocities make it difficult for lamprey to pass through the wall passage orifices. This plating would provide an attachment surface for lamprey to attach and rest as they swim upstream through the fish ladder.
- **Install additional refuge boxes at Bonneville Project** Construct metal refuge boxes on the floor of the fish ladder to provide a protected resting environment for lamprey migrating upstream. Additional refuge boxes would be installed in the Washington shore and Bradford Island fish ladders.
- **Install a wetted wall in the fish ladder at Bonneville Project** Install a metal wall in the serpentine section of the Washington shore fish ladder at Bonneville Project (similar to that already installed in the Bradford Island ladder). This would provide an alternate upstream passage route for migrating adult lamprey and allow the lamprey to escape the higher water velocities in the fish ladder.
- **Install entrance weir caps at McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite** Round edges at fish ladder entrance weirs to eliminate 90-degree surfaces, which hinder lamprey from entering fish ladders on the lower Snake projects and at McNary. Rounding these edges would provide lamprey a constant attachment surface to overcome the high water velocities encountered at the entrance of the fish ladders. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Install improved fish passage turbines at John Day

This measure will be referred to as “Improved Fish Passage Turbines” throughout the remainder of this EIS. This measure would install improved fish passage (IFP) turbines at the John Day Project to improve hydraulic conditions for fish passing through the turbines. These IFP turbines are designed to improve hydropower turbine efficiency and hydraulic conditions

for fish passing through the turbines, similar to the IFP turbines at the Ice Harbor Project. The existing 16 turbines would be replaced two at a time over a period of approximately 8 to 12 years. This measure would contribute to meeting objectives 4 and 5 by installing new turbines for an efficient and reliable power supply that minimizes greenhouse gas emissions, indirectly improve water quality by reducing TDG. Because the turbines are designed to minimize negative impacts to fish passing through the powerhouse, it would also contribute to meeting objective 1, which strives to improve passage and survival for ESA juvenile anadromous fish.

OPERATIONAL MEASURES

Operate spill test to evaluate latent mortality hypothesis; alternate base spill and spill cap 120/115 percent TDG

This measure will be referred to as “Block Spill Test (Base + 120/115%)” throughout the remainder of this EIS. This measure is to operate the lower Snake River and lower Columbia River projects in a manner that allows comparison of two different fish passage spill operations by alternating between a base spill operation and a test spill operation. The details of the two spill operations are contained in Table 2-5. The base spill would be implemented first in year one, and the test block operations implemented first the following year. These operations would be implemented annually from April 3 to June 20 for the lower Snake River projects and from April 10 to June 15 for the lower Columbia River projects. The block spill operations would exchange specific dates biannually while holding overall spill dates constant. This measure would contribute to meeting objective 1, as it is intended to improve passage for ESA-listed anadromous fish.

Table 2-5. Juvenile Fish Passage Spill Measure for Multiple Objective Alternative 1

Location	Spring Base Spill Operation: (Volume/Percent of Total Flow Routed to Spillway)	Spring Test Spill Operation: (Volume/Percent of Total Flow Routed to Spillway)
Lower Granite	20 kcfs	120/115% Gas Cap ^{1/}
Little Goose	30%	120/115% Gas Cap ^{1/}
Lower Monumental	120/115% Gas Cap ^{1/}	120/115% Gas Cap ^{1/}
Ice Harbor	30%	120/115% Gas Cap ^{1/}
McNary	48%	120/115% Gas Cap ^{1/}
John Day	32%	120/115% Gas Cap ^{1/}
The Dalles	40%	120/115% Gas Cap ^{1/}
Bonneville	100 kcfs	120/115% Gas Cap ^{1/}

1/ 120/115% Gas Cap spill is spill to the maximum level that meets, but does not exceed, the TDG criteria allowed under state law in 2017. Co-lead agencies would manage juvenile fish passage spill on a daily 24-hour basis. Implementation of the daily spill averaging would facilitate integration of renewable power, including solar and wind power.

Modify summer juvenile fish passage spill operations to end based on fish collection numbers

This measure will be referred to as “Summer Spill Stop Trigger” throughout the remainder of this EIS. The existing spill regime at the lower Snake and lower Columbia River projects would

be modified to curtail fish passage spill when fish collection numbers at the projects remain below 300 juvenile fish for four consecutive days. This has potential to end summer spill at one or more of the lower Snake River projects as early as August 1, and all spill operations would cease by August 31. This operation would begin annually June 21, and end when the criteria described here is met. This measure would modify current spill operations, which are undertaken to improve ESA-listed juvenile fish passage. Thus, it contributes to meeting objective 1.

Change start of juvenile fish transportation during spring juvenile fish passage spill operations

This measure will be referred to as “Early Start Transport” throughout the remainder of this EIS. The transport of juvenile salmon collected at the Lower Granite, Little Goose, and Lower Monumental Projects would begin on April 15, approximately 2 weeks earlier than current fish transport operations described in the No Action Alternative, to potentially increase the total number of juvenile fish transported. Transport operations would end September 30 at Lower Monumental and October 31 at Lower Granite and Little Goose. Collected juvenile fish would be transported to a location below the Bonneville Project via barge or truck on a daily or every-other-day schedule, depending on the numbers of fish collected at the collector projects. This measure was developed to contribute to meet objective 1, which is intended to improve survival and passage of ESA-listed juvenile anadromous fish.

Allow contingency reserves to be carried within juvenile fish passage spill

This measure will be referred to as “Contingency Reserves Within Juvenile Fish Passage Spill” throughout the remainder of this EIS. This measure would allow operations to change fish spill for short durations during fish passage spill season. The change would be implemented to meet energy demands that are caused by unexpected events such as transmission interruption or the failure of a generator. These events are rare and, when they occur, the co-lead agencies may be able to cover the contingencies without temporarily reducing spill. This measure would provide operating flexibility to allow Bonneville to carry required reserves on the turbines to ensure grid reliability. This measure would be implemented at all lower Snake River and lower Columbia River projects during the fish spill season. This measure would contribute to meeting objective 4 to provide an adequate, efficient, and reliable power supply.

Modify Libby draft and refill operations when water supply forecast is 6.9 Maf or less

This measure will be referred to as “Modified Draft at Libby” throughout the remainder of this EIS. This measure would base the date for initiation of refill of Lake Kootenai on the local forecast of water volume in the Kootenai River Basin of the CRS during lower water years, rather than on the No Action Alternative practice of initiating refill based upon water volume forecast in the lower Columbia River at The Dalles. This would modify water operations at Libby to provide water managers more flexibility to respond to local conditions in the upper basin. The measure would change flow management so that local flood durations and the start of refill operations are tied to Kootenai Basin runoff. The new procedure will also take into consideration other planned releases for resources such as resident fish.

This measure would provide more flood space for local high spring flow, and lower the risk of filling the reservoir early, which can result in a need to spill to create more flood space before the end of the FRM operations season. This measure was developed to contribute to meet objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions. As this operation is implemented, adjustments to provide more space in the reservoir may be made in coordination with interested parties if new information emerges about nutrient flushing and temperature impacts that could not be captured with the current modeling tools.

Eliminate end-of-December variable draft at Libby and replace with single draft target

This measure will be referred to as “December Libby Target Elevation” throughout the remainder of this EIS. This measure would change current operations at Libby from a variable draft implemented at the end of December to a fixed draft target of elevation 2,420 feet NGVD29 to prevent over-drafting of the reservoir in years that have less precipitation than forecasted. In most years, this operation would allow the reservoir draft to be shifted from November/December to January/February, holding more water in the reservoir longer to meet demand in drier years, and providing flexibility for water managers to adapt to a wide range of runoff conditions throughout the water year. It would support delivery of nutrients and water temperatures that support sturgeon during the sturgeon flow augmentation operation. This measure was developed to contribute to meet objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Update the upstream Storage Corrections Method as applied to the Grand Coulee Storage Reservoir Diagram

This measure will be referred to as “Update System FRM Calculation” throughout the remainder of this EIS. This measure would change the end-of-month maximum flood space elevation of Lake Roosevelt at Grand Coulee based on whether the storage reservoirs upstream of Grand Coulee had drafted to reach their required flood space elevations at the end of the months of January, February, March, and April. If one or more upstream storage reservoirs were unable to draft down to their required flood space elevations at the end of each of those months, then Lake Roosevelt would be used to provide additional flood storage space for the CRS. This measure differs from the No Action Alternative by allowing the Grand Coulee Project to better respond to changing conditions in the upstream storage reservoirs. There would be no change to the current level of FRM, but rather, a shift in where flood space is held. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Decrease the Grand Coulee Project draft rate used in planning drawdown

This measure will be referred to as “Planned Draft Rate at Grand Coulee” throughout the remainder of this EIS. This measure would change the way that Lake Roosevelt is drawn down

to reach flood space elevations in winter and spring at Grand Coulee. Under the proposed operation, the reservoir drawdown would begin earlier, and the reservoir elevations would be lowered more slowly in order to reduce the risk of landslides along the shoreline. The current rate would be reduced in the Planned Draft Rate at Grand Coulee from 1 foot per day to 0.8 feet per day. Ultimately, the deepest lake elevations for system FRM are not changed by this measure, but the timing and rate for reaching those lower reservoir elevations would change. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Operational constraints for ongoing Grand Coulee maintenance of power plants

This measure will be referred to as “Grand Coulee Maintenance Operations” throughout the remainder of this EIS. This measure would expedite the maintenance schedule for the power plants and spillways of the Grand Coulee Project relative to the No Action Alternative schedule. The maintenance on the power plants would reduce the number of units available, requiring additional spill in some situations. The project would keep 27 of the 40 regulating gates and/or eight drum gates in service and take the others out of service to perform spillway maintenance activities at an accelerated rate. The expedited maintenance schedule has the potential to complete maintenance activities sooner; this could increase reliability and hydraulic capacity through powerplants while decreasing the risk of unplanned maintenance that often leads to non-fish passage spill. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions. This measure would also contribute to meeting objective 4 to provide a reliable power supply by supporting maintenance of the turbines at Grand Coulee.

Develop draft requirements/assessment approach to protect against rain-induced flooding

This measure will be referred to as “Winter System FRM Space” throughout the remainder of this EIS. This measure would increase flood space in Grand Coulee by 650,000 acre-feet to protect against rain-induced flooding downstream. In order to provide the necessary space, Grand Coulee would be drafted more deeply from mid-December through March. All other existing winter operations described in the No Action Alternative would remain the same. This measure is intended to increase operational flexibility to maintain flood risk protection for the lower Columbia River. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Increase volume of water pumped from Lake Roosevelt during annual irrigation season

This measure will be referred to as “Lake Roosevelt Additional Water Supply” throughout the remainder of this EIS. This measure would deliver 4,472,138 acre-feet of water, the amount of water required to irrigate the full number of authorized acres for the CBP, by increasing the amount of water pumped from Lake Roosevelt for irrigation and M&I water supply. This is an

increase of 1,154,138 acre-feet over current withdrawals. This water volume could be delivered annually, generally during the irrigation season (April through October), from Lake Roosevelt at Grand Coulee, as the demand arises. Additionally, this measure would change the timing of delivery of recently developed water supplies for the Odessa Subarea of the CBP (164,000 acre-feet for irrigation and 15,000 acre-feet for M&I of the current supplies) from September and October to when the water is needed, on demand. This measure would contribute to meeting objective 7 to meet existing water supply obligations and provide for additional authorized regional water supply.

Increase water managers' flexibility to store and release water from Hungry Horse Reservoir

This measure will be referred to as "Hungry Horse Additional Water Supply" throughout the remainder of this EIS. This measure would change water management operations at Hungry Horse to ensure that an additional 90,000 acre-feet of water is available for delivery annually to fulfill the water rights settlement with the Confederated Salish and Kootenai Tribes. Operations would prioritize maintaining enough water to meet flow augmentation requirements and the delivery of 90,000 acre-feet of water to the Confederated Salish and Kootenai Tribes for irrigation and M&I purposes, as outlined in the settlement. This measure would contribute to meeting objective 7 to meet existing water supply obligations and provide for additional authorized regional water supply.

Increase water diversion from the Columbia River for the Chief Joseph Dam Project

This measure will be referred to as "Chief Joseph Dam Project Additional Water Supply" throughout the remainder of this EIS. This measure would prioritize annual delivery of 9,600 acre-feet of irrigation water to the Chief Joseph Dam Project. Deliver the full congressionally authorized amount of water for the irrigation of lands downstream of Chief Joseph Dam using water from the Chief Joseph Project. This measure would contribute to meeting objective 7 to meet existing water supply obligations and provide for additional authorized regional water supply.

Increase forebay operating range flexibility at the lower Snake River and John Day Projects for hydropower generation flexibility

This measure will be referred to as "Increased Forebay Range Flexibility" throughout the remainder of this EIS. This measure would provide operating flexibility during the fish passage season (April 3 to August 31) by changing the operating elevation range restriction at the lower Snake and John Day projects. The lower Snake projects would operate within a 1.5-foot MOP range, and John Day would operate within a 2-foot MIP range (262.5 to 264.5 feet NGVD29), except from April 1 to May 31 when the John Day forebay operating range would remain between elevations 263.5 and 265 feet NGVD29. This operating range restriction would end when spill is reduced or ends. Safety-related restrictions would continue, including, but not limited to, maintaining ramp rates to minimize shoreline erosion and maintain power grid reliability. This measure is intended to increase flexibility for water management, shaping hydropower production to meet energy demand and maintain power grid reliability. This

measure would contribute to meeting objective 4, with the goal of providing an adequate, efficient, economical, and reliable power supply that supports the Columbia River power system.

Implement modified timing of the lower Snake Basin reservoir draft for additional cooler water

This measure will be referred to as “Modified Dworshak Summer Draft” throughout the remainder of this EIS. This measure would alter the current draft schedule at Dworshak to provide more cooling water in the lower Snake River to benefit migrating adult salmonids at different times than described in the No Action Alternative. The draft would be tied to water temperatures from year to year, but generally, drafting from Dworshak Reservoir would begin June 21 to August 1 for migrating sockeye salmon and summer Chinook. The later draft (September 1 to September 30) would provide cooling water for fall Chinook and steelhead. This measure would contribute to meeting objective 2, which is intended to improve passage and migration for adult ESA-listed anadromous fish.

Implement a sliding-scale summer draft at Libby and Hungry Horse

This measure will be referred to as “Sliding Scale at Libby and Hungry Horse” throughout the remainder of this EIS. The trigger for summer draft from the Libby and Hungry Horse Projects for downstream fish will be changed from a system forecast point to a local forecast point. The Libby and Hungry Horse Projects would be operated based on local water supply conditions to allow water managers more flexibility to balance local resident fish priorities in the upper basin with downstream flow augmentation for the middle and lower basin. In addition, the change in draft elevation would occur over a range, a “sliding scale,” rather than an abrupt point when the water supply forecast changes. This measure would contribute to meeting objective 3 to improve resident fish survival and spawning success at CRS projects.

Manipulate lower Columbia River reservoir elevations to disrupt juvenile salmonid predator reproduction

This measure will be referred to as “Predator Disruption Operations” throughout the remainder of this EIS. This measure would manipulate reservoir elevations on the John Day Reservoir to disrupt avian nesting on islands in the reservoir. The action would dissuade colonies of species known to consume high numbers of outmigrating juvenile salmon and steelhead from nesting. The measure would allow water managers to fluctuate pool elevations between 263.5 and 265 feet NGVD29, a 1.5-foot operating range, during the months of April and May. This measure would contribute to meeting objective 1, intended to improve the survival and passage of ESA-listed juvenile anadromous fish.

2.4.4 Multiple Objective Alternative 2

MO2 was developed to increase hydropower production and reduce regional greenhouse gas emissions while avoiding or minimizing negative impacts to other authorized project purposes

and co-lead agency missions. It would slightly relax the No Action Alternative's restrictions on operating ranges and ramping rates to evaluate the potential to increase hydropower production efficiency and increase operators' flexibility to respond to changes in power demand and changes in generation of other renewable resources. The measures within MO2 would increase the ability to meet power demand with hydropower production during the most valuable periods (e.g., winter, summer, and daytime peak demands). The upper basin storage projects would be allowed to draft slightly deeper, up to 10 feet below URC values (Appendix I, *Hydroregulation*, modeling data sheets), allowing more hydropower generation in the winter and less during the spring.

MO2 also differs from the other alternatives by excluding the water supply measures and evaluating an expanded juvenile fish transportation operation season. This alternative proposes to transport all collected ESA-listed juvenile fish for release downstream of the Bonneville Project by barge or truck and reducing juvenile fish passage spill operations to a target of near 110 percent TDG. Inclusion of the target near 110 percent TDG spill operation provides the lowest end of the range of juvenile fish passage spill operations evaluated in this EIS.

Structural measures of MO2 are aimed at benefits for ESA-listed fish and lamprey. These measures are similar to other alternatives and include making improvements to adult fish ladders, upgrading spillway weirs, adding powerhouse surface passage, and turbine upgrades at John Day. A brief description of the measures contained in MO2 are provided in Table 2-6 and listed below.

Table 2-6. Measures of Multiple Objective Alternative 2

Measure Descriptions	Abbreviated Measure Name
Structural Measures	
Install improved fish passage turbines at John Day	Improved Fish Passage Turbines
Construct powerhouse and/or spill surface passage routes at John Day, McNary, and Ice Harbor Dams	Additional Powerhouse Surface Passage
Cease installation of fish screens at Ice Harbor, McNary, and John Day Projects	Fewer Fish Screens
Upgrade spillway weirs to ASWs	Upgrade to Adjustable Spillway Weirs
Install pumping systems to provide deeper, cooler water in adult fish ladders at Lower Monumental and Ice Harbor Dams	Lower Snake Ladder Pumps
Expand network of LPSs to bypass impediments	Lamprey Passage Structures
Modify turbine cooling water strainer systems to safely exclude Pacific lamprey	Turbine Strainer Lamprey Exclusion
Modify turbine intake bypass screens that cause juvenile lamprey impingement	Bypass Screen Modifications for Lamprey
Modify existing fish ladders, incorporating lamprey passage features and criteria	Lamprey Passage Ladder Modifications
Operational Measures	
<i>Fish Passage</i>	
Limit fish passage spill to near 110 percent TDG	Spill to 110% TDG

*Columbia River System Operations Environmental Impact Statement
Chapter 2, Alternatives*

Measure Descriptions	Abbreviated Measure Name
Juvenile fish transportation at Lower Granite, Little Goose, Lower Monumental, and McNary to Bonneville Dam to begin April 25 and end Aug. 31 at McNary, end September 30 at Lower Monumental, and October 31 at Little Goose and Lower Granite	Increase Juvenile Fish Transportation
Allow contingency reserves to be carried within juvenile fish passage spill	Contingency Reserves Within Juvenile Fish Passage Spill
<i>Water Management</i>	
Modify Libby draft and refill operations when water supply forecast is 6.9 Maf or less	Modified Draft at Libby
Eliminate end-of-December variable draft at Libby and replace with single draft target	December Libby Target Elevation
Update the upstream Storage Corrections Method as applied to the Grand Coulee SRD	Update System FRM Calculation
Decrease the Grand Coulee Dam draft rate used in planning drawdown	Planned Draft Rate at Grand Coulee
Operational constraints for ongoing Grand Coulee maintenance of power plants	Grand Coulee Maintenance Operations
Develop draft requirements/assessment approach to protect against rain-induced flooding	Winter System FRM Space
<i>Hydropower</i>	
Ramping rate limitations at all projects will be defined only for safety or engineering	Ramping Rates for Safety
At the four lower Snake River projects, operate within the full reservoir operating range year-round	Full Range Reservoir Operations
At John Day, allow project to operate up to full pool except as needed for FRM	John Day Full Pool
The storage projects may be drafted slightly deeper for hydropower	Slightly Deeper Draft for Hydropower
Operate turbines across their full range of capacity year-round	Full Range Turbine Operations
Zero generation operations may occur on lower Snake River projects November through February	Zero Generation Operations
<i>Other Operational</i>	
Implement sliding scale summer draft at Libby and Hungry Horse Dams	Sliding Scale at Libby and Hungry Horse

2.4.4.1 Multiple Objective Alternative 2 Description of Measures

STRUCTURAL MEASURES

Improved Fish Passage Turbines

This measure is the same as described in MO1. This measure would contribute to meeting objectives 4 and 5 by installing new turbines for an efficient and reliable power supply that minimizes greenhouse gas emissions. Because the turbines are designed to minimize negative impacts to fish passing through the powerhouse, it would also contribute to meeting objective 1, which strives to improve passage and survival for ESA juvenile anadromous fish.

Additional Powerhouse Surface Passage

This measure is the same as described in MO1, though it also includes the John Day Project. This measure would contribute to meeting objective 1 to improve passage for ESA-listed juvenile anadromous fish.

Cease installation of fish screens at Ice Harbor, McNary, and John Day Projects

This measure will be referred to as “Fewer Fish Screens” throughout the remainder of this EIS. This measure would potentially cease installation of fish screens to increase the efficiency of hydropower turbines at the Ice Harbor, McNary, and John Day Dams once IFP turbines are installed. This measure is intended to consider running the new IFP turbines unscreened if warranted biologically similar to the process implemented once turbines were replaced at the first powerhouse at Bonneville Dam. The co-lead agencies would collaborate with NMFS and USFWS to develop a Turbine Intake Bypass Screen Management and Future Strategy process to monitor success of the improved fish passage turbines and determine when best to remove fish screens at these projects.

Upgrade to Adjustable Spillway Weirs

Removal of fish screens would make hydropower production more efficient. Thus, this measure would contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply.

Lower Snake Ladder Pumps

This measure is the same as described in MO1. This measure would contribute to meeting objective 2 to improve adult ESA-listed anadromous fish migration.

Lamprey Passage Structures

This measure is the same as described in MO1. This measure would contribute to meeting the objective to improve conditions for pacific lamprey.

Turbine Strainer Lamprey Exclusion

This measure is the same as described in MO1. This measure would contribute to meeting the objective to improve conditions for pacific lamprey.

Bypass Screen Modifications for Lamprey

This measure is the same as described in MO1. This measure would contribute to meeting the objective to improve conditions for pacific lamprey.

Lamprey Passage Ladder Modifications

This measure is the same as described in MO1. This measure would contribute to meeting the objective to improve conditions for pacific lamprey.

OPERATIONAL MEASURES

Limit fish passage spill to 110 percent TDG

This measure will be referred to as “Spill to 110% TDG” throughout the remainder of this EIS. This measure would decrease spill for juvenile fish passage from the current operational levels, and limit fish passage spill to near the 110 percent TDG levels, as measured in-river (including tailraces and downstream forebays), except when minimum spill levels are higher, including spill needed for the powerhouse surface passage routes, for the spillway weirs, and/or for adult attraction to fish ladders. These operations would be implemented at the four lower Snake River and the four lower Columbia River projects. Spill during high flow and flood events would not be constrained to a cap of 110 percent TDG, but would be set to levels necessary to ensure public safety. Lack of market spill would follow the spill priority list set by TMT. These spill operations would be implemented annually beginning April 3 at the lower Snake River projects and April 10 at the lower Columbia River projects. Juvenile fish passage spill at all projects would cease at midnight July 31 each year. This measure would improve hydropower production, and thus, contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply.

Juvenile fish transportation at Lower Granite, Little Goose, Lower Monumental, and McNary Dams down to Bonneville Dam April 25 to August 31

This measure will be referred to as “Increase Juvenile Fish Transportation” throughout the remainder of this EIS. This measure would transport all juvenile fish that enter juvenile fish bypasses at Lower Granite, Little Goose, Lower Monumental, and at the powerhouse surface passage facility at McNary for release below Bonneville Dam. Juvenile salmon would be transported by barge or by truck, and transport would be conducted from April 25 to August 31 at McNary, and extend through September 30 at Lower Monumental, and October 31 at Little Goose and Lower Granite. This would extend the current juvenile transport season, starting slightly earlier than the No Action Alternative, and ending at a fixed end date, which is later in the summer than current transport operations. This measure would contribute to meeting objective 1 and is intended to benefit ESA-listed juvenile anadromous fish.

Contingency Reserves Within Juvenile Fish Passage Spill

This measure is the same as described in MO1. This measure would contribute to meeting objective 4 to provide an adequate, efficient, and reliable power supply.

Modified Draft at Libby

This measure is the same as described in MO1. This measure was developed to meet objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

December Libby Target Elevation

This measure is the same as described in MO1, but the target elevation is 2,400 feet, not 2,420 feet NGVD29. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Update System FRM Calculation

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Planned Draft Rate at Grand Coulee

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Grand Coulee Maintenance Operations

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions. This measure would also contribute to meeting objective 4 to provide a reliable power supply by supporting maintenance of the turbines at Grand Coulee.

Winter System FRM Space

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Ramping rate limitations at all projects will be defined only for safety or engineering

This measure will be referred to as “Ramping Rates for Safety” throughout the remainder of this EIS. This measure would provide operational flexibility for hydropower generation by applying ramping rates only for safety or engineering purposes (e.g., erosion in the tailrace), relaxing all other ramping rate constraints such as those implemented to benefit fish and wildlife. This would allow operators to change flow operations within a 24-hour period to meet

changes in hydropower demand. The measure would apply at all 14 CRS projects. This measure would contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply, by allowing additional flexibility to generate hydropower.

At all four lower Snake River projects, operate within the full reservoir operating range year-round

This measure will be referred to as “Full Range Reservoir Operations” throughout the remainder of this EIS. This measure would allow the four lower Snake River projects (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor) to operate within their full normal operating range to provide greater flexibility to meet demand for hydropower generation. This would remove the current requirement that the projects operate within a 1-foot MOP range during fish passage season (April through August). This measure would contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply that supports the integrated Columbia River power system.

At John Day, allow project to operate up to full pool, except as needed for flood risk management

This measure will be referred to as “John Day Full Pool” throughout the remainder of this EIS. This measure would remove current restrictions on seasonal pool elevations at the John Day Project, allowing more operating flexibility for hourly and daily shaping of hydropower generation. The measure would allow for operation of the reservoir across the full range possible, between 262.5 and 266.5 feet NGVD29 all year, except as needed for FRM. By providing additional operating flexibility this measure would contribute to meeting objective 4 for an adequate, efficient, economical, and reliable power supply.

The storage projects may be drafted slightly deeper for hydropower

This measure will be referred to as “Slightly Deeper Draft for Hydropower” throughout the remainder of this EIS. This measure would provide slightly more operational flexibility (up to 10 feet below URC values [Appendix I, *Hydroregulation*]) for hydropower generation by relaxing restrictions on seasonal pool elevations at the storage projects (Libby, Hungry Horse, Albeni Falls, Grand Coulee, and Dworshak). The operations in this measure would allow deeper drafting of the FRM pool to meet hydropower demand. This measure would contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply that supports the integrated Columbia River power system.

Operate turbines across their full range of capacity year-round

This measure will be referred to as “Full Range Turbine Operations” throughout the remainder of this EIS. This measure would lift the requirement to operate hydropower turbines within 1 percent of peak efficiency during fish passage season at the lower Snake and lower Columbia projects: Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. This would allow the turbines to operate across the full range

of their generating capacity and provide more flexibility to generate hydropower to meet demand. Removing the limitation would allow more water to pass through the turbines during periods of high flow, potentially reducing TDG levels in the river. This measure would contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply that supports the integrated Columbia River power system.

Zero generation operations may occur on lower Snake River projects November through February

This measure will be referred to as “Zero Generation Operations” throughout the remainder of this EIS. This measure would allow the lower Snake River projects to cease hydropower generation when there is little demand, unless limited by grid stability requirements. Currently, these projects are allowed to operate at zero generation mid-December through mid-February. This measure would extend that period to begin in September and extend through March. This would allow operators to save water in low-demand periods to use during high-demand periods in order to meet demand for hydropower. This measure would contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply that supports the integrated Columbia River power system.

Sliding Scale at Libby and Hungry Horse

This measure is the same as described in MO1. This measure would contribute to meeting objective 3 to improve resident fish survival and spawning success at CRS projects.

2.4.5 Multiple Objective Alternative 3

MO3 was developed to integrate actions for water management flexibility, hydropower production, and water supply with measures that would breach the four lower Snake River dams (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor). In addition to breaching these four projects, MO3 differs from the other alternatives by carrying out a juvenile fish passage spill operation that sets flow through the spillways up to a target of no more than 120 percent TDG in the tailrace of the four lower Columbia River projects (McNary, John Day, The Dalles, and Bonneville). The alternative also proposes an earlier end to summer juvenile fish passage spill operations than the No Action Alternative. Instead, flows would transition to increased hydropower production when low numbers of juvenile fish are anticipated.

Structural measures in this alternative include breaching the four lower Snake River dams by removing the earthen embankment at each dam location, resulting in a controlled drawdown.

Operational measures in MO3 are intended to improve juvenile fish travel times, improve conditions for resident fish in the upper basin, increase hydropower generation flexibility, provide more flexibility to water managers, and provide additional water supply.

A brief description of the measures contained in MO3 is listed in Table 2-7 and the following paragraphs.

Table 2-7. Measures of Multiple Objective Alternative 3

Measure Descriptions	Abbreviated Measure Name
Structural Measures	
Construct additional powerhouse and/or spill surface passage routes at McNary Dam	Additional Powerhouse Surface Passage
Cease installation of fish screens at McNary Dam and John Day	Fewer Fish Screens
Upgrade spillway weirs to ASWs	Upgrade to Adjustable Spillway Weirs
Modify the upper ladder serpentine flow control ladder sections at Bonneville Dam	Modify Bonneville Ladder Serpentine Weir
Expand network of LPSs to bypass impediments	Lamprey Passage Structures
Modify turbine cooling water strainer systems to safely exclude Pacific lamprey	Turbine Strainer Lamprey Exclusion
Modify turbine intake bypass screens that cause juvenile lamprey impingement	Bypass Screen Modifications for Lamprey
Modify existing fish ladders, incorporating lamprey passage features and criteria	Lamprey Passage Ladder Modifications
Install improved fish passage turbines at John Day	Improved Fish Passage Turbines
<i>Dam Breach</i>	
Remove earthen embankments and adjacent structures, as required, at each lower Snake River dam	Breach Snake Embankments
Modify equipment and infrastructure to adjust to drawdown conditions at each lower Snake River dam	Lower Snake Infrastructure Drawdown
Operational Measures	
<i>Dam Breach</i>	
Develop procedures to operate existing equipment during reservoir drawdown	Drawdown Operating Procedures
Develop contingency plans to address unexpected issues with drawdown operations	Drawdown Contingency Plans
<i>Fish Passage</i>	
Limit fish passage spill to 120 percent TDG at McNary, John Day, The Dalles, and Bonneville Dams	Spring Spill to 120% TDG
Reduce the duration of summer juvenile fish passage spill	Reduced Summer Spill
Allow contingency reserves to be carried within juvenile fish passage spill	Contingency Reserves Within Juvenile Fish Passage Spill
<i>Water Management</i>	
Modify Libby draft and refill operations when water supply forecast is 6.9 Maf or less	Modified Draft at Libby
Eliminate end-of-December variable draft at Libby and replace with single draft target	December Libby Target Elevation
Update the upstream Storage Corrections Method as applied to the Grand Coulee SRD with flat spot retained	Update System FRM Calculation
Decrease the Grand Coulee Dam draft rate used in planning drawdown	Planned Draft Rate at Grand Coulee

Measure Descriptions	Abbreviated Measure Name
Operational constraints for ongoing Grand Coulee maintenance of power plants	Grand Coulee Maintenance Operations
<i>Water Supply</i>	
Increase volume of water pumped from Lake Roosevelt during annual irrigation season	Lake Roosevelt Additional Water Supply
Increase water managers' flexibility to store and release water from Hungry Horse Reservoir	Hungry Horse Additional Water Supply
Increase water diversion from the Columbia River for the Chief Joseph Dam Project	Chief Joseph Dam Project Additional Water Supply
<i>Hydropower</i>	
Ramping rate limitations at all projects will be defined only for safety or engineering	Ramping Rates for Safety
At John Day, allow project to operate up to full pool except as needed for FRM	John Day Full Pool
Operate turbines within and above 1 percent peak efficiency in juvenile fish passage season	Above 1% Turbine Operations
<i>Other Operational</i>	
Implement sliding scale summer draft at Libby and Hungry Horse Dams	Sliding Scale at Libby and Hungry Horse

2.4.5.1 Multiple Objective Alternative 3 Description of Measures

STRUCTURAL MEASURES

Remove earthen embankments and adjacent structures, as required, at each lower Snake River dam

This measure will be referred to as “Breach Snake Embankments” throughout the remainder of this EIS. This measure would breach the lower Snake River dams. The demolition would remove the earthen embankments, abutments, and portions of existing structures at the dams to eliminate the reservoirs behind the Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Projects. In order to minimize impacts to migrating salmon and ensure safety, the removal of the embankments would be conducted in two phases during the low water period in the river. Drawdown would begin in August, with the removal of structures during October, months when few ESA-listed salmon would be present in the Snake River. To do this, the north embankments at the Lower Granite and Little Goose Projects would be removed the first year, and the south embankment at Lower Monumental and north embankment at Ice Harbor would be removed the second year. The co-lead agencies would implement a controlled drawdown, at a rate of 2 feet per day, beginning in August and continuing through December, in order to safely evacuate the reservoir and minimize damages to infrastructure (highways, bridges, railroads) adjacent to the reservoirs. In-water structures such as anchored concrete blocks would be installed at Ice Harbor to produce resting pools and hydraulic conditions needed for fish passage. This measure was developed to contribute to meeting objective 1 for improvements to ESA-listed juvenile salmonid rearing, passage, and survival.

Modify equipment and infrastructure to adjust to drawdown conditions at each lower Snake River dam

This measure will be referred to as “Lower Snake Infrastructure Drawdown” throughout the remainder of this EIS. In order to implement breaching, the reservoirs would be drawn down to spillway elevations. In order to evacuate the reservoirs below this level, three turbines at each of the four lower Snake River dams would be modified so that they could be used as low-level water outlets to support a controlled drawdown of the reservoirs. The turbines would be modified to operate over a range of low head conditions, requiring modification to the cooling water systems, and removal of the turbine blades. This would allow maximum discharge of water through the turbine passages at low head. These actions would be taken several months in advance of initiation of drawdown. This measure was developed to contribute to meeting objective 1 for improvements to ESA-listed juvenile salmonid rearing, passage, and survival.

Additional Powerhouse Surface Passage

This measure is the same as described in MO1, but without inclusion of the Ice Harbor Project on the lower Snake River. This measure would contribute to meeting objective 1 to improve passage for ESA-listed juvenile anadromous fish.

Fewer Fish Screens

This measure is the same as described in MO2, but without inclusion of the Ice Harbor Project on the lower Snake River. Removal of fish screens would make hydropower production more efficient. Thus, this measure would contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply.

Upgrade to Adjustable Spillway Weirs

This measure is the same as described in MO1 but applies only to the lower Columbia River projects and does not include the lower Snake River projects. This measure was developed to contribute to meeting objective 1 for improvements to ESA-listed juvenile salmonid rearing, passage, and survival.

Modify Bonneville Ladder Serpentine Weir

This measure is the same as described in MO1. This measure is intended to benefit adult fish passage and would contribute to meeting objective 2 for adult ESA-listed anadromous fish.

Lamprey Passage Structures

This measure is the same as described in MO1. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Turbine Strainer Lamprey Exclusion

This measure is the same as described in MO1. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Bypass Screen Modifications for Lamprey

This measure is the same as described in MO1 but would only be implemented at McNary. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Lamprey Passage Ladder Modifications

This measure is the same as described in MO1 but would not be implemented at the lower Snake River projects. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Improved Fish Passage Turbines

This measure is the same as described in MO1. This measure would contribute to meeting objectives 4 and 5 by installing new turbines for an efficient and reliable power supply that minimizes greenhouse gas emissions. Because the turbines are designed to minimize negative impacts to fish passing through the powerhouse, it would also contribute to meeting objective 1, which strives to improve passage and survival for ESA juvenile anadromous fish.

OPERATIONAL MEASURES

Develop procedures to operate existing equipment during reservoir drawdown

This measure will be referred to as “Drawdown Operating Procedures” throughout the remainder of this EIS. This measure would be implemented in conjunction with the structural measures described above. Under this measure, equipment at the dams to be used for drawdown would be tested and calibrated to establish operational limits. Engineers, and powerhouse and transmission operators would establish manual operations and procedures using the modified equipment to facilitate a controlled and safe reservoir evacuation to support dam breaching. This measure was developed to contribute to meeting objective 1 for improvements to ESA-listed juvenile salmonid rearing, passage, and survival.

Develop contingency plans to address unexpected issues with drawdown operations

This measure will be referred to as “Drawdown Contingency Plans” throughout the remainder of this EIS. Corps staff that operate the dams would develop plans for unexpected operations or emergency shutdown during reservoir drawdown. To address the risks of breaching such large dams, training would be provided to dam and transmission system operators to implement emergency actions during unanticipated circumstances to ensure the safety of the general public and construction and dam personnel during reservoir drawdown. This measure

was developed to contribute to meeting objective 1 for improvements to ESA-listed juvenile salmonid rearing, passage, and survival.

Limit fish passage spill to 120 percent TDG at McNary, John Day, The Dalles, and Bonneville Dams

This measure will be referred to as “Spring Spill to 120 Percent TDG” throughout the remainder of this EIS. This measure would modify spring juvenile fish passage spill to allow spill up to 120 percent tailrace gas cap. Juvenile fish passage spill to 120 percent TDG would be implemented annually at the McNary, John Day, The Dalles, and Bonneville Projects from April 10 to June 15. McNary, John Day, and The Dalles would spill to 120 percent in the tailrace, while Bonneville would spill to 120 percent in the tailrace not to exceed a 150-kcfs spill constraint. The juvenile fish spill volumes at each project are described in Table 2-8. This measure is intended to contribute to meeting objective 1 to improve the passage and survival of juvenile ESA-listed salmonids.

Table 2-8. Juvenile Fish Passage Spill Measure for Multiple Objective Alternative 3

Location	Spill Regime
McNary	120% tailrace Spill Cap ^{1/}
John Day	120% tailrace Spill Cap ^{1/}
The Dalles	120% tailrace Spill Cap ^{1/}
Bonneville	120% tailrace Spill Cap ^{1/} , not to exceed 150 kcfs spill

^{1/} The term “spill cap” refers to the maximum spill level at each project that is estimated to meet, but not exceed, the gas cap in the tailrace unless the spill cap is constrained (e.g.,150 kcfs maximum spill for Bonneville Dam). In this measure, spill caps will be set to meet, but not exceed, the gas cap of 120% TDG as measured at the tailrace fixed monitoring stations. This gas cap is consistent with the current Oregon TDG water quality standard modification and with Washington State’s current short-term modification to its TDG water quality standard (2019), which removed the 115% TDG criteria.

Reduce the duration of summer juvenile fish passage spill

This measure will be referred to as “Reduced Summer Spill” throughout the remainder of this EIS. This measure would reduce the period of fish passage spill in the summer, ending all summer spill operations at midnight July 31 at McNary, John Day, The Dalles, and Bonneville Dams to allow for an increase in hydropower production during periods when low numbers of juvenile fish are migrating. This measure would contribute to meeting objective 4, and is intended to provide an adequate, efficient, economical, and reliable power supply that supports the integrated Columbia River power system.

Ramping Rates for Safety

This measure is the same as described in MO2. This measure would contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply, by allowing additional flexibility to generate hydropower.

John Day Full Pool

This measure is the same as described in MO2. By providing additional operating flexibility this measure would continue to meet objective 4 for an adequate, efficient, economical, and reliable power supply.

Operate turbines within and above 1 percent peak efficiency during juvenile fish passage season

This measure will be referred to as “Above 1 Percent Turbine Operations” throughout the remainder of this EIS. This measure would lift the requirement to operate hydropower turbines only within a 1 percent peak efficiency during the fish passage season at McNary, John Day, The Dalles, and Bonneville Dams. This would allow turbine operation within and above the current 1 percent peak efficiency limit to increase flexibility for hydropower generation to meet demand during high flow periods. This measure would contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply that supports the integrated Columbia River power system.

Sliding Scale at Libby and Hungry Horse

This measure is the same as described in MO1. This measure would contribute to meeting objective 3 to improve resident fish survival and spawning success at CRS projects.

Contingency Reserves Within Juvenile Fish Passage Spill

This measure is the same as described in MO1. This measure would contribute to meeting objective 4 to provide an adequate, efficient, and reliable power supply.

Modified Draft at Libby

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

December Libby Target Elevation

This measure is the same as described in MO1, but with a target elevation of 2,400 feet NGVD29. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Update System FRM Calculation

This measure is the same as described in MO1, except that the SRD maintains what is known as the “flat spot” from the No Action Alternative. The flat spot is a range of water supply conditions that does not require additional draft, but rather requires a consistent draft (“flat”)

of 1,222.7 feet NGVD29 over those conditions. This slight adjustment to the flood risk draft elevation reduces impacts to water supply operations. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Planned Draft Rate at Grand Coulee

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Grand Coulee Maintenance Operations

This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions. This measure would also contribute to meeting objective 4 to provide a reliable power supply by supporting maintenance of the turbines at Grand Coulee.

Lake Roosevelt Additional Water Supply

This measure is the same as described in MO1. This measure would contribute to meeting objective 7 to meet existing water supply obligations and provide for additional authorized regional water supply.

Hungry Horse Additional Water Supply

This measure is the same as described in MO1. This measure would contribute to meeting objective 7 to meet existing water supply obligations and provide for additional authorized regional water supply.

Chief Joseph Dam Project Additional Water Supply

This measure is the same as described in MO1. This measure would contribute to meeting objective 7 to meet existing water supply obligations and provide for additional authorized regional water supply.

2.4.6 Multiple Objective Alternative 4

MO4 was developed to examine an additional combination of measures to benefit ESA-listed fish integrated with measures for water management flexibility, hydropower production, and additional water supply. The additional combination of fish measures that differ from the other alternatives include proposing spillway weir notch inserts, changes to the juvenile fish transportation operations, the highest spill target in the range considered in this EIS. Annually drawing down the lower Snake River and Columbia River reservoirs to their minimum operating pools, a measure for establishment of riparian vegetation, dry-year augmentation of spring flow

with water stored in upper basin reservoirs, and increased powerhouse surface passage for kelt and overshoots.

The structural measures in this alternative are primarily focused on improving passage conditions for ESA-listed salmonids and Pacific lamprey. The inclusion of spillway weir notch inserts is the only structural measure difference from the other action alternatives. The operational measures are focused on making improvements and providing flexibility across authorized project purposes. In MO4, the juvenile fish transport program is proposed to operate only in the spring and fall, while juvenile fish passage spill is set to a target of no more than 125 percent TDG during the spring and summer spill season. The alternative also contains a measure for flows from the Libby Project targeted for downstream riparian vegetation establishment that is intended to improve conditions for ESA-listed resident fish, bull trout, and Kootenai River white sturgeon in the upper Columbia River Basin.

A brief description of the measures contained in MO4 is listed in Table 2-9 and the following paragraphs.

Table 2-9. Measures of Multiple Objective Alternative 4

Measure Descriptions	Abbreviated Measure Name
Structural Measures	
Construct additional powerhouse surface passage routes to meet system-wide PITPH target	Additional Powerhouse Surface Passage
Improve adult ladder passage through modification of adult trap at Lower Granite Dam	Lower Granite Trap Modifications
Install pumping systems to provide deeper, cooler water in adult fish ladders at Lower Monumental and Ice Harbor Dams	Lower Snake Ladder Pumps
Install improved fish passage turbines at John Day	Improved Fish Passage Turbines
Expand network of LPSs to bypass impediments	Lamprey Passage Structures
Modify turbine intake bypass screens that cause juvenile lamprey impingement	Bypass Screen Modifications for Lamprey
Modify existing fish ladders, incorporating lamprey passage features and criteria	Lamprey Passage Ladder Modifications
Addition of spillway weir notch gate inserts	Spillway Weir Notch Inserts
Modify turbine cooling water strainer systems to safely exclude Pacific lamprey	Turbine Strainer Lamprey Exclusion
Operational Measures	
<i>Fish Passage</i>	
Spill through surface passage structures for steelhead overshoots, overwintering steelhead, and kelt	Spill for Adult Steelhead
Set juvenile fish passage spill to not exceed 125 percent TDG	Spill to 125% TDG
Allow contingency reserves to be carried within juvenile fish passage spill	Contingency Reserves Within Juvenile Fish Passage Spill
Implement juvenile fish transportation during spring and fall periods at Lower Granite, Little Goose, and Lower Monumental Dams	Spring & Fall Transport
Cease juvenile transport during portions of summer spill period at Lower Granite, Little Goose, and Lower Monumental Dams	No Summer Transport

*Columbia River System Operations Environmental Impact Statement
Chapter 2, Alternatives*

Measure Descriptions	Abbreviated Measure Name
<i>Water Management</i>	
Modify Libby draft and refill operations when water supply forecast is 6.9 Maf or less	Modified Draft at Libby
Eliminate end-of-December variable draft at Libby and replace with single draft target	December Libby Target Elevation
Update the upstream Storage Corrections Method as applied to the Grand Coulee SRD	Update System FRM Calculation
Decrease the Grand Coulee Dam draft rate used in planning drawdown	Planned Draft Rate at Grand Coulee
Operational constraints for ongoing Grand Coulee maintenance of power plants and spillways	Grand Coulee Maintenance Operations
Develop draft requirements/assessment approach to protect against rain-induced flooding	Winter System FRM Space
<i>Water Supply</i>	
Increase volume of water pumped from Lake Roosevelt during annual irrigation season	Lake Roosevelt Additional Water Supply
Increase water managers' flexibility to store and release water from Hungry Horse Reservoir	Hungry Horse Additional Water Supply
Increase water diversion from the Columbia River for the Chief Joseph Dam Project	Chief Joseph Dam Project Additional Water Supply
Operate turbines within and above 1 percent peak efficiency in juvenile fish passage season	Above 1% Turbine Operations
<i>Other Operational Measures</i>	
Strive to hold minimum 220 kcfs spring flow/200 kcfs summer flow at McNary Dam using upstream storage	McNary Flow Objective
Reservoir drawdown to Minimum Operating Pool to reduce outmigration travel time	Drawdown to MOP
Implement sliding scale summer draft at Libby and Hungry Horse	Sliding Scale at Libby and Hungry Horse
Support establishment of vegetation at Libby Dam by limiting Bonners Ferry stage height November through March	Winter Stage for Riparian

Note: PITPH = probability of passing powerhouses.

2.4.6.1 Multiple Objective Alternative 4 Description of Measures

STRUCTURAL MEASURES

Additional Powerhouse Surface Passage

This measure is the same as described in MO1, but under MO4, the additional powerhouse surface passage route would be used to measure PITPH. As stated in the May 13, 2019, Fish Passage Center Memorandum, "PITPH is an index that describes the probability that an average juvenile fish will experience powerhouse passage under specific project operations. PITPH is an index used to characterize the effects of spill in CSS analyses. CSS analyses have shown that the probability of passing powerhouses (PITPH) influences juvenile travel time, juvenile survival,

and smolt-to-adult return rates” (Fish Passage Center [FPC] 2019). This measure would contribute to meeting objective 1 to improve passage for ESA-listed juvenile anadromous fish.

Lower Granite Trap Modifications

This measure is the same as described in MO1. This measure would contribute to meeting objective 2 to improve passage for adult ESA-listed anadromous fish.

Lower Snake Ladder Pumps

This measure is the same as described in MO1. This measure would contribute to meeting objective 2 to improve adult ESA-listed anadromous fish migration.

Improved Fish Passage Turbines

This measure is the same as described in MO1. This measure would contribute to meeting objectives 4 and 5 by installing new turbines for an efficient and reliable power supply that minimizes greenhouse gas emissions. Because the turbines are designed to minimize negative impacts to fish passing through the powerhouse, it would also contribute to meeting objective 1, which strives to improve passage and survival for ESA juvenile anadromous fish.

Lamprey Passage Structures

This measure is the same as described in MO1. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Bypass Screen Modifications for Lamprey

This measure is the same as described in MO1. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Lamprey Passage Ladder Modifications

This measure is the same as described in MO1. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Turbine Strainer Lamprey Exclusion

This measure is the same as described in MO1. This measure would contribute to meeting the objective to improve conditions for Pacific lamprey.

Add spillway weir notch gate inserts

This measure will be referred to as “Spillway Weir Notch Inserts” throughout the remainder of this EIS. Modify existing spillway weirs at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, and John Day Dams. A notch gate would be installed in one spillway weir at each dam to create a smaller opening in the weir and enable reduced spill flow velocities. The

notched weirs would be operated October 1 to November 31 at all dams. This measure would contribute to meeting objective 1 and is intended to improve the passage and survival of ESA-listed juvenile anadromous fish.

OPERATIONAL MEASURES

Spill through surface passage structures for steelhead overshoots, overwintering steelhead and kelt

This measure will be referred to as “Spill for Adult Steelhead” throughout the remainder of this EIS. Implementation of this measure would require modification of the spillway weirs as described above for the Spillway Weir Notch Inserts measure to facilitate downstream passage of adult salmon, steelhead, and kelt. Flows would be directed through the weirs at the Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, and John Day Projects from October 1 to November 31. The measure is intended to increase adult salmon and steelhead survival by decreasing passage mortality of adult steelhead. This measure would contribute to meeting objective 2, intended to benefit adult ESA-listed anadromous fish.

Set juvenile fish passage spill to not exceed 125 percent TDG

This measure will be referred to as “Spill to 125 Percent TDG” throughout the remainder of this EIS. This measure would set the target for juvenile fish passage spill up to 125 percent TDG, as measured in the tailrace, at the four lower Snake River and four lower Columbia River projects. Juvenile fish passage spill to this level would be dependent upon availability of sufficient flow to meet minimum generation requirements for hydropower. Upstream storage reservoirs would not be drafted specifically to reach 125 percent TDG spill levels. This juvenile fish passage spill regime would be implemented March 1 to August 31 at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville Dams. This measure is intended to improve passage for juvenile ESA-listed salmonids, and as such, would contribute to meeting objective 1.

Allow contingency reserves to be carried within juvenile fish passage spill

This measure will be referred to as “Contingency Reserves Within Juvenile Fish Passage Spill” throughout the remainder of this EIS. This measure is the same as described in MO1. This measure would contribute to meeting objective 4 to provide an adequate, efficient, and reliable power supply.

Implement juvenile fish transportation during spring and fall periods at Lower Granite, Little Goose, and Lower Monumental Dams

This measure will be referred to as “Spring & Fall Transport” throughout the remainder of this EIS. Juvenile fish transportation on barges and trucks would be implemented in two timeframes, April 25 to June 14, and August 16 to November 15, rather than transport beginning no later than May 1 through the migration season. During these two transport

seasons, all juvenile salmonids that enter the juvenile fish bypass systems at Lower Granite, Little Goose, and Lower Monumental Dams would be collected and transported to a location downstream of Bonneville Dam for release. This measure would contribute to meeting objective 1 to improve passage and survival of juvenile ESA-listed salmonids.

Cease juvenile transport during portions of summer spill period at Lower Granite, Little Goose, and Lower Monumental Dams

This measure will be referred to as “No Summer Transport” throughout the remainder of this EIS. The juvenile transport program at Lower Granite, Little Goose, and Lower Monumental Dams would be suspended during the full summer timeframe (June 15 to August 15). Instead of collection for transport, all juvenile fish entering the fish bypasses at these projects would be returned to the river to migrate during the June 15 to August 15 window. This measure is a variation of the current and proposed transport program, which is intended to improve passage and survival of juvenile ESA-listed salmonids. As such, it would contribute to meeting objective 1.

Modified Draft at Libby

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions

December Libby Target Elevation

This measure is the same as described in MO1, with a target elevation of 2,420 feet NGVD29. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Update System FRM Calculation

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Planned Draft Rate at Grand Coulee

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Grand Coulee Maintenance Operations

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable

water management strategies in order to be responsive to changing conditions. This measure would also contribute to meeting objective 4 to provide a reliable power supply by supporting maintenance of the turbines at Grand Coulee.

Winter System FRM Space

This measure is the same as described in MO1. This measure was developed to contribute to meeting objective 6, which would maximize operating flexibility by implementing adaptable water management strategies in order to be responsive to changing conditions.

Lake Roosevelt Additional Water Supply

This measure is the same as described in MO1. This measure would contribute to meeting objective 7 to meet existing water supply obligations and provide for additional authorized regional water supply.

Hungry Horse Additional Water Supply

This measure is the same as described in MO1. This measure would contribute to meeting objective 7 to meet existing water supply obligations and provide for additional authorized regional water supply.

Chief Joseph Dam Project Additional Water Supply

This measure is the same as described in MO1. This measure would contribute to meeting objective 7 to meet existing water supply obligations and provide for additional authorized regional water supply.

Above 1 Percent Turbine Operations

This measure is the same as described in MO3, but would include the Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Projects. This measure would contribute to meeting objective 4 to provide an adequate, efficient, economical, and reliable power supply that supports the integrated Columbia River power system.

Strive to hold minimum 220 kcfs spring flow/200 kcfs summer flow at McNary using upstream storage

This measure will be referred to as “McNary Flow Target” throughout the remainder of this EIS. This measure would augment flows in the lower Columbia River during the juvenile salmon outmigration period in low water years. The summer flow objective at McNary is supported by various flow augmentation measures in the No Action Alternative that would continue, however, this measure would provide additional flow augmentation. Even with this additional water, there is a limited amount of water available for flow augmentation and flow objectives are provided as a biological guideline. To meet this minimum flow objective for the lower Columbia River, up to 2.0 Maf of storage water from the Hungry Horse, Libby, Albeni Falls, and

Grand Coulee Projects would be provided above that provided currently, in order to meet spring or summer flow objectives established for the McNary Project. Grand Coulee would be drafted from first to meet the flow objective, with no more than 40 kcfs being released in a single day and drafting the reservoir to no more than the minimum pool elevation. Then, Hungry Horse, Libby, and Albeni Falls reservoirs would be drafted to support the augmented flow target as well as to refill Grand Coulee’s reservoir, but to a reduced refill elevation. Local resident fish operations in the upper basin, such as minimum flows for resident fish, would be maintained. In the event that all 2.0 Maf of water has not been used by June 15, then the remaining volume of water would be released to meet a reduced minimum flow objective of 200 kcfs at McNary through to July 31. This measure is not anticipated be implemented every year, but rather only when the system-wide April to August water supply forecast is below 87.5 Maf, the current 30-year average for the period 1981 to 2008, which will be updated after 2020. This measure is intended to benefit ESA-listed juvenile anadromous fish migration, and as such, would contribute to meeting objective 1.

Reservoir drawdown to Minimum Operating Pool to reduce outmigration travel time

This measure will be referred to as “Drawdown to MOP” throughout the remainder of this EIS. The lower Snake River and lower Columbia River projects would be operated at lower elevations to reduce travel times for juvenile fish out-migration while providing slightly increased operating range flexibility at the lower Snake River projects. These operations would be implemented at the lower Snake River projects from March 15 to August 15, and at the lower Columbia projects from March 25 to August 15. The projects would be drafted down to the following reservoir elevations (Table 2-10).

Table 2-10. Drawdown to MOP Measure for Multiple Objective Alternative 4

Location	MO4 MOP Forebay Elevation
Lower Granite	733.0 + 1.5 ft range
Little Goose	633.0 + 1.5 ft range
Lower Monumental	537 + 1.5 ft range
Ice Harbor	437 + 1.5 ft range
McNary	337.0 + 1.0 ft range
John Day	261.0 + 1.5 ft range
The Dalles	155.0 + 1.5 ft range
Bonneville	71.5 + 1.5 ft range

This measure is intended to benefit ESA-listed juvenile anadromous fish migration, and as such, would contribute to meeting objective 1.

Sliding Scale at Libby and Hungry Horse

This measure is the same as described in MO1. This measure would contribute to meeting objective 3 to improve resident fish survival and spawning success at CRS projects.

Support establishment of vegetation at Libby Dam by limiting Bonners Ferry stage height November through March

This measure will be referred to as “Winter Stage for Riparian” throughout the remainder of this EIS. Operate to limit the Bonners Ferry river elevations to a maximum of 1,753 feet NGVD29 from November through March to create conditions that would increase survival of riparian vegetation downstream of Libby Dam. The riparian vegetation is considered an important factor in creating good conditions for Kootenai white sturgeon and bull trout (Table 2-9). This measure would contribute to meeting objective 3 to improve resident fish survival and spawning success at CRS projects.

2.5 ALTERNATIVES CONSIDERED BUT REMOVED FROM FURTHER CONSIDERATION

Initially, eight single objective-focused alternatives were developed to maximize certain project purposes and emphasize specific resources, in a hypothetical condition where other purposes do not constrain the possibility of actions that could be taken. These single objective alternatives provided the framework for the exchange of expertise across technical disciplines throughout the Columbia River Basin. The technical teams collaborated to determine where measures would be most effective and if they were compatible across the 14 projects in the CRS. If measures were determined to be conflicting, or experts felt one measure would perform better at accomplishing the objective as compared to a similar measure, the team decided which measure to retain or modify to meet the intended single objective. In some cases, measures were suggested, either through scoping or by technical team members, but were not selected for further consideration. This unrestrained development of single objective-focused alternatives helped the co-lead agencies understand which measures the technical teams prioritized and understood to be most effective and formed the basis for framing the MO process with a manageable suite of measures.

As information was exchanged, redundancies between alternatives and conflicts between proposed measures became more clearly understood, leading to refinement of the draft alternatives. The MOs were then developed to meet a blend of actions and benefits across project authorities.

The single objective-focused alternatives (Table 2-11) are summarized in the following sections, with additional detail in Appendix A, *Alternatives Development*.

Table 2-11. List of Draft Single Objective Focus Alternatives

Single Objective Alternatives
Spill to 125% TDG with Extended Duration
Juvenile Anadromous Fish Survival
Adult Anadromous Fish Survival
ESA-Listed Resident Fish Survival
Hydropower Generation
Water Management
Water Supply
Lower Snake River Dam Breach

2.5.1 Single Objective Focus Alternative for Increased Spill to 125 Percent TDG with Extended Duration

The Single Focus Alternative for Increased Spill to 125 Percent TDG with Extended Duration was not an objective-focused alternative. Rather, it was developed based on scoping comments specifically requesting analysis of an increased juvenile fish passage spill target level. This alternative is comprised of two operational measures but has no associated structural measures. The first operational measure involves increasing the proportion of flow released over the spillway (referred to as “spill”), relative to the No Action Alternative, at the lower Snake and lower Columbia River dams. Juvenile fish passage spill levels would be increased to a target not to exceed 125 percent TDG, as measured in the tailrace of each project. The second operational measure to cease summer transportation was added because flows associated with this level of spill results in very few fish entering the fish collection facilities at the Lower Granite, Little Goose, and Lower Monumental Projects. The Single Focus Alternative for Increased Spill to 125 Percent TDG with Extended Duration was intended to benefit juvenile fish migration during the March 1 to August 31 timeframe each year.

This alternative was refined and became part of MO4 for analysis.

2.5.2 Single Objective Focus Juvenile Anadromous Fish Survival Alternative

The Single Objective Focus Juvenile Anadromous Fish Survival Alternative was designed to maximize juvenile salmonid survival through the CRS by prioritizing juvenile-focused actions above some of the other congressionally authorized project purposes and above other salmonid life stages. Although juvenile anadromous fish do not experience the CRS separately from their adult counterparts, this alternative emphasizes how actions to benefit the survival of juvenile salmonids affects both the adult life stage and other co-lead agency missions (e.g., FRM, hydropower production, and water quality).

The measures from this alternative were refined and became part of the MOs.

2.5.3 Single Objective Focus Adult Anadromous Fish Survival Alternative

The Single Objective Focus Adult Anadromous Fish Survival Alternative contains a mix of structural and operational measures intended to improve the migration and survival of anadromous adult steelhead and salmon. Structural measures are focused on improving conditions for adult salmon migrating upstream through the fish ladders. Under this alternative, the adult fish trap and bypass loop at Lower Granite Dam would be modified to shorten the time it takes an adult salmon to travel through the bypass. Pumps would be installed at Lower Monumental and Ice Harbor Dams to provide cooling water for the fish ladders. The Washington shore and Bradford Island fish ladders at Bonneville Dam would be modified to a vertical slot fishway to reduce upstream travel times for adult salmon and steelhead. In addition, the alternative includes a measure to transport all juvenile salmonids from the collector projects, which includes Lower Granite, Little Goose, Lower Monumental, and McNary Dams. Juvenile salmonids collected at these projects would be transported downstream via

barge or truck for release below Bonneville Project. Spill would be reduced to provide only fish attraction spill and spill for steelhead overshoots, overwintering steelhead, and downstream passage for kelt.

The majority of measures from this alternative were refined and became part of the MOs.

2.5.4 Single Objective Focus ESA-Listed Resident Fish Survival Alternative

The Single Objective Focus ESA-Listed Resident Fish Survival Alternative was intended to improve river and reservoir habitat conditions for the two ESA-listed resident fish in the Columbia River Basin, bull trout and Kootenai River white sturgeon, through improving water temperature management, creating conditions for higher reservoir productivity during the summer months, and improving the likelihood of releasing instream flow objectives for resident fish in the CRS. This alternative focused on the upper Columbia River dams and did not include changes to the lower Columbia or Snake River operations. The Single Objective Focus ESA-Listed Resident Fish Survival Alternative emphasized the survival of resident fish juveniles and adults in CRS reservoirs through measures developed for improving condition for spawning, egg-hatching success, and food resource availability.

The measures from this alternative were refined and became part of the MOs.

2.5.5 Single Objective Focus on Hydropower Generation Alternative

The Single Objective Focus on Hydropower Generation Alternative describes action that would maximize hydropower generation at CRS projects. The proposed measures would create circumstances similar to conditions that existed prior to implementation of the Northwest Power Act and actions implemented for BiOps and other agreements. Restrictions on ramping rates, turbine operating ranges, reservoir operating ranges, and similar measures have reduced the flexibility needed for enough hydropower generation to serve hourly, daily, and seasonal power demands. The Single Objective Focus on Hydropower Generation Alternative includes relaxing current restrictions on operating ranges and ramping rates found in the No Action Alternative in order to evaluate the potential to increase hydropower production efficiency and increase flexibility to respond to changing power demands. This alternative does not provide spill for juvenile fish passage.

Most of the measures from this alternative were modified or refined and became part of the MOs. The majority of the measures became part of MO2.

2.5.6 Single Objective Focus Water Management Alternative

The Single Objective Focus Water Management Alternative would provide water managers with the increased flexibility to react to unanticipated changes in river flow and forecast runoff volume, as well as prepare for the operational constraints of implementing ongoing maintenance at Grand Coulee Project. This alternative does not include any structural measures or operational changes to the lower Columbia and Snake River dams. The operational measures

at Grand Coulee, Libby, Hungry Horse, and Dworshak Projects included in this alternative are intended to update FRM and improve the likelihood of achieving storage project refill. This, in turn, would provide downstream flow augmentation and recreational benefits, faster turnover of the Libby reservoir to support downstream nutrient delivery, and better management of outflow temperature during Kootenai River white sturgeon spawning.

As storage reservoirs are drafted for FRM, situations can occur where rapid and large water releases are required in the March to April timeframe to achieve FRM draft goals (e.g., high runoff during late winter/early spring or years with rapidly increasing water supply forecasts). Drafting large volumes in a short timeframe can require increased spill (lack of market/lack of turbine) to achieve the maximum FRM elevation or a deviation from FRM draft requirements, which could result in high TDG levels or slight increases in flood risk in a given year. In addition, heavy rain often results in near-term high runoff that cannot be forecasted in the same way as longer-term, snowmelt-induced runoff. Water management operating procedures that more explicitly account for the rain component of runoff would afford greater flexibility and adaptability in reservoir operations. The Single Objective Focus Water Management Alternative is expected to maintain the current level of flood risk, meet contractual water supply obligations, maintain infrastructure to ensure safe and reliable operations, and maintain commercial navigation.

The measures from this alternative were refined and became part of the MOs.

2.5.7 Single Objective Focus Water Supply Alternative

The Single Objective Focus Water Supply Alternative was formulated to assess providing additional water to authorized, but not yet developed, lands within the Columbia Basin Project and the Chief Joseph Dam Project. In addition, the alternative assesses delivering 90,000 acre-feet of water from Hungry Horse Dam for currently undefined use by the Confederated Salish and Kootenai Tribes. The scope for this alternative is limited to the diversion of water from the Columbia and South Fork Flathead Rivers and does not describe how that water is used or where. To clarify, the scope of this alternative as related to the Columbia Basin Project is limited to the diversion of water from Grand Coulee's Lake Roosevelt into Banks Lake using the John W. Keys Pumping Plant and does not include pumping that water from Banks Lake to the additional acres of land.

The Single Objective Focus Water Supply Alternative is focused on upper basin dams and river segments, including Lake Roosevelt and the Columbia River above Grand Coulee Dam, Hungry Horse Dam and reservoir on the Flathead River, and Chief Joseph Dam on the Columbia River and proposes to maintain the No Action Alternative's configuration and general operations. This alternative was developed with the assumption that there would be a warranted, future demand to irrigate the remaining authorized acreage within the Columbia River Basin, which would require delivery of the total authorized volume of water.

The Single Objective Focus Water Supply Alternative included only operational measures. These measures were focused on water diversion from Grand Coulee's Lake Roosevelt via the John W.

Keys Pumping Plant, delivery of water from Hungry Horse, and diversion of water for the Chief Joseph Dam Project. At Lake Roosevelt, water diverted to Banks Lake would be increased to supply an additional 1,154,138 acre-feet of water to irrigate an additional 256,475 acres of land as authorized under the Columbia Basin Project. Presently, only 772,525 acres have been developed for delivery. Hungry Horse Reservoir was originally authorized for irrigation but has never been used for that purpose. The release of 90,000 acre-feet for the Confederated Salish and Kootenai Tribes could be used for irrigation, M&I, or in-stream uses. Since the use of the water is not currently defined, the entire 90,000 acre-feet of water is assumed to be diverted from the river at Flathead Lake so as to evaluate the most extreme impact of using this water. Finally, 9,600 acre-feet of water would be diverted from the Columbia River into the Chief Joseph Dam Project (a Reclamation irrigation project not to be confused by the Corps' dam of the same name). However, the John W. Keys Pumping Plant would not be reconfigured under this alternative, because the existing design is capable of pumping the increased volume proposed. Instead, monthly volumes of diversion flow from Lake Roosevelt would be reshaped to prevent substantial drafting of Banks Lake as an operational measure.

The measures from this alternative were refined and became part of MO1, MO3, and MO4.

2.5.8 Single Objective Focus Lower Snake River Dam Breaching Alternative

The Single Objective Focus Lower Snake River Dam Breaching Alternative was not an objective-focused alternative. It was developed based on formal scoping comments specifically requesting analysis of this action. The hypothesis for this alternative was that habitat conditions for 4 of the 13 listed anadromous species in the Columbia River Basin could potentially be restored. The alternative proposed breaching the four lower Snake River dams (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor) by removing the earthen embankments at each location. The reservoirs behind the dams would be drawn down slowly to avoid damage to adjacent infrastructure (e.g., roads, bridges, and railroads) and ensure life safety of downstream populations. The concrete portions of the dams would remain in place, but the powerhouses would be mothballed. The generators would be modified for use as outlets during a controlled reservoir drawdown. The breaching would occur over a 2-year period, with the two upstream dams (Lower Granite and Little Goose) breached first and followed the next year by Lower Monumental and Ice Harbor. Spreading the breaching over 2 years allows the work to occur during the in-water work window, when very few ESA-listed fish are present in the reservoirs and inflows are relatively small.

This alternative was refined and included in MO3 for analysis in this EIS.

2.5.9 Multiple Objective Alternative Crosswalk

Table 2-12 represents how the measures of the Single Objective Focus Alternatives were distributed in the MOs.

Table 2-12. Multiple Objective Alternative Crosswalk

CRSO Measure Name	Spill to 125% TDG	Juvenile Anadrom. Focus	Adult Anadromous Focus	Resident Fish Focus	Hydropower Focus	Water Management	Water Supply Focus	LSR Dam Breach Focus	MO1	MO2	MO3	MO4	Measure source from Alternatives
Structural Measures													
Additional Powerhouse Surface Passage	-	Juv	-	-	-	-	-	-	Juv	Juv	Juv	Juv	Juvenile
Upgrade to Adjustable Spillway Weirs	-	Juv	-	-	-	-	-	-	Juv	Juv	Juv	-	Juvenile
Lower Granite Trap Modifications	-	-	Adu	-	-	-	-	-	Adu	-	-	Adu	Adult
Modify Bonneville Ladder Serpentine Weir	-	-	Adu	-	-	-	-	-	Adu	-	Adu	-	Adult
Lower Snake Ladder Pumps	-	-	Adu	-	-	-	-	-	Adu	Adu	-	Adu	Adult
Spillway Weir Notch Inserts	-	-	-	-	-	-	-	-	-	-	-	X	MO4
Fewer Fish Screens	-	-	-	-	Hyd	-	-	-	-	Hyd	Hyd	-	Hydropower
Improved Fish Passage Turbines	-	-	-	-	-	-	-	-	X	X	X	X	MO1,2,3,4
Lamprey Passage Structures	-	-	-	-	-	-	-	-	X	X	X	X	MO1,2,3,4
Turbine Strainer Lamprey Exclusion	-	-	-	-	-	-	-	-	X	X	X	X	MO1,2,3,4
Bypass Screen Modifications for Lamprey	-	-	-	-	-	-	-	-	X	X	X	X	MO1,2,3,4
Lamprey Passage Ladder Modifications	-	-	-	-	-	-	-	-	X	X	X	X	MO1,2,3,4

Columbia River System Operations Environmental Impact Statement
Chapter 2, Alternatives

CRSO Measure Name	Spill to 125% TDG	Juvenile Anadrom. Focus	Adult Anadromous Focus	Resident Fish Focus	Hydropower Focus	Water Management	Water Supply Focus	LSR Dam Breach Focus	MO1	MO2	MO3	MO4	Measure source from Alternatives
<i>Dam Breach</i>													
Breach Snake Embankments	-	-	-	-	-	-	-	LSR	-	-	LSR	-	LSR Breach
Lower Snake Infrastructure Drawdown	-	-	-	-	-	-	-	LSR	-	-	LSR	-	LSR Breach
Operational Measures													
<i>Dam Breach</i>													
Drawdown Operating Procedures	-	-	-	-	-	-	-	LSR	-	-	LSR	-	LSR Breach
Drawdown Contingency Plans	-	-	-	-	-	-	-	LSR	-	-	LSR	-	LSR Breach
<i>Fish Passage</i>													
Block Spill Test (Base + 120/115%)	-	-	-	-	-	-	-	-	X	-	-	-	MO1
Summer Spill Stop Trigger	-	-	-	-	-	-	-	-	X	-	-	-	MO1
Early Start Transport	-	-	-	-	-	-	-	-	X	-	-	-	MO1
Contingency Reserves Within Juvenile Fish Passage Spill	-	-	-	-	-	-	-	-	X	X	X	X	MO1,2,3,4
Spill to 110% TDG	-	-	-	-	-	-	-	-	-	X	-	-	MO2
Spring & Fall Transport	-	-	-	-	-	-	-	-	-	-	-	X	MO4
No Summer Transport	-	-	-	-	-	-	-	-	-	-	-	X	MO4
Reduced Summer Spill	-	-	-	-	-	-	-	-	-	-	X	-	MO3
Spill to 125% TDG	125	-	-	-	-	-	-	-	-	-	-	125	125%
Spring Spill to 120% TDG	-	Juv	-	-	-	-	-	-	-	-	Juv	-	Juvenile
Spill for Adult Steelhead	-	-	Adu	-	-	-	-	-	-	-	-	Adu	Adult

Columbia River System Operations Environmental Impact Statement
Chapter 2, Alternatives

CRSO Measure Name	Spill to 125% TDG	Juvenile Anadrom. Focus	Adult Anadromous Focus	Resident Fish Focus	Hydropower Focus	Water Management	Water Supply Focus	LSR Dam Breach Focus	MO1	MO2	MO3	MO4	Measure source from Alternatives
Increase Juvenile Fish Transportation	-	-	Adu	-	-	-	-	-	-	Adu	-	-	Adult
<i>Water Management</i>													
Modified Draft at Libby	-	-	-	-	-	WM	-	-	WM	WM	WM	WM	Water Mgmt
December Libby Target Elevation	-	-	-	Res	-	WM	-	-	WM	WM	WM	WM	Water Mgmt
Update System FRM Calculation	-	-	-	-	-	WM	-	-	WM	WM	WM	WM	Water Mgmt
Planned Draft Rate at Grand Coulee	-	-	-	-	-	WM	-	-	WM	WM	WM	WM	Water Mgmt
Grand Coulee Maintenance Operations	-	-	-	-	-	WM	-	-	WM	WM	WM	WM	Water Mgmt
Winter System FRM Space	-	-	-	-	-	WM	-	-	WM	WM	-	WM	Water Mgmt
<i>Water Supply</i>													
Lake Roosevelt Additional Water Supply	-	-	-	-	-	-	WS	-	WS	-	WS	WS	Water Supply
Hungry Horse Additional Water Supply	-	-	-	-	-	-	WS	-	WS	-	WS	WS	Water Supply
Chief Joseph Dam Project Add'l Water Supply	-	-	-	-	-	-	WS	-	WS	-	WS	WS	Water Supply
<i>Hydropower</i>													
Increased Forebay Range Flexibility	-	-	-	-	Hyd	-	-	-	Hyd	-	-	-	Hydropower
Slightly Deeper Draft for Hydropower	-	-	-	-	Hyd	-	-	-	-	Hyd	-	-	Hydropower

Columbia River System Operations Environmental Impact Statement
Chapter 2, Alternatives

CRSO Measure Name	Spill to 125% TDG	Juvenile Anadrom. Focus	Adult Anadromous Focus	Resident Fish Focus	Hydropower Focus	Water Management	Water Supply Focus	LSR Dam Breach Focus	MO1	MO2	MO3	MO4	Measure source from Alternatives
Ramping Rates for Safety	-	-	-	-	Hyd	-	-	-	-	Hyd	Hyd	-	Hydropower
John Day Full Pool	-	-	-	-	Hyd	-	-	-	-	Hyd	Hyd	-	Hydropower
Full Range Reservoir Operations	-	-	-	-	Hyd	-	-	-	-	Hyd	-	-	Hydropower
Full Range Turbine Operations	-	-	-	-	Hyd	-	-	-	-	Hyd	-	-	Hydropower
Above 1% Turbine Operations	-	-	-	-	Hyd	-	-	-	-	-	Hyd	Hyd	Hydropower
Zero Generation Operations	-	-	-	-	Hyd	-	-	-	-	Hyd	-	-	Hydropower
<i>Other Operational Measures</i>													
McNary Flow Target	-	Juv	-	-	-	-	-	-	-	-	-	Juv	Juvenile
Drawdown to MOP	-	Juv	-	-	-	-	-	-	-	-	-	Juv	Juvenile
Predator Disruption Operations	-	Juv	-	-	-	-	-	-	Juv	-	-	-	Juvenile
Modified Dworshak Summer Draft	-	-	Adu	-	-	-	-	-	Adu	-	-	-	Adult
Sliding Scale at Libby and Hungry Horse	-	-	-	Res	-	-	-	-	Res	Res	Res	Res	Resident
Winter Stage for Riparian	-	-	-	Res	-	-	-	-	-	-	-	Res	Resident

Note: – = not applicable; LSR = lower Snake River.

2.5.10 Other Proposals and Measures Considered but Removed from Further Consideration

Within this EIS, other proposals and measures were considered but removed from consideration early in the alternative development process. These measures were removed from further consideration for several reasons: because they had been previously studied or considered and found to be ineffective; because the measures were already being examined under a separate NEPA effort; or because they were outside of the scope of this EIS. Examples and brief rationale of specific measures considered but removed from further consideration include:

- Reintroduction of salmon above Grand Coulee Dam and installation of fish passage at Grand Coulee and Chief Joseph Dams. Reintroduction is an important and complex, large-scale concept. Its consideration, evaluation, and implementation should involve multiple tribal, federal, state, and other entities. A coordinated approach among water users, tribes, states, multiple federal agencies, and others would be necessary. To allow so many differing interests to coordinate on such a complex topic, which may include international considerations, a decision-making framework and a series of regional workshops would be necessary just to approach the first step of defining reintroduction objectives. Given the incompatibility of such a wildlife management decision-making framework with an analysis of the operation of the CRS, it is not feasible to proceed with a detailed consideration of reintroduction in this EIS. Moreover, to meaningfully analyze reintroduction as a measure, the details of the proposal would need to be understood well enough to include in hydrologic, water quality, and fish models. That information is not presently available, and development of those details was not possible in the timeframe of this NEPA process. Nevertheless, the agencies and interested regional sovereigns are developing a framework to address critical information gaps.
- Creation of “natural rivers” to mimic pre-dam construction conditions, which was previously studied and found to be infeasible. The co-lead agencies concluded that breaching all 14 dams would be unreasonable for several reasons, including that this action would either preclude or significantly alter the co-lead agencies’ ability to meet their congressionally authorized purposes in the system and it would likely result in significant human health and safety concerns. In addition, the co-lead agencies have no existing data for breaching the remaining dams such that completion of necessary analysis would take years to gather data and develop a model.
- A comprehensive FRM study for the Columbia River Basin. The scope of analysis of this EIS is limited to analyzing those measures that are part of the water management operations, associated maintenance, and structural configuration of the 14 Federal dam and reservoir projects. The Purpose and Need Statement includes a necessary constraint on the alternatives development to provide for a reliable level of flood risk by operating the Columbia River System to afford safeguards for public safety, infrastructure, and property. This screened out re-evaluating system flood risk management from further consideration in this EIS. However, FRM is an authorized project purpose and is assessed for each alternative in this EIS. Interest from states and tribes in a process to assess potential

changes to the current level of flood risk protection was identified during the Columbia River Treaty (CRT) Sovereign Review Process completed in December 2013. The Regional Recommendation stated that the Pacific Northwest states and tribes support the pursuit of Congressional authorization and appropriations for a region-wide public process to assess potential changes to the current level of flood risk protection in the Columbia River Basin to enhance spring and summer flows. However, no such authorization or appropriation was provided and, as such, a study for this purpose was determined to be outside of the scope of this EIS.

- The Columbia Basin spans the United States and Canada. The Columbia River's flow at the U.S.-Canada border is affected in part by how the Columbia River Treaty operations in Canada are managed. The 2016 CRT-related operations were applied in the EIS analysis, as the best-available information. If CRT-related operations change in a manner that presents new information or circumstances resulting in significant changes that were not previously addressed, those changes will be addressed by this NEPA process if they are identified in time or subsequently in another NEPA process, if necessary.