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CHAPTER 4 - CLIMATE

This chapter provides an overview of projected changes in future regional climate and assesses how these changes may affect resources and the effectiveness of the alternatives of this environmental impact statement (EIS). The first part of this chapter discusses changes in regional trends for air temperature, precipitation, snowpack, streamflow, and water temperature based on recent regional climate change studies. The second part of this chapter assesses the effects of these projected climate changes on the resources included for analysis for each of the alternatives.

4.1 CLIMATE CHANGE IN THE COLUMBIA RIVER BASIN

The environmental consequences on the physical, biological, economic, social, and cultural resources discussed in Chapter 3 reflect modeling and analyses based on observed climate in the region over the 80-year period of 1929 to 2008. Temperatures have increased during and after that time period and are expected to continue to increase (U.S. Global Change Research Program [USGCRP] 2017; River Management Joint Operating Committee [RMJOC] 2018). As a result of these rising temperatures, other aspects of the environment are changing as well, such as receding glaciers, diminishing snow cover, shrinking sea ice, rising sea levels, and increasing atmospheric water vapor (USGCRP 2017). According to the Fourth National Climate Assessment Volume I (USGCRP 2017), annual trends of earlier spring snow melt and reduced snowpack are already affecting water resources in the western United States, and these trends are expected to continue. Numerous studies have projected that as warming continues, snowpack in the Columbia River Basin is likely to decline, winter streamflows will tend to increase, peak seasonal snowmelt season will tend to occur earlier in the spring, and summer flows will likely decrease (RMJOC 2018).

The basis for climate assessment in this EIS includes projected regional temperature, precipitation, snowpack, and streamflow changes from the first part of the second RMJOC long-term planning study, commonly referred to as the RMJOC-II study. Part 1 of this study presents the results of a 4-year research project completed by the University of Washington and Oregon State University, with resource support and technical expertise provided by the RMJOC¹ agencies and regional stakeholders (RMJOC 2018). This study presents the most recent and best available scientific information on the future hydroclimate for the Columbia River Basin. The RMJOC-II report (2018) found the following for the 2020 to 2049 time period (referred to as the 2030s):

- Temperatures in the region have warmed about 1.5 degrees Fahrenheit (0.8 degrees Celsius) since the 1970s. They are expected to warm another 1 to 4 degrees Fahrenheit (0.6 to 2.2 degrees Celsius) by the 2030s.

1 The RMJOC comprises the Bonneville Power Administration (Bonneville), U.S. Army Corps of Engineers (Corps), and U.S. Bureau of Reclamation (Reclamation), also referred to collectively as the co-lead agencies throughout this EIS. An objective of the committee is to evaluate and anticipate vulnerabilities, risk, and resiliency of the Federal Columbia River Power System.

- 36 • Warming in the region is likely to be greatest in the interior with a greater range of possible
37 outcomes. Less pronounced warming is projected near the coast.
- 38 • Future precipitation trends are more uncertain, but a general upward trend is likely for the
39 rest of the twenty-first century, particularly in the winter months. Already dry summers
40 could become drier.
- 41 • Average winter snowpacks are very likely to decline over time as more winter precipitation
42 falls as rain instead of snow, especially on the United States side of the Columbia River
43 Basin.
- 44 • By the 2030s, higher average fall and winter flows, earlier peak spring runoff, and longer
45 periods of low summer flows are very likely. The earliest and greatest streamflow changes
46 are likely to occur in the Snake River Basin, although that basin has the greatest modeling
47 uncertainty.

48 The RMJOC-II report concludes that “such precipitation increases, along with a warming
49 climate, could have profound implications on both the magnitude and seasonality of future
50 streamflows for hydroregulation operations and planning.”

51 **4.1.1 Approach**

52 This EIS uses climate and hydrology projections from the RMJOC-II study to assess potential
53 effects to the resources and effectiveness of the alternatives of the EIS. In 2013, the RMJOC
54 commissioned a research team from the University of Washington and Oregon State University
55 to develop a set of unregulated streamflows derived from the latest global climate model
56 projections from the Intergovernmental Panel on Climate Change’s (IPCC’s) Fifth Assessment
57 (RMJOC 2018). These unregulated streamflows are largely unaffected by human activity in the
58 Columbia River Basin (i.e., no human regulation, dams, or irrigation withdrawals). The resulting
59 report provides air temperature, precipitation, snowpack, and streamflow changes that are
60 projected to occur as the regional climate changes. A second part of the RMJOC-II study, which
61 is not yet available, will provide an assessment of how these projected unregulated
62 streamflows perform in a regulated Columbia River system.²

63 The RMJOC-II projections include scenarios for two Representative Concentration Pathways
64 (RCPs), RCP 4.5 and RCP 8.5, which represent future scenarios for emissions of greenhouse
65 gases (GHGs). Over the next 20- to 30-year time horizon, both RCP 4.5 and RCP 8.5 project a
66 similar increase in regional temperatures (Moss et al. 2010; RMJOC 2018). However, where
67 applicable, conclusions for the two different RCPs are identified separately.

68 The RMJOC-II study focused on changes in air temperature, precipitation, snowpack, and
69 streamflow. Other aspects of climate change, such as water temperature and sea level rise, may
70 have implications for regional resources as well, but were not modeled in the RMJOC-II study.

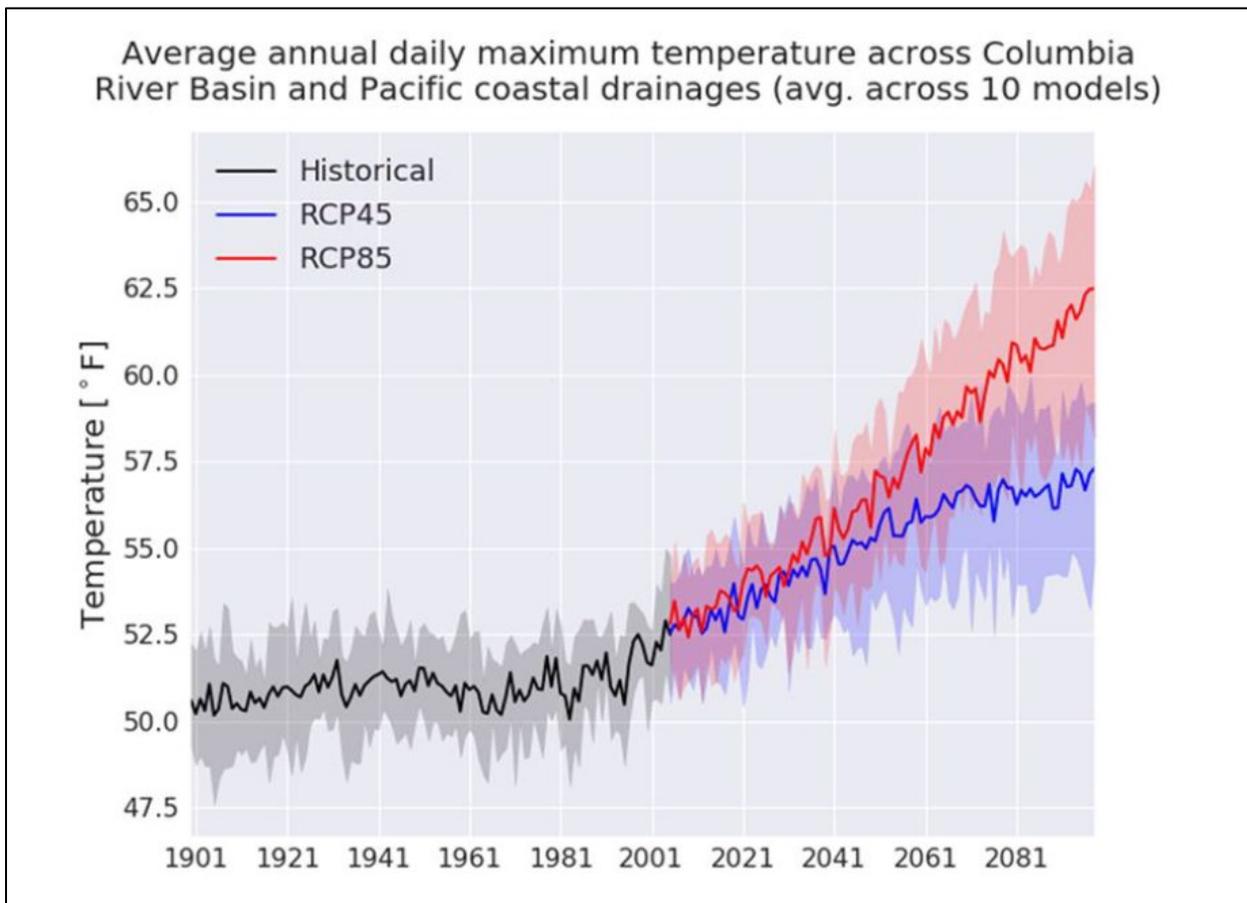
² The co-lead agencies expect this study to be published in spring 2020 after release of the draft EIS and will review the study to determine if any information presented in the draft EIS needs to be updated.

71 Where applicable, other climate research and literature are incorporated to assess these
72 potential effects on resources.

73 4.1.2 Projected Changes in Hydroclimate

74 4.1.2.1 Air Temperature

75 Temperatures have already warmed in the Columbia River Basin by about 1.5 degrees
76 Fahrenheit since the 1970s (Figure 4-1) (RMJOC 2018). The RMJOC-II study found that warming
77 is nearly certain to continue with annual projected temperature increases from the historical
78 period (1970 to 1999) to the 2030s, ranging from 2.0 to around 5.5 degrees Fahrenheit across
79 the Columbia River Basin. However, these projections vary both by geographic location and
80 seasonally. Interior areas of the basin are projected to experience more warming than areas
81 near the Pacific Coast, where warming of 1.5 to 2.5 degrees Fahrenheit is projected. Warming is
82 also projected to be greater during the summer months compared to the other seasons.



83
84 **Figure 4-1. Average Annual Daily Maximum Temperatures for the Columbia River Basin and**
85 **Pacific Coastal Drainages in Washington and Oregon Through 2100 for RCP 4.5 and 8.5**

86 Source: RMJOC (2018)

87 **4.1.2.2 Precipitation**

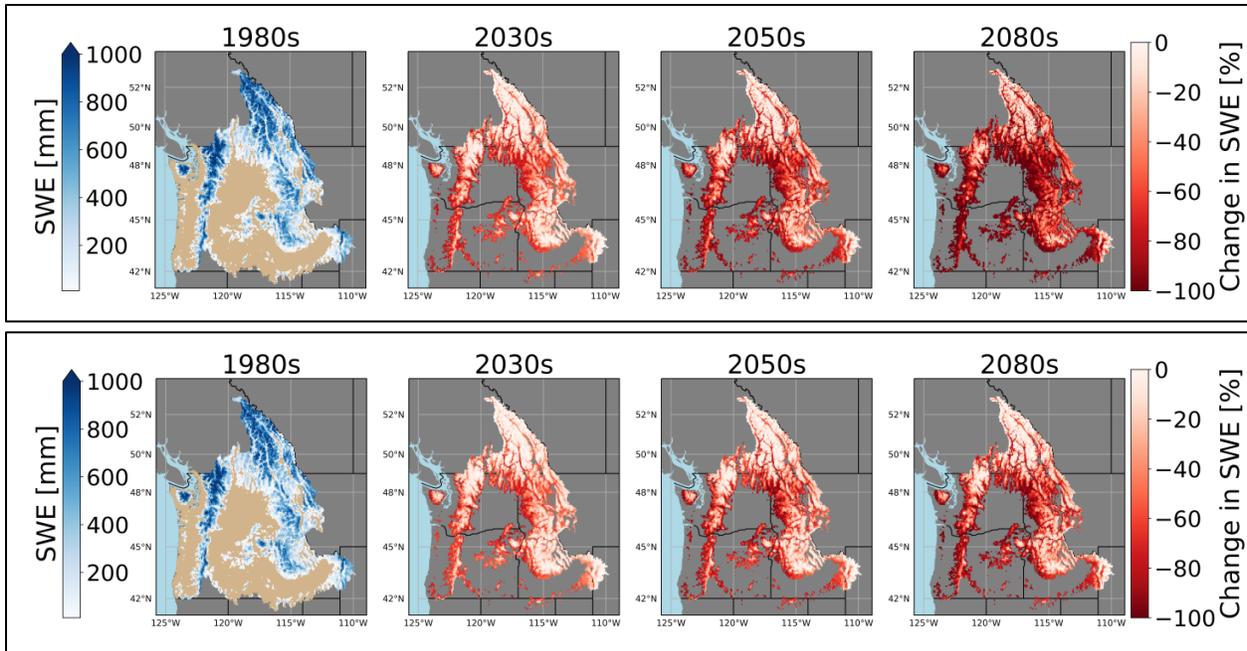
88 The large annual variability in precipitation in the Columbia River Basin is projected to continue.
89 However, there is a general tendency for precipitation to increase, and by the 2030s,
90 precipitation will begin to exceed the long-term average more often than not (RMJOC 2018).
91 Changes in precipitation are likely to vary across seasons, with a tendency for higher winter
92 precipitation and lower summer precipitation. However, some model projections imply that
93 summer precipitation could increase over the southern half of the Columbia River Basin. While
94 precipitation trends are more uncertain than temperature trends, these results have been
95 supported by other recent climate model projections (Salathé et al. 2014; Department of
96 Energy [DOE] 2017; Rupp, Abatzoglou, and Mote 2017).

97 **4.1.2.3 Snowpack**

98 The RMJOC-II study projects that snowpack in the Columbia River Basin will decrease over time.
99 Even with the possibility of more precipitation in the winter, warming temperatures are very
100 likely to result in declining snowpacks available to support spring and summer runoff. Given
101 that historically most of the Columbia River Basin's annual precipitation and flow have been
102 snow-dominated, with at least half of the annual precipitation falling as snow, these changes
103 over time represent perhaps the greatest hydroclimate change in the region.

104 As depicted in Figure 4-2, the snowpack on April 1 (the date near where the snowpack typically
105 reaches its annual maximum in the U.S. portion of the Columbia River Basin) is projected to
106 decrease. By the 2030s³ (2020 to 2049), the April 1 Snow Water Equivalent is projected to be
107 between 10 to 60 percent lower in the Cascades, coastal mountains, and lower portions of the
108 Clearwater and Spokane River Basins, with continued decreases over time as more precipitation
109 falls as rain instead of snow. One exception to these trends is in the Canadian portion of the
110 Columbia River Basin where average winter temperatures, even with the degree of warming
111 expected, are unlikely to be great enough to lead to significant reductions in snowpack through
112 the 2030s (RMJOC 2018).

³ Standard nomenclature for climate change studies referring to the 30-year period surrounding the 2020s (2010 to 2039).



113

114

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

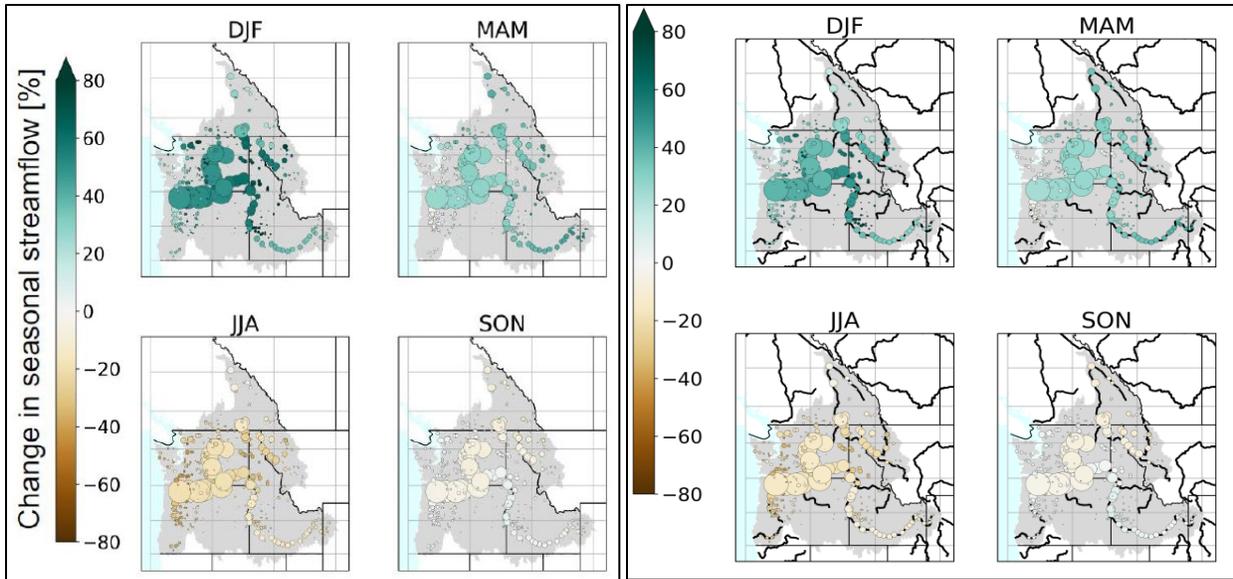
117 Note: Top is RCP 8.5 and bottom is RCP 4.5. Areas in tan historically have less than 10 millimeters (0.4 inches) of
118 snow-water equivalent. Although this EIS focuses on the 2030s, the 2050s and 2080s are included in the analysis to
119 show trends.

120 Source: University of Washington

121 **4.1.2.4 Streamflow**

122 The RMJOC-II study (2018) concluded that by the 2030s, the Columbia River Basin will likely
123 experience higher average winter flows, earlier peak spring runoff, lower average summer
124 flows, a longer period of low summer flows, or a combination of all of these. These findings
125 align with those of previous studies, including the RMJOC-I report (2010), the Fourth National
126 Climate Assessment (USGCRP 2017), the DOE Report to Congress (DOE 2017), and the
127 Reclamation SECURE Water Act Assessment (Reclamation 2016).

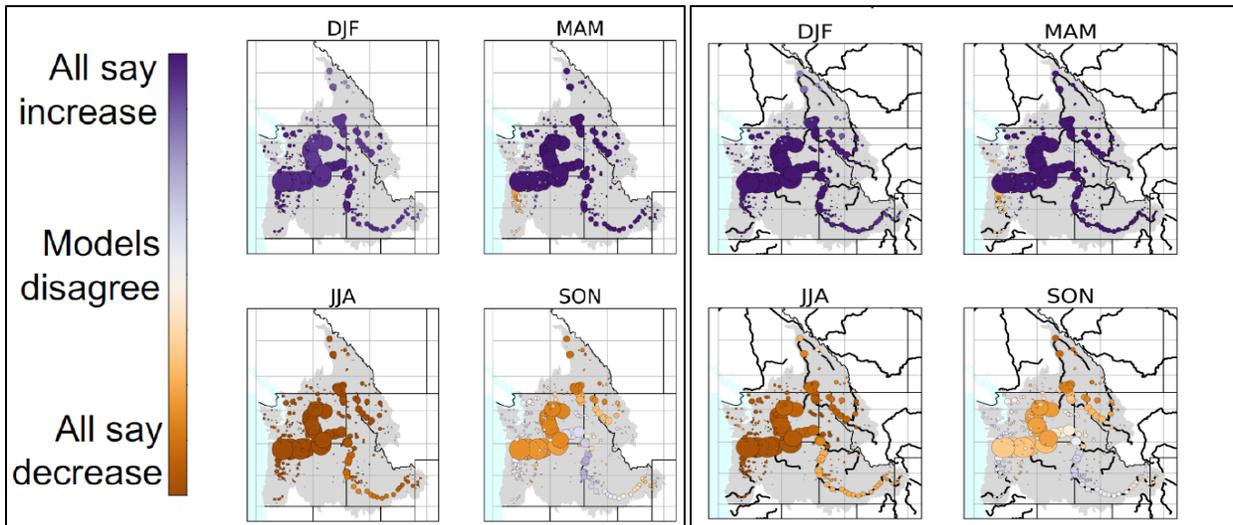
128 For the Columbia River Basin as a whole, the warming temperatures and tendency for increased
129 precipitation, particularly in the already wet winter months, will result in higher winter and
130 spring volumes with earlier spring flow peaks. In the summer, there is a tendency for slightly
131 lower flows or a longer period of low flows. However, these results are not necessarily universal
132 across all basins. The Willamette River Basin and coastal drainage areas have a tendency
133 toward lower spring flows, and there is some disagreement across models in the Snake River
134 Basin where some scenarios show the possibility of increased fall streamflows (RMJOC 2018).
135 Figure 4-3 and Figure 4-4 show the projected changes in seasonal streamflow by location across
136 the Columbia River Basin.



137
138 **Figure 4-3. Percent Change in Annual Volume from the Historical Period (1976–2005) and the**
139 **2030s (2020–2049) by Season**

140 Note: Left is RCP 8.5 and right is RCP 4.5. DJF = December to February/winter; MAM = March-May/spring; JJA =
141 June to August/summer; SON = September to November/fall. Circle size denotes relative annual volumes in the
142 historical period (1976–2005).

143 Source: University of Washington



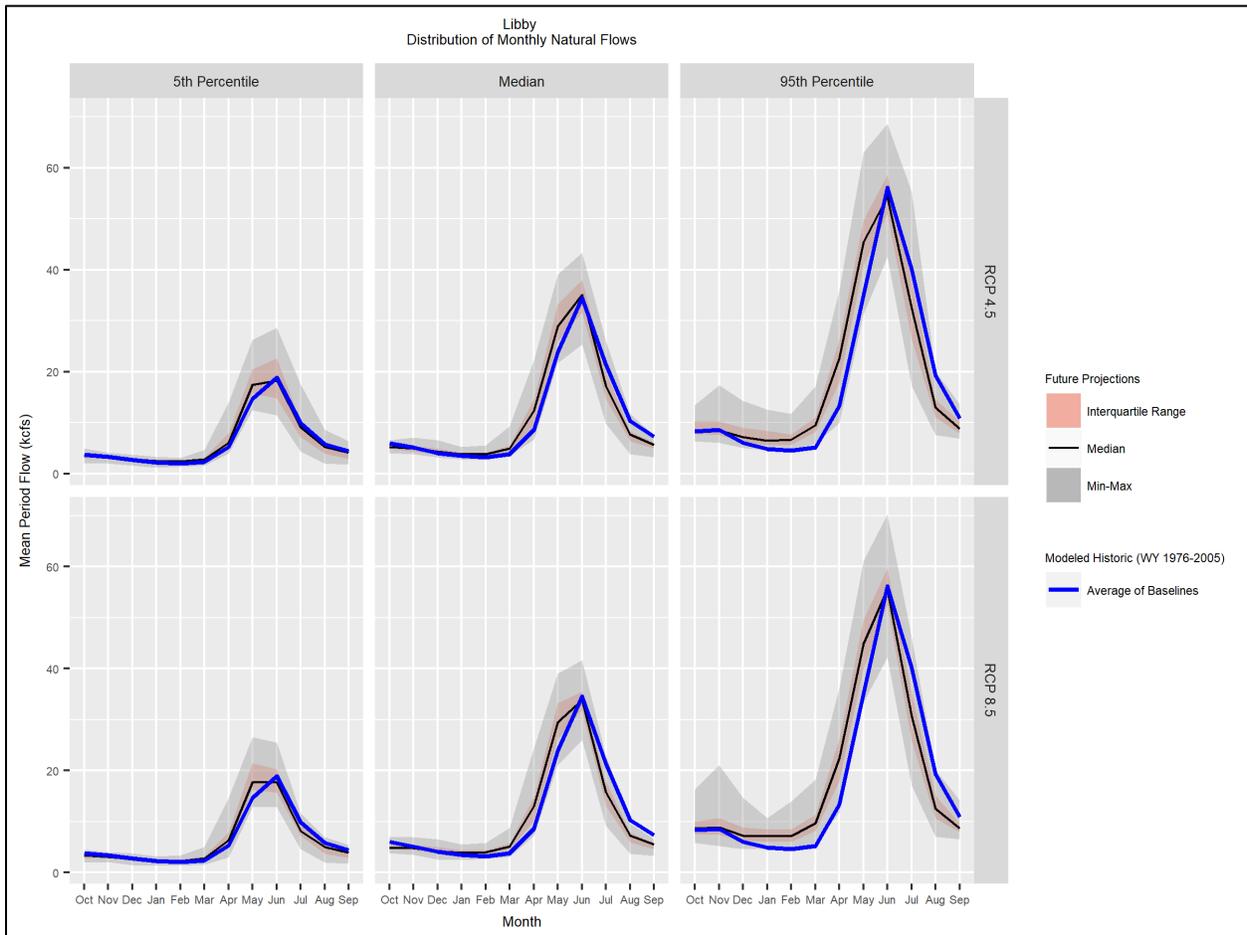
144
145 **Figure 4-4. Annual Volume Change from the Historical Period (1976–2005) and the 2030s**
146 **(2020–2049) by Season**

147 Note: Left is RCP 8.5 and right is RCP 4.5. DJF = December to February/winter; MAM = March-May/spring; JJA =
148 June to August/summer; SON = September to November/fall.

149 Source: University of Washington

150 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

151 Changes in these upper basins tend to be more modest through the 2030s, largely because
 152 winter precipitation is projected to continue to fall as snow for some time. However, even here
 153 the scenarios still project increased temperatures and annual precipitation, and changes in
 154 spring and early summer streamflow. Some scenarios indicate higher spring freshet peaks that
 155 tend to occur 1 or 2 weeks earlier, by the 2030s (RMJOC 2018). Decreasing summer flow
 156 volumes are pervasive in these basins. At the headwater of the Pend Oreille River, changes in
 157 inflows to Hungry Horse Dam are relatively modest by the 2030s, with slightly earlier timing and
 158 intensified high flows in winter and early spring (Table 4-1, Table 4-2, Table 4-3, Figure 4-5,
 159 Figure 4-6, and Figure 4-7).



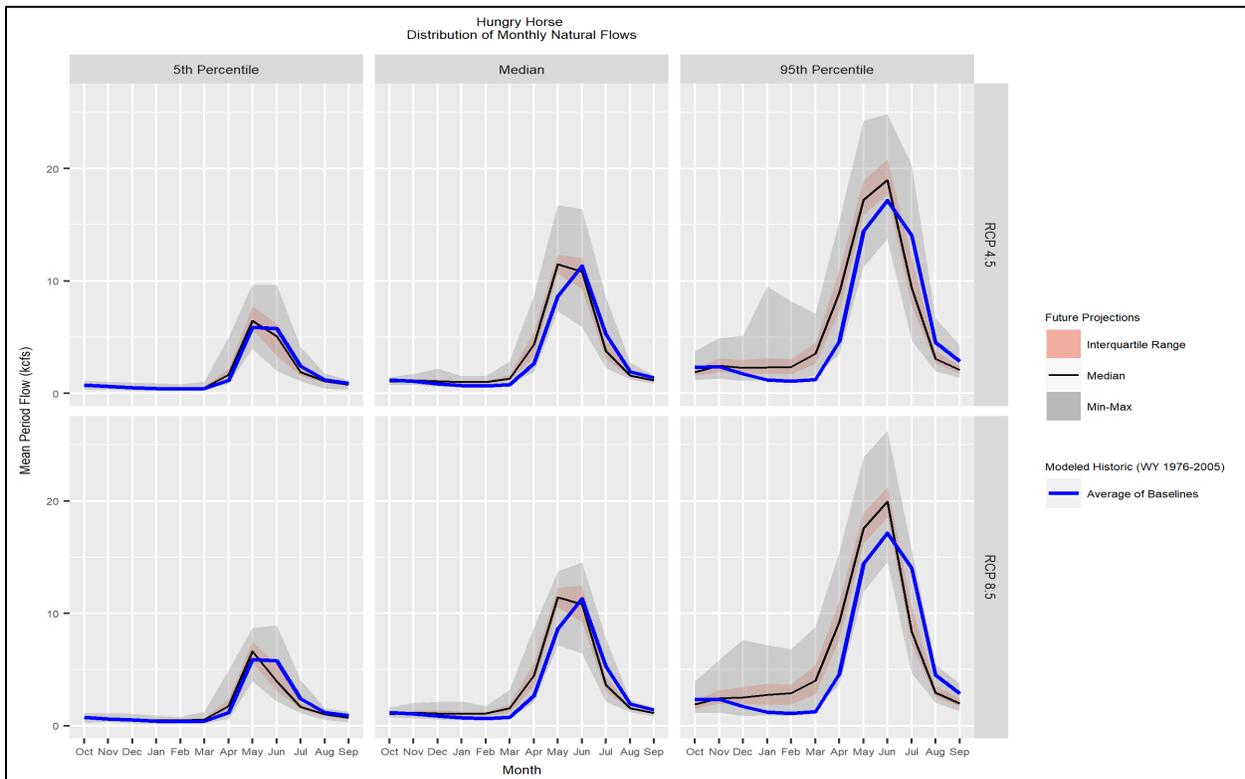
160
 161 **Figure 4-5. Distribution of the RMJOC-II Naturalized Flows, by Month at Libby Dam for the**
 162 **2030s Time Period for RCP 4.5 and 8.5**

163 Note: The “average of the baselines” represents four hydrology models/parameter sets that were used to model a
 164 30-year historical (1976–2005) condition for RMJOC-II, with each historical condition being modeled. Each of the
 165 four historical conditions were modeled with a different hydrology model or parameter set. The RMJOC-II modeled
 166 historical conditions are not equivalent to the 80-year water conditions described previously in this EIS because
 167 they include adjustments for temperature biases in historical datasets (RMJOC 2018).

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

Month	5th Percentile Flow		50th Percentile Flow		95th Percentile Flow	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Oct	-38 to 26 (-5)	-39 to 15 (-12)	-31 to 12 (-12)	-37 to 20 (-18)	-17 to 55 (4)	-29 to 88 (5)
Nov	-37 to 27 (-5)	-33 to 22 (-12)	-24 to 27 (-5)	-28 to 30 (-6)	-33 to 88 (3)	-33 to 128 (3)
Dec	-41 to 36 (2)	-46 to 36 (-5)	-25 to 54 (6)	-33 to 53 (2)	-16 to 152 (21)	-19-159 (21)
Jan	-46 to 50 (12)	-40 to 38 (8)	-25 to 58 (11)	-32 to 65 (11)	-7 to 190 (33)	-8-146 (45)
Feb	-40 to 60 (24)	-35 to 65 (18)	-19 to 72 (21)	-23 to 90 (25)	0 to 177 (43)	-4-229 (60)
Mar	-25 to 94 (18)	-26 to 92 (19)	-1 to 136 (28)	-14 to 123 (34)	21 to 256 (82)	26-296 (83)
Apr	-16 to 142 (17)	-34 to 115 (21)	-5 to 130 (36)	0 to 139 (47)	-13 to 152 (70)	0-145 (63)
May	-17 to 82 (24)	-17 to 54 (27)	-9 to 52 (22)	-9 to 59 (25)	-2 to 74 (30)	-1-62 (28)
Jun	-41 to 48 (-4)	-34 to 32 (-5)	-25 to 27 (2)	-23 to 15 (-3)	-27 to 24 (-4)	-28-27 (-2)
Jul	-46 to 60 (-13)	-42 to 17 (-19)	-43 to 11 (-23)	-51 to 2 (-27)	-45 to 27 (-21)	-45 to -3 (-25)
Aug	-48 to 30 (-17)	-49 to 9 (-20)	-49 to 0 (-30)	-52 to -12 (-34)	-55 to -9 (-35)	-53 to -7 (-34)
Sep	-40 to 23 (-14)	-42 to 10 (-19)	-49 to -1 (-26)	-47 to -11 (-30)	-38 to 22 (-18)	-40 to 28 (-20)

169 Note: The relative change was computed by comparing the value of the flow quantile for the 2030s (2020–2049) to
 170 that of the historical modeled baseline period (1976–2005). The ranges of relative change for each set of 80
 171 projections are presented, and the median change is reported in parentheses for each emission scenario. The color
 172 gradient scale of the shading reflects reductions of volume of the median projection of 50% or greater as dark
 173 brown and increases of 50% or greater dark green. These colors lighten to white as the relative change approaches
 174 zero. Bold text indicates that 90% of the projections agree on the direction of change in volume.

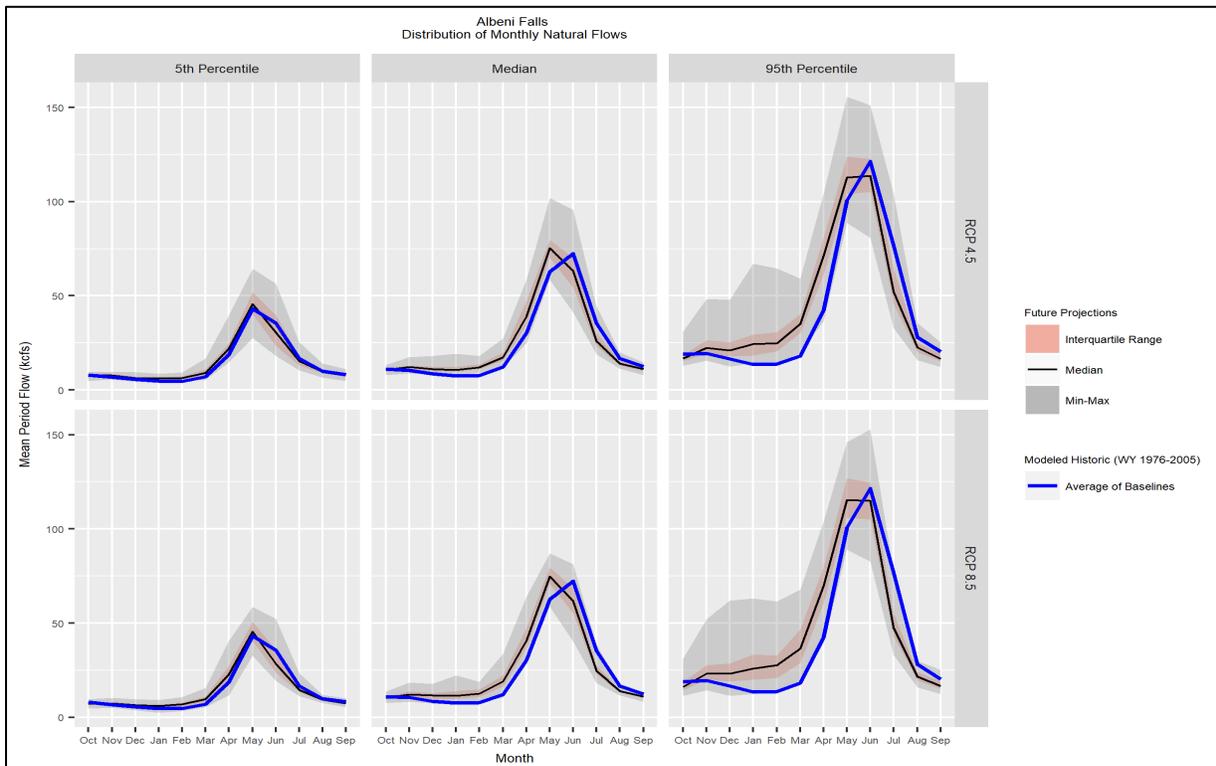


175 **Figure 4-6. Distribution of the RMJOC-II Naturalized Flows, by Month at Hungry Horse Dam**
 176 **for the 2030s Time Period for RCP 4.5 and 8.5**
 177

178 **Table 4-2. Relative Change (%) in Unregulated Monthly Streamflow at Hungry Horse Dam**

Month	5th Percentile Flow		50th Percentile Flow		95th Percentile Flow	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Oct	-50 to 31 (-4)	-64 to 29 (-12)	-42 to 24 (-13)	-39 to 41 (-15)	-53 to 70 (-19)	-54 to 79 (-19)
Nov	-36 to 58 (8)	-28 to 59 (6)	-25 to 70 (9)	-35 to 99 (12)	-33 to 88 (6)	-43 to 125 (4)
Dec	-54 to 57 (7)	-46 to 75 (6)	-22 to 158 (29)	-32 to 152 (34)	-27 to 161 (32)	-44 to 288 (50)
Jan	-40 to 96 (15)	-57 to 103 (15)	-19 to 125 (40)	-31 to 213 (51)	-14 to 757 (100)	-27 to 546 (128)
Feb	-35 to 127 (24)	-58 to 122 (25)	-7 to 147 (54)	-15 to 178 (63)	-9 to 666 (120)	-23 to 538 (153)
Mar	-28 to 158 (20)	-39 to 206 (31)	12 to 269 (71)	-23 to 354 (95)	23 to 520 (186)	12 to 617 (222)
Apr	-24 to 261 (45)	-48 to 313 (51)	-14 to 215 (61)	-5 to 232 (64)	-3 to 186 (99)	8 to 210 (101)
May	-30 to 67 (14)	-39 to 57 (13)	5 to 74 (31)	4 to 78 (33)	-11 to 81 (19)	2 to 70 (23)
Jun	-66 to 56 (-13)	-62 to 53 (-33)	-47 to 41 (-7)	-42 to 25 (-5)	-22 to 46 (12)	-11 to 55 (16)
Jul	-51 to 34 (-19)	-49 to 30 (-28)	-52 to 26 (-25)	-51 to 14 (-31)	-62 to 23 (-31)	-63 to -10 (-37)
Aug	-58 to 39 (-11)	-46 to 16 (-15)	-38 to 25 (-18)	-39 to 4 (-18)	-57 to 19 (-29)	-54 to 14 (-31)
Sep	-58 to 23 (-13)	-60 to 25 (-22)	-41 to 11 (-15)	-40 to 14 (-16)	-49 to 51 (-28)	-52 to 32 (-30)

179 Note: The relative change was computed by comparing the value of the flow quantile for the 2030s (2020–2049) to
 180 that of the historical modeled baseline period (1976–2005). The ranges of relative change for each set of 80
 181 projections are presented, and the median change is reported in parentheses for each emission scenario. The color
 182 gradient scale of the shading reflects reductions of volume of the median projection of 50% or greater as dark
 183 brown and increases of 50% or greater dark green. These colors lighten to white as the relative change approaches
 184 zero. Bold text indicates that 90% of the projections agree on the direction of change in volume.



185 **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 8.5**
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 187

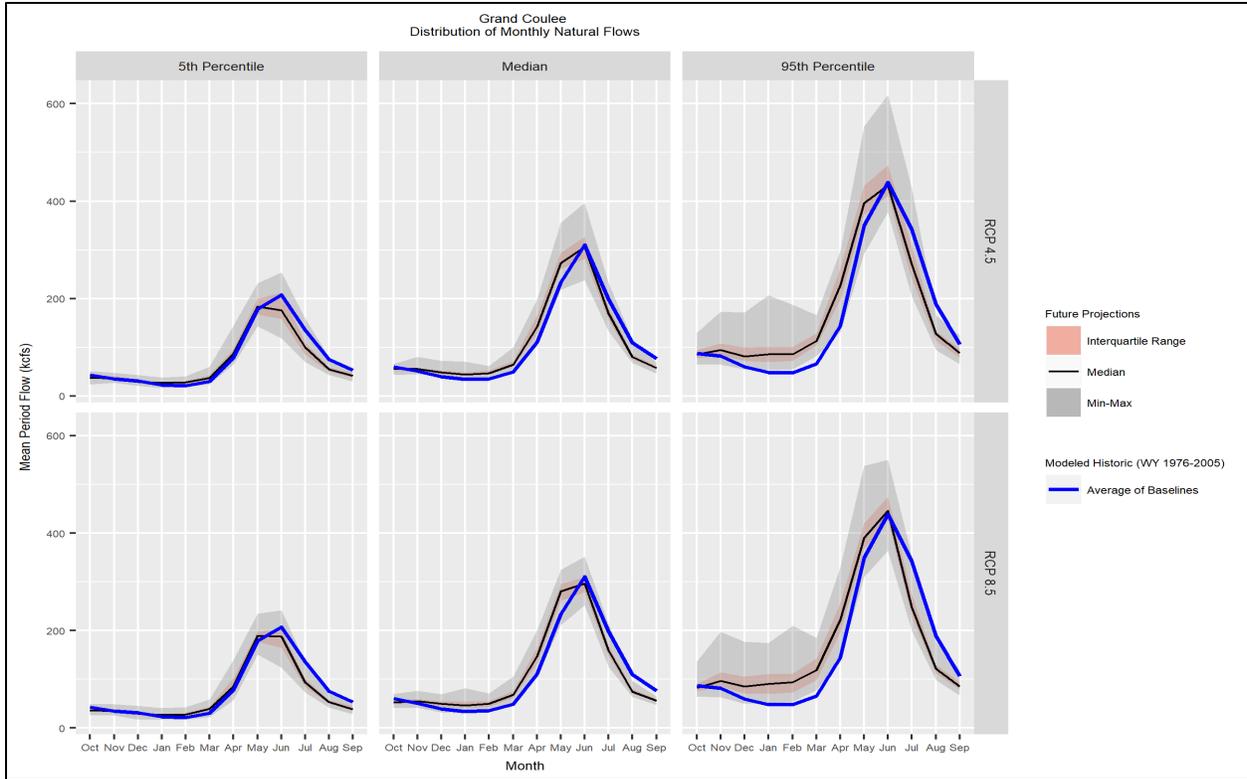
188 **Table 4-3. Relative Change (%) in Unregulated Monthly Streamflow at Albeni Falls Dam**

Month	5th Percentile Flow		50th Percentile Flow		95th Percentile Flow	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Oct	-35 to 18 (-5)	-36 to 15 (-10)	-25 to 15 (-4)	-29 to 26 (-7)	-25 to 41 (-10)	-33 to 42 (-14)
Nov	-11 to 53 (15)	-13 to 57 (9)	-11 to 68 (15)	-17 to 78 (17)	-17 to 117 (21)	-24 to 133 (23)
Dec	-12 to 62 (14)	-22 to 78 (14)	1 to 115 (28)	-11 to 113 (35)	-18 to 199 (26)	-35 to 287 (39)
Jan	-16 to 86 (27)	-49 to 94 (28)	7 to 173 (41)	-2 to 217 (53)	1 to 429 (86)	-5 to 397 (93)
Feb	-9 to 129 (40)	-33 to 133 (49)	16 to 136 (56)	1 to 158 (68)	-1 to 370 (75)	5 to 348 (104)
Mar	-8 to 129 (30)	-19 to 124 (35)	4 to 133 (43)	-9 to 188 (57)	18 to 210 (88)	16 to 254 (105)
Apr	-19 to 127 (15)	-37 to 133 (23)	-9 to 92 (33)	3 to 99 (36)	-2 to 119 (72)	6 to 150 (68)
May	-35 to 47 (9)	-29 to 35 (8)	-5 to 56 (20)	-2 to 38 (21)	-22 to 69 (11)	-14 to 44 (15)
Jun	-51 to 55 (-13)	-47 to 50 (-22)	-42 to 25 (-13)	-39 to 14 (-12)	-36 to 18 (-7)	-26 to 20 (-6)
Jul	-37 to 42 (-9)	-33 to 32 (-13)	-47 to 16 (-25)	-50 to 1 (-28)	-57 to 20 (-29)	-53 to -19 (-35)
Aug	-31 to 48 (-2)	-23 to 25 (-3)	-29 to 15 (-16)	-29 to -5 (-17)	-44 to 9 (-21)	-44 to 10 (-22)
Sep	-37 to 36 (0)	-29 to 17 (-7)	-33 to 14 (-11)	-30 to 8 (-12)	-34 to 16 (-17)	-36 to 20 (-17)

189 Note: The relative change was computed by comparing the value of the flow quantile for the 2030s (2020–2049) to
 190 that of the historical modeled baseline period (1976–2005). The ranges of relative change for each set of 80
 191 projections is presented, and the median change is reported in parentheses for each emission scenario. The color
 192 gradient scale of the shading reflects reductions of volume of the median projection of 50% or greater as dark
 193 brown and increases of 50% or greater dark green. These colors lighten to white as the relative change approaches
 194 zero. Bold text indicates that 90% of the projections agree on the direction of change in volume.

195 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

196 Cumulative streamflow in Region B integrates flows from Region A and the Upper Columbia,
 197 the northernmost part of the Columbia Basin in British Columbia. Similar to Region A,
 198 streamflow projections show modest change, as snowpack at high elevations of the upper basin
 199 display less sensitivity to lower amounts of warming (Figure 4-2). However, a shift toward
 200 earlier spring and summer streamflow volumes is projected. Some projections indicate higher
 201 spring freshet peaks, which tend to occur 1 or 2 weeks earlier by the 2030s as precipitation
 202 increases in this part of the basin and the climate warms. Nearly all projections indicate
 203 decreased volume of flow in the summer months (Figure 4-8 and Table 4-4).



204
205 **Figure 4-8. Distribution of the RMJOC-II Naturalized Flows, by Month, at Grand Coulee Dam**
206 **for the 2030s Time Period for RCP 4.5 and 8.5**

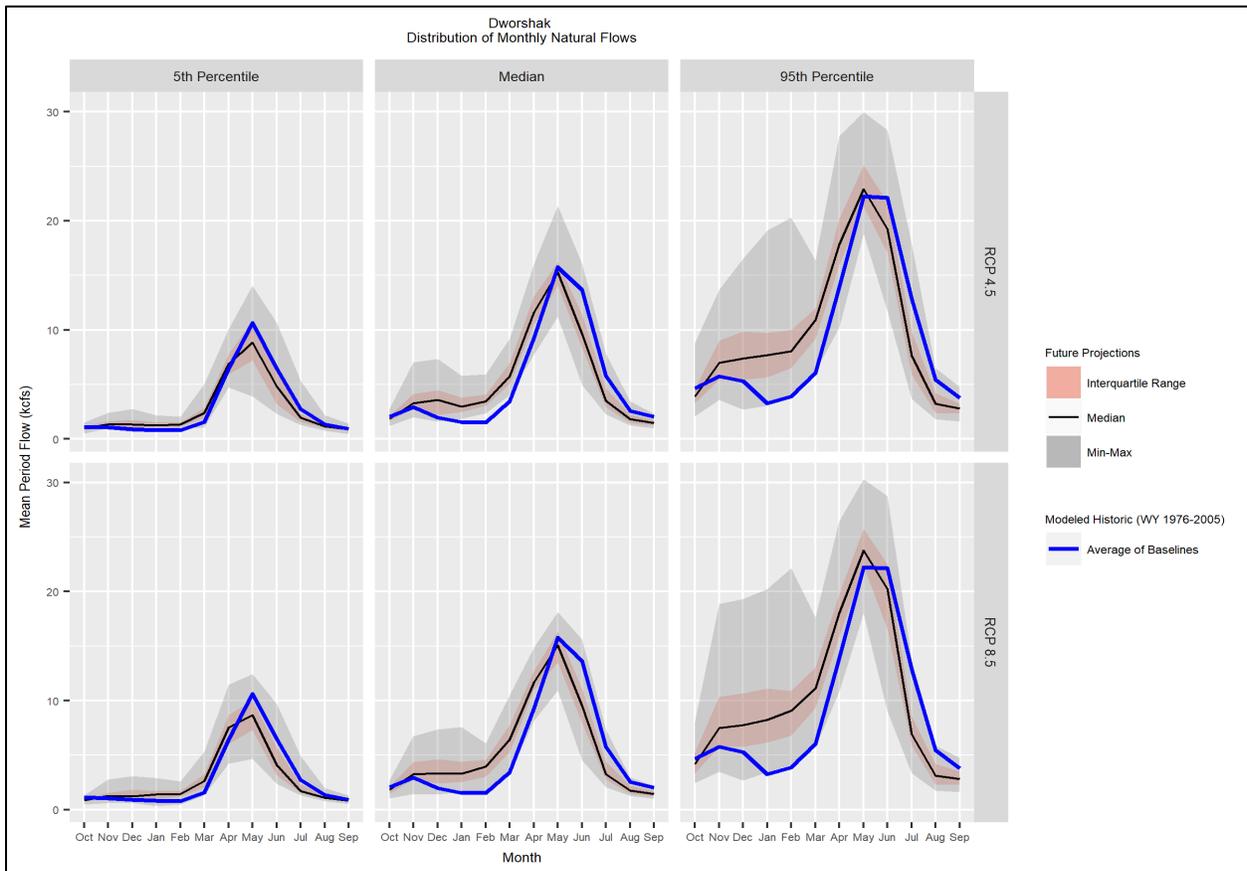
207 **Table 4-4. Relative Change (%) in Unregulated Monthly Streamflow at Grand Coulee Dam**

Month	5th Percentile Flow		50th Percentile Flow		95th Percentile Flow	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Oct	-45 to 17 (-10)	-40 to 14 (-13)	-27 to 14 (-8)	-31 to 20 (-13)	-20 to 38 (-1)	-26 to 45 (-5)
Nov	-22 to 33 (2)	-23 to 36 (-2)	-12 to 56 (8)	-17 to 49 (8)	-19 to 89 (17)	-15 to 116 (22)
Dec	-31 to 41 (-7)	-44 to 48 (-8)	4 to 86 (19)	-15 to 79 (27)	-5 to 186 (34)	-12 to 195 (43)
Jan	-27 to 73 (17)	-27 to 86 (14)	4 to 116 (28)	-13 to 150 (37)	7 to 364 (74)	4 to 290 (82)
Feb	-17 to 108 (33)	-19 to 115 (31)	8 to 76 (31)	-8 to 100 (40)	13 to 302 (77)	9 to 349 (95)
Mar	-18 to 103 (23)	-23 to 99 (28)	3 to 103 (33)	-7 to 123 (41)	28 to 135 (72)	22 to 186 (82)
Apr	-21 to 87 (9)	-31 to 80 (8)	-2 to 82 (33)	4 to 82 (32)	4 to 97 (62)	13 to 119 (52)
May	-22 to 31 (4)	-18 to 33 (6)	0 to 42 (18)	0 to 43 (19)	-8 to 56 (14)	-9 to 58 (11)
Jun	-43 to 20 (-15)	-41 to 15 (-10)	-22 to 25 (-1)	-17 to 11 (-4)	-15 to 38 (0)	-12 to 25 (2)
Jul	-51 to 19 (-27)	-46 to -3 (-31)	-33 to 6 (-14)	-37 to -2 (-20)	-40 to 7 (-21)	-38 to -8 (-27)
Aug	-44 to 11 (-28)	-46 to -11 (-30)	-41 to 2 (-27)	-43 to -8 (-31)	-53 to -15 (-33)	-52 to -12 (-35)
Sep	-46 to 19 (-23)	-48 to 11 (-28)	-41 to -12 (-23)	-39 to -16 (-28)	-38 to 11 (-16)	-36 to 5 (-18)

208 Note: The relative change was computed by comparing the value of the flow quantile for the 2030s (2020–2049) to
209 that of the historical modeled baseline period (1976–2005). The ranges of relative change for each set of 80
210 projections are presented, and the median change is reported in parentheses for each emission scenario. The color
211 gradient scale of the shading reflects reductions of volume of the median projection of 50% or greater as dark
212 brown and increases of 50% or greater dark green. These colors lighten to white as the relative change approaches
213 zero. Bold text indicates that 90% of the projections agree on the direction of change in volume.

214 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
215 **HARBOR DAMS**

216 In the Snake River Basin, most scenarios project even greater warming relative to the historical
217 period compared to the other basins, but with a larger range of possible temperature
218 outcomes. Precipitation is projected to increase in both winter and spring (RMJOC 2018).
219 Projections for summer precipitation are more uncertain, with most indicating drier summers,
220 but some also suggesting a potential for wetter summers. Models suggest that as early as the
221 2020s, snowpacks in this basin are likely to decrease with streamflow timing changes appearing
222 earlier here than other parts of the Columbia River Basin. The RMJOC-II study projects higher
223 fall and winter flows, with the potential for multiple winter flow peaks and earlier and higher
224 spring flow peaks. The period of low summer flows that historically extend from mid-July to
225 October may shift earlier over time (Table 4-5, Table 4-6, Figure 4-9 and Figure 4-10; RMJOC
226 2018).

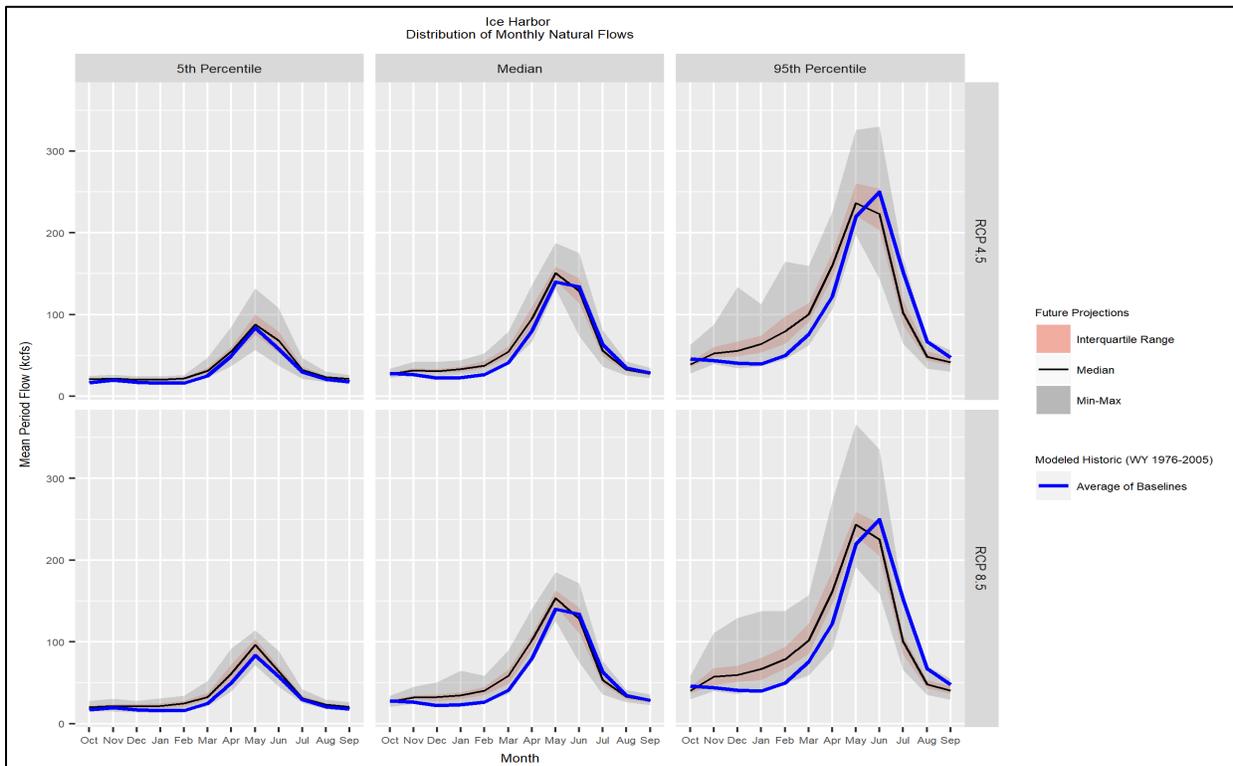


227 **Figure 4-9. Distribution of the RMJOC-II Naturalized Flows, by Month at Dworshak Dam for**
228 **the 2030s Time Period for RCP 4.5 and 8.5**
229

230 **Table 4-5. Relative Change (%) in Unregulated Monthly Streamflow at Dworshak Dam**

Month	5th Percentile Flow		50th Percentile Flow		95th Percentile Flow	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Oct	-51 to 63 (-13)	-49 to 35 (-23)	-25 to 12 (-10)	-37 to 21 (-11)	-48 to 85 (-18)	-38 to 69 (-13)
Nov	-15 to 108 (31)	-48 to 138 (22)	-14 to 99 (14)	-39 to 92 (15)	-16 to 75 (31)	-14 to 141 (37)
Dec	-7 to 171 (48)	-18 to 211 (56)	11 to 207 (63)	-1 to 208 (80)	-23 to 143 (53)	-23 to 192 (61)
Jan	-25 to 166 (61)	-50 to 253 (66)	29 to 264 (98)	13 to 377 (120)	17 to 397 (147)	40 to 425 (160)
Feb	3 to 188 (66)	-46 to 262 (90)	45 to 287 (131)	3 to 297 (151)	13 to 323 (113)	24 to 361 (134)
Mar	-34 to 305 (51)	-22 to 310 (70)	15 to 177 (67)	8 to 198 (92)	18 to 146 (74)	9 to 159 (92)
Apr	-23 to 76 (9)	-29 to 74 (15)	-13 to 89 (23)	-10 to 80 (29)	-12 to 106 (27)	-7 to 102 (30)
May	-64 to 34 (-15)	-56 to 13 (-18)	-32 to 54 (-2)	-34 to 29 (-3)	-23 to 38 (4)	-23 to 34 (8)
Jun	-64 to 51 (-29)	-63 to 35 (-37)	-62 to -2 (-29)	-65 to 1 (-28)	-44 to 18 (-10)	-58 to 18 (-7)
Jul	-56 to 40 (-25)	-52 to 29 (-31)	-53 to -2 (-34)	-59 to -9 (-38)	-66 to 1 (-39)	-70 to -14 (-42)
Aug	-39 to 36 (-14)	-38 to 22 (-16)	-43 to 2 (-25)	-43 to -13 (-28)	-56 to -12 (-38)	-58 to -11 (-42)
Sep	-50 to 43 (-4)	-34 to 30 (-6)	-47 to 1 (-23)	-48 to 8 (-25)	-47 to 6 (-27)	-46 to 36 (-24)

231 Note: The relative change was computed by comparing the value of the flow quantile for the 2030s (2020–2049) to
 232 that of the historical modeled baseline period (1976–2005). The ranges of relative change for each set of 80
 233 projections are presented, and the median change is reported in parentheses for each emission scenario. The color
 234 gradient scale of the shading reflects reductions of volume of the median projection of 50% or greater as dark
 235 brown and increases of 50% or greater dark green. These colors lighten to white as the relative change approaches
 236 zero. Bold text indicates that 90% of the projections agree on the direction of change in volume.



237 **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 8.5**
 238
 239

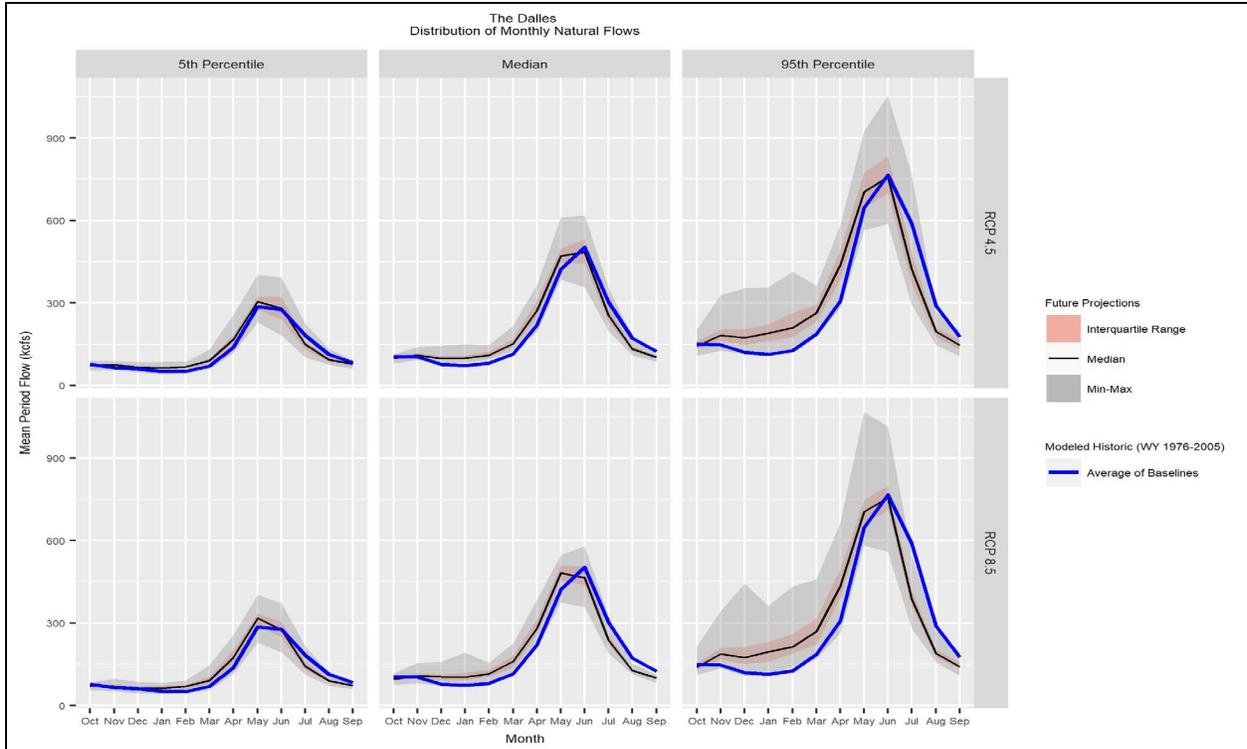
240 **Table 4-6. Relative Change (%) in Unregulated Monthly Streamflow at Ice Harbor Dam**

Month	5th Percentile Flow		50th Percentile Flow		95th Percentile Flow	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Oct	3 to 59 (20)	-7 to 74 (15)	-17 to 15 (-5)	-22 to 18 (-4)	-35 to 37 (-15)	-30 to 26 (-12)
Nov	-3 to 33 (10)	-20 to 51 (9)	6 to 60 (20)	-6 to 59 (21)	-9 to 89 (21)	-9 to 139 (33)
Dec	-2 to 59 (21)	-15 to 80 (23)	7 to 96 (39)	-4 to 136 (45)	-15 to 205 (39)	-10 to 194 (50)
Jan	2 to 60 (25)	-13 to 93 (31)	15 to 95 (42)	0 to 188 (49)	-9 to 187 (61)	9 to 250 (71)
Feb	3 to 67 (35)	-3 to 113 (54)	11 to 98 (44)	-3 to 117 (53)	-8 to 198 (62)	-2 to 150 (65)
Mar	-12 to 90 (26)	-10 to 105 (33)	-9 to 88 (32)	-10 to 101 (44)	-11 to 88 (37)	-10 to 98 (36)
Apr	-30 to 56 (9)	-19 to 76 (25)	-12 to 63 (20)	4 to 65 (25)	-1 to 70 (31)	-13 to 102 (38)
May	-26 to 57 (4)	-10 to 51 (14)	-16 to 45 (9)	-21 to 42 (11)	-11 to 49 (9)	-9 to 57 (11)
Jun	-35 to 81 (19)	-21 to 45 (12)	-41 to 30 (-4)	-40 to 26 (-4)	-39 to 25 (-9)	-33 to 30 (-11)
Jul	-21 to 49 (10)	-8 to 31 (7)	-36 to 20 (-11)	-33 to 9 (-13)	-53 to -4 (-34)	-48 to -13 (-37)
Aug	-10 to 40 (12)	-5 to 47 (13)	-22 to 12 (-2)	-19 to 14 (-5)	-48 to -7 (-24)	-42 to 9 (-29)
Sep	-5 to 55 (17)	-5 to 59 (12)	-14 to 21 (-4)	-16 to 23 (-2)	-35 to 26 (-11)	-31 to 17 (-15)

241 Note: The relative change was computed by comparing the value of the flow quantile for the 2030s (2020–2049) to
 242 that of the historical modeled baseline period (1976–2005). The ranges of relative change for each set of 80
 243 projections presented, and the median change is reported in parentheses for each emission scenario. The color
 244 gradient scale of the shading reflects reductions of volume of the median projection of 50% or greater as dark
 245 brown and increases of 50% or greater dark green. These colors lighten to white as the relative change approaches
 246 zero. Bold text indicates that 90% of the projections agree on the direction of change in volume.

247 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

248 Region D integrates the flow volumes projected for upstream regions described in the
 249 preceding sections. Consistent with projected changes in precipitation (Section 4.1.2.2) and
 250 changes in seasonal snowpack (Section 4.1.2.3), changes in volume are concentrated by season,
 251 with higher winter and spring volumes, and generally lower summer volumes. The greatest
 252 amount of change is projected for high-flow extremes during winter months (Figure 4-11;
 253 Table 4-7).



254
255 **Figure 4-11. Distribution of the RMJOC-II Naturalized Flows, by Month at The Dalles Dam for**
256 **the 2030s Time Period for RCP 4.5 and 8.5**

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

Month	5th Percentile Flow		50th Percentile Flow		95th Percentile Flow	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Oct	-29 to 13 (-4)	-27 to 7 (-8)	-21 to 9 (-5)	-25 to 13 (-9)	-24 to 28 (-6)	-24 to 31 (-10)
Nov	-15 to 34 (13)	-12 to 43 (5)	-13 to 35 (4)	-21 to 49 (6)	-12 to 75 (23)	-9 to 100 (26)
Dec	-19 to 48 (7)	-21 to 47 (8)	7 to 90 (28)	-4 to 109 (34)	0 to 183 (42)	-6 to 224 (46)
Jan	-11 to 68 (23)	-14 to 64 (24)	10 to 114 (39)	-3 to 172 (43)	4 to 221 (63)	12 to 235 (76)
Feb	-10 to 70 (34)	-4 to 76 (43)	17 to 84 (37)	-4 to 85 (45)	7 to 208 (64)	15 to 203 (67)
Mar	-11 to 94 (28)	-23 to 111 (32)	13 to 85 (32)	-2 to 98 (39)	11 to 88 (46)	-2 to 105 (48)
Apr	-22 to 61 (17)	-17 to 75 (22)	-5 to 61 (26)	6 to 64 (31)	-3 to 82 (44)	-1 to 106 (44)
May	-20 to 30 (3)	-11 to 42 (8)	-10 to 36 (13)	-10 to 30 (15)	-11 to 53 (11)	-15 to 64 (11)
Jun	-38 to 37 (2)	-30 to 30 (-2)	-28 to 19 (-3)	-26 to 11 (-7)	-24 to 21 (-3)	-20 to 27 (-3)
Jul	-37 to 18 (-18)	-34 to 7 (-21)	-31 to 7 (-15)	-36 to 0 (-21)	-48 to 1 (-28)	-46 to -18 (-32)
Aug	-32 to 22 (-18)	-36 to 4 (-19)	-37 to 2 (-23)	-35 to -10 (-26)	-51 to -16 (-31)	-45 to -15 (-35)
Sep	-27 to 20 (-8)	-26 to 14 (-14)	-33 to -3 (-18)	-34 to -5 (-20)	-34 to 5 (-17)	-33 to 10 (-20)

258 Note: The relative change was computed by comparing the value of the flow quantile for the 2030s (2020–2049) to
259 that of the historical modeled baseline period (1976–2005). The ranges of relative change for each set of 80
260 projections is presented, and the median change is reported in parentheses for each emission scenario. The color
261 gradient scale of the shading reflects reductions of volume of the median projection of 50% or greater as dark
262 brown and increases of 50% or greater dark green. These colors lighten to white as the relative change approaches
263 zero. Bold text indicates that 90% of the projections are in agreement on the direction of change in volume.

264 **4.1.2.5 Relative Sea level Change**

265 Sea level rise is closely linked to increasing global temperatures. Global mean sea level has risen
266 by about 7 to 8 inches since 1900 and is very likely to rise by another 0.5 to 1.3 feet by 2050
267 (USGCRP 2017). Locally affected future sea level is referred to as relative sea level change
268 (RSLC). RSLC reflects integrated global effects, plus local changes of geologic or oceanographic
269 origin. In the Pacific Northwest, the RSLC is likely to be less than the global average (USGCRP
270 2017). The RSLC has the potential to affect river water surface elevation as far inland as the
271 extent of the tidal influence. Tidal effects in the Columbia River extend upriver to Bonneville
272 Dam (River Mile [RM] 146).

273 Corps policy guidance (ER 1100-2-8162, Corps, 2013) applies a scenario-based approach to
274 evaluate the effects of RSLC. This scenario approach bounds a range of RSLC using three equally
275 plausible scenarios. Each of the three scenarios is based on the latest actionable science from
276 the IPCC, National Oceanic and Atmospheric Administration (NOAA) and National Research
277 Council (NRC). The RSLC scenarios are specific for a given coastal location and generated for
278 each NOAA tide station that meets quality control protocol requirements (Corps 2013). The
279 low, intermediate, and high scenarios for NOAA tide gauges can be obtained using the Corps
280 online sea level calculator at http://corpsmapu.usace.army.mil/rccinfo/slc/slcc_calc.html.

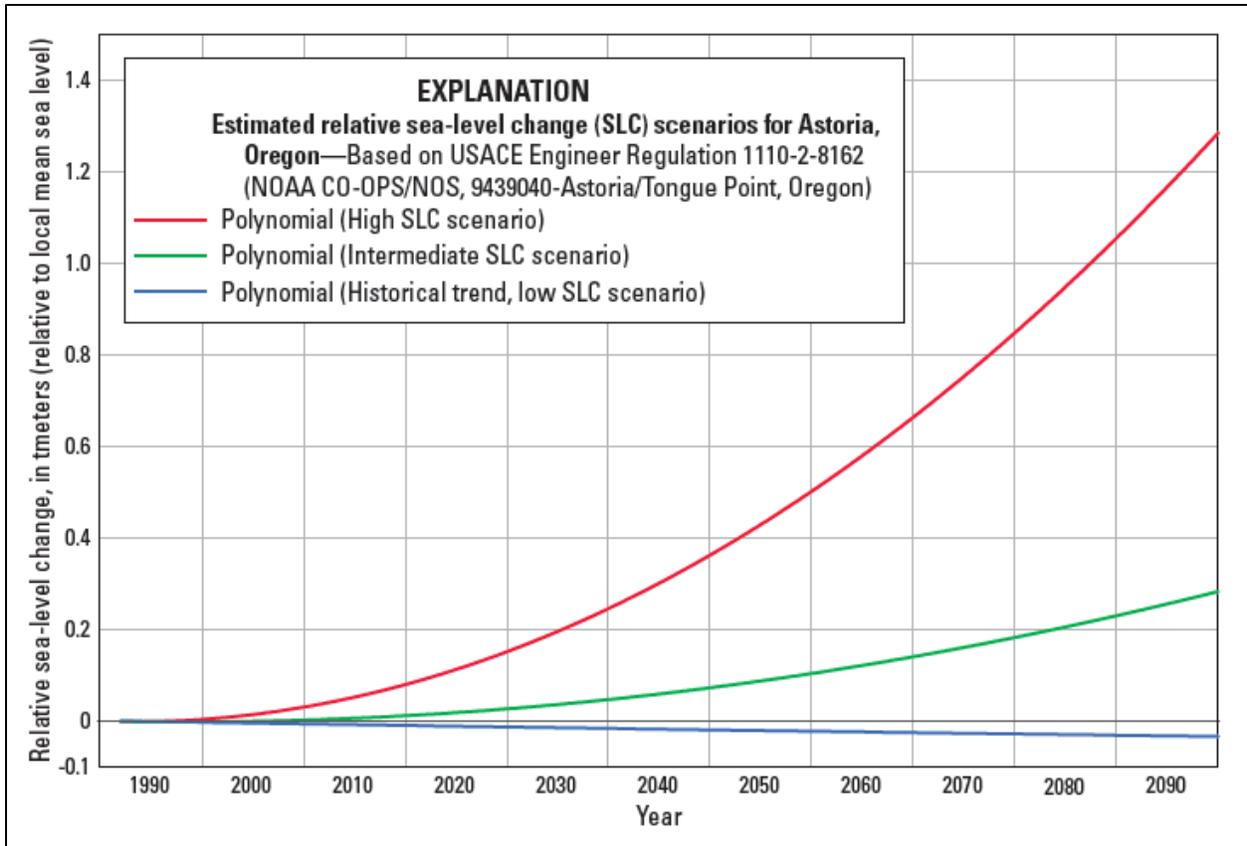
281 Figure 4-12 shows the three RSLC scenarios applicable for Astoria/Tongue Point, Oregon, NOAA
282 Tidal Station 9439040. Corps projections for the future RSLC are based on a start date of 1992,
283 which corresponds to the midpoint of the present National Tidal Datum Epoch⁴ of 1983 to
284 2001.

285 The “USACE Low” scenario for future RSLC is extrapolated from the observed historical rate
286 derived from NOAA tide gages. For 2050, the USACE Low scenario projection for Astoria is -0.05
287 feet using 2020 as the base year. The value is negative due to the regional rate of landmass
288 uplift being greater than the sea level rise.

289 The “USACE Intermediate” scenario focuses its projection primarily on thermal expansion of the
290 ocean and is computed from the modified NRC Curve I, considering both the most recent IPCC
291 projections and modified NRC projections. For 2050, the USACE Intermediate scenario
292 projection for Astoria is 0.15 feet using 2020 as the base year.

293 The “USACE High” scenario accounts for the thermal expansion of the ocean and
294 accommodates for a potential rapid loss of ice from Antarctica and Greenland. It is estimated
295 using the modified NRC Curve III. For 2050, the USACE High scenario projection for Astoria is
296 1.05 feet using 2020 as the base year.

⁴ The National Tidal Datum Epoch (NTDE) is “the specific 19-year period adopted by the National Ocean Service as the official time segment over which tide observations are taken and reduced to obtain mean values for tidal datums. It is necessary for standardization because of periodic and apparent secular trends in sea level. The present NTDE is 1983 through 2001 and is actively considered for revision every 20-25 years” (NOAA 2019).



297
298 **Figure 4-12. Estimated Sea Level Change Scenarios at Astoria, Oregon**

299 Note: Figure taken from U.S. Geological Survey (USGS) (2019).

300 The amount that the RLSC surcharges river water surface elevation dissipates upriver from the
301 mouth of the Columbia River at the Pacific Ocean (RM 0). This surcharge can also vary with river
302 flow conditions, whereas low flow conditions will be affected more. At Woodland Islands,
303 Washington, located in the lower Columbia River (RM 86), stage surcharge is estimated to be
304 0.5 foot, 0.15 foot, and 0.0 foot for the High, Intermediate, and Low RLSC scenarios,
305 respectively (Corps 2019). During extreme high-flow conditions of the Columbia River near
306 Vancouver, Washington (RM 106.5), 1 meter (3.3 feet) of RLSC results in a difference in peak
307 river stage of approximately 0.5 foot (USGS 2019).

308 **4.1.2.6 Increased Occurrences of Wildfire**

309 The Cascade Range and Rocky Mountains of the Columbia River Basin are some of the most
310 fire-prone regions in the western United States. The incidence of large forest fires has increased
311 since the early 1980s and is projected to continue increasing as temperatures rise (USGCRP
312 2017). Wildfire alters the land surface and can have strong influences on runoff generation,
313 vegetation dynamics, erosion and sediment transport, and ecosystem processes. Strong
314 seasonality and dependence on spring snowmelt positions the basin to be at risk for increased
315 fires due to the effects of climate change. Historically, the greatest increases in wildfire
316 frequency have been in the heavily forested areas of the Kootenai and Lower Snake regions,

317 followed by northwestern regions, including the lower and middle Columbia River (Westerling
318 et al. 2003; Dennison et al. 2014).

319 Historical fire regimes and fire-climate relationships vary depending on topography, forest
320 management practices, vegetation, soil moisture, and regional climate factors, including
321 seasonal temperature and precipitation. Generally, the most severe fire activity occurs in the
322 heavily forested areas of the Lower Snake region. Wildfire activity in forested regions across the
323 basin exhibits strong negative correlations to precipitation and positive correlations to
324 temperature (Littell et al. 2009). Drier and warmer summers lead to increased wildfire
325 frequency and burned areas. For the semi-arid climatic regions of the middle and lower
326 Columbia, fire-climate relationships exhibit moderate positive correlations to interannual
327 precipitation due to the production of fine fuels (e.g., grass and shrubs) in the understory that
328 become dead fuels (fuel with a moisture content < 30 percent) in subsequent years (Littell et al.
329 2009; McKenzie and Littell 2016).

330 Low soil moisture and high vegetative fuel are key drivers for wildfire potential. Recent
331 hydroclimatic projections indicate that climate change will lead to declining mountain
332 snowpack and advances in the timing of spring snowmelt, reducing summer soil moisture
333 storage in heavily forested regions (Gergel et al. 2017). Projected increases in annual
334 precipitation could moderately increase soil moisture in the semi-arid regions of the middle and
335 lower Columbia (Gergel et al. 2017); however, a lack of agreement across projections for
336 predicted precipitation patterns leads to greater uncertainty in future soil moisture. For all
337 regions across the basin, vegetative fuel is projected to increase (Gergel et al. 2017). Overall,
338 effects of climate change on wildfire potential are likely to be most severe in the Kootenai and
339 Lower Snake regions that are already experiencing increasing wildfire activity, whereas there is
340 more uncertainty in projected changes in wildfire potential for the semi-arid middle and lower
341 Columbia regions.

342 **4.2 POTENTIAL EFFECTS OF CLIMATE CHANGE BY RESOURCE**

343 The following sections describe potential effects from projected hydroclimatic changes on the
344 resources evaluated in the EIS. For each resource area, the potential effects are described for
345 the No Action Alternative. Unless otherwise noted, the potential effects of climate change to
346 the other alternatives are expected to be similar to the No Action Alternative. For some
347 resources, there are no projected effects from climate change, including Noise, Visual, and
348 Indian Trust Assets. While there are no projected effects to the identified Indian Trust Assets,
349 any of the potential negative effects to habitat relied upon by treaty or trust resources (e.g.,
350 anadromous fish) is a significant concern for regional tribes.

351 During the evaluation, resource teams conducted a qualitative assessment using the climate
352 change information provided in Section 4.1 along with resource effects for the alternatives as
353 described in Chapter 3. The following question was used to focus the evaluation:

- 354 • What measures could ameliorate or exacerbate potential effects of climate change
355 identified for the No Action Alternative?

356 In the following sections, the effects to the Multiple Objective Alternative (MO) operations are
357 the same as those discussed in the No Action Alternative except where explicitly modified by a
358 measure as described in each subsequent subsection. The effects described for each MO are
359 relative to the No Action Alternative.

360 **4.2.1 Hydrology and Hydraulics**

361 The following regional descriptions of the climate change effects on hydrology and operations
362 (regulated streamflows and reservoir elevations) rely on the hydrological projections described
363 in Section 4.1. Potential effects to the regulation of the current system are inferred from these
364 projections of climate and unregulated streamflow volumes and are described in the No Action
365 Alternative subsections. The following regional descriptions use this qualitative analysis to
366 describe expected effects to system operations under the No Action Alternative and with
367 additional relevant MO measures under climate change.

368 **4.2.1.1 Region A – Libby, Hungry Horse, and Albeni Falls Dams**

369 **NO ACTION ALTERNATIVE**

370 At the headwater projects (project used to mean dams and their associated reservoirs), Libby
371 Dam and Hungry Horse Dam, projected reduced late summer inflow volume (Section 4.1.2.4),
372 coupled with fixed outflows to meet downstream summer minimum flow objectives, will likely
373 result in lower pool elevations in late summer through October and November. Projected
374 higher inflows during winter (Section 4.1.2.4) may support a faster recovery of reservoir storage
375 from fall. Potential higher winter inflows and increased frequency of systemwide winter flood
376 events (Section 4.1.2.4) could lead to more variable reservoir outflows and pool elevations
377 during winter. Potential increases in spring runoff volumes (Section 4.1.2.4) could also lead to
378 deeper reservoir drafts for spring flood risk management (FRM).

379 At Albeni Falls Dam, reservoir outflow during the summer and fall could decrease due to
380 potential reduced inflows (Section 4.1.2.4). Higher winter inflows and increased frequency of
381 systemwide winter flood events will likely lead to higher and more variable reservoir outflows
382 and pool elevations, as water is stored and evacuated to manage system flood risk during
383 winter. The reservoir is likely to fill earlier in the year as inflows shift earlier (Section 4.1.2.4).

384 **MULTIPLE OBJECTIVE ALTERNATIVES 1 AND 3**

385 Hungry Horse is expected to be drafted deeper than under the No Action Alternative at the end
386 of the water year due to the effects of the water supply measure. These effects could be
387 exacerbated by decreased summer and early fall inflows. Projected higher inflows during winter
388 may support a faster recovery of reservoir storage.

389 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

390 Hungry Horse and Libby are expected to be drafted deeper than the No Action Alternative in
391 winter for the *Slightly Deeper Draft for Hydropower* measure. Potential increased winter flow

392 (Section 4.1.2.4) could reduce the need for this draft. Due to this measure, reservoir outflows in
393 June and July would be less than the No Action Alternative. This could potentially exacerbate
394 effects of the projected decreases in streamflow during these months (Section 4.1.2.4).

395 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

396 This alternative also includes the *McNary Flow Target* measure, that increases outflow from
397 Libby and Hungry Horse May through July during dry years. This operation results in greater
398 outflow early in the summer and less outflow during August to October compared to the No
399 Action Alternative. This operation may increase in frequency as streamflow volumes are
400 projected to shift to earlier in the year, and late spring/summer flow declines (Section 4.1.2.4).
401 Streamflow volumes are projected to shift early in the year (Section 4.1.2.4), and late
402 spring/summer flows are projected to decrease. The *McNary Flow Target* measure could
403 reduce effects of lower late spring and early summer flows, but could exacerbate effects of
404 lower flows later in the summer.

405 **4.2.1.2 Region B – Grand Coulee and Chief Joseph Dams**

406 **NO ACTION ALTERNATIVE**

407 Projected decreases in late summer and early fall inflow (Section 4.1.2.4) could lead to lower
408 outflow from Grand Coulee and Chief Joseph Dams and lower elevations at Lake Roosevelt
409 during fall, with respect to historical fall conditions. During winter, higher inflows to the
410 reservoir and Columbia River downstream are projected (Section 4.1.2.4). This could result in
411 higher outflows and variability of storage, as Grand Coulee stores and evacuates water for
412 downstream system FRM objectives. This could lead to increased spills from Grand Coulee and
413 Chief Joseph Dams. The peak spring freshet is projected to occur earlier in the year (Section
414 4.1.2.4). This could result in increased outflows in March and April and therefore causes a
415 reduction of outflows earlier in the year than occurred historically in order to refill the
416 reservoir. Operations for mitigating winter flood events and operations for meeting system
417 spring FRM space requirements may conflict more often, as inflow from winter flood events is
418 stored during periods that the reservoirs are typically drafting for spring flood risk.

419 During summer, flow volumes are projected to decrease (Section 4.1.2.4), resulting in lower
420 outflows. Grand Coulee would continue to refill in early July and draft to meet summer
421 elevation targets. Meeting minimum flows at Bonneville Dam through drafting more often may
422 be necessary. Lower inflows could challenge Grand Coulee's ability to refill to 1,283 feet by the
423 end of September and potentially to fill the reservoir (1,288 feet) by the end of October in
424 preparation for winter chum and hydropower operations. Lower inflows could result in longer
425 reservoir retention times.

426 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

427 MO1 includes the *Winter System FRM Space* measure, providing additional storage for flood
428 operations in December. With projected winter inflow increases (Section 4.1.2.4), this space

429 may be filled and evacuated during and after winter flood events more frequently, leading to
430 greater fluctuations in reservoir elevation and outflows. The measure could reduce potential
431 increases in winter peak flows in the lower river that may result from climate change.

432 Higher projected winter unregulated flows (Section 4.1.2.4) and winter FRM operations could
433 lead to upstream projects having more trapped storage for spring FRM. Trapped storage is
434 when reservoirs fail to evacuate storage for FRM requirements. In response to potential
435 increases in trapped storage, the *Update System FRM Calculation* measure could require Lake
436 Roosevelt to be drafted deeper than the No Action Alternative.

437 Upstream measures could reduce reservoir inflows in the fall (e.g., *Hungry Horse Additional*
438 *Water Supply*). The Lake Roosevelt Additional Water Supply measure could make it more
439 difficult to meet summer flow targets due to projected lower inflows.

440 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

441 Lake Roosevelt is expected to be drafted deeper than the No Action Alternative in winter for
442 the *Slightly Deeper Draft for Hydropower* measure. Projected increased winter flow (Section
443 4.1.2.4) could reduce the need for this draft. Due to this measure reservoir outflows in June and
444 July would be less than the No Action Alternative. This could potentially exacerbate effects of
445 the projected decreases in streamflow during these months (Section 4.1.2.4). See MO1 for
446 effects of FRM measures included in this alternative.

447 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

448 See the No Action Alternative discussion above, as the effects are anticipated to be similar.

449 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

450 Upstream measures could reduce reservoir inflows in the fall (e.g., *Hungry Horse Additional*
451 *Water Supply* and *McNary Flow Target*) in addition to the projected decreases in unregulated
452 flows (Section 4.1.2.4). This could lead to deeper drafts to support downstream flows for power
453 and navigation. See MO1 for potential effects of FRM measures.

454 This alternative also includes the *McNary Flow Target* measure that increases outflow from
455 Grand Coulee in May through July during dry years. This operation may increase in frequency as
456 streamflow volumes are projected to shift to earlier in the year, and late spring/summer flow
457 declines (Section 4.1.2.4). This operation results in greater outflow early in the summer and less
458 outflow during August to October compared to the No Action Alternative. Streamflow volumes
459 are projected to shift early in the year (Section 4.1.2.4), and late spring/summer flows are
460 projected to decrease. The *McNary Flow Target* measure could reduce effects of lower late
461 spring and early summer flows, but could exacerbate effects of lower flows later in the
462 summer. The *Lake Roosevelt Additional Water Supply* measure could further exacerbate the
463 effects of projected decreases in summer flow on meeting summer flow targets.

464 **4.2.1.3 Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice**
465 **Harbor Dams**

466 **NO ACTION ALTERNATIVE**

467 Higher inflows are projected (Section 4.1.2.4) through the winter. These will result in higher
468 elevations in the Dworshak reservoir and higher releases. Increasing frequency of winter floods
469 will also increase system winter FRM operations. That could lead to higher and more variable
470 outflows and pool elevations as water is stored and evacuated during the winter. In the spring,
471 inflow from the snowmelt freshet is projected to occur earlier and could lead to higher outflow
472 in April and earlier refill. Projected decreases in summer inflow (Section 4.1.2.4) will likely lead
473 to decreased outflow as the reservoir maintains a similar elevation.

474 In the lower Snake River, changes in regulated streamflow will mimic the direction and seasonal
475 patterns of changes in unregulated volumes (Section 4.1.2.4). Streamflow volumes in late fall
476 and winter are projected to be greater (Section 4.1.2.4). Due to the projected changes in flow
477 timing in spring (Section 4.1.2.4), streamflow in April and May could increase, and flow in June
478 could be less than historical levels. Lower flow is projected throughout the summer months
479 (Section 4.1.2.4).

480 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

481 The *Modified Dworshak Summer Draft* measure will result in higher releases in July and
482 September and lower releases in August compared to the No Action Alternative. The increased
483 releases from this measure may partially offset projected flow decreases in July and September
484 (Section 4.1.2.4), while the outflow reduction in August could exacerbate the projected
485 decreases in August flow (Section 4.1.2.4).

486 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

487 Dworshak Reservoir is expected to be drafted deeper in the winter as a result of the *Slightly*
488 *Deeper Draft for Hydropower* measure. Projected increases in winter flow (Section 4.1.2.4)
489 could reduce the need for this draft. Due to this measure reservoir outflows in spring and
490 summer could be less than the No Action Alternative. This could potentially exacerbate effects
491 of the projected decreases in streamflow during these months (Section 4.1.2.4).

492 **MULTIPLE OBJECTIVE ALTERNATIVES 3 AND 4**

493 See the No Action Alternative discussion above, as the effects are anticipated to be similar.

494 **4.2.1.4 Region D – McNary, John Day, The Dalles, and Bonneville Dams**

495 **NO ACTION ALTERNATIVE**

496 Flows are likely to be higher than historical conditions in the late fall and winter months of
497 October through March due to increased likelihood of rainfall events and higher winter

498 baseflow in the drainages that feed into Region D: the lower Columbia, lower Snake, and
499 Clearwater Rivers (Section 4.1.2.4). Winter outflows and storage fluctuations could become
500 more variable as reservoirs store and evacuate water for downstream FRM. Unregulated spring
501 flow from snowmelt that passes through the dams in Region D is projected to occur earlier,
502 with potential decreases in flow starting in June (Section 4.1.2.4). Streamflow in the summer is
503 projected to decrease, and lower flows could span longer durations compared to historical
504 conditions (Section 4.1.2.4). This could lead to difficulty in meeting the minimum flow
505 objectives of these dams during summer. In years with exceptionally low summer flow volumes,
506 fall and early winter outflow could be less than historical conditions as the upstream storage
507 projects recover from depleted storage. Sea level rise could increase river stages below
508 Bonneville Dam (Section 4.1.2.4). The effects of sea level rise will be larger at lower-flow
509 conditions and with increasing proximity to the Pacific Ocean.

510 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

511 MO1 includes the *Winter System FRM Space* measure, providing additional storage for system
512 flood operations at Grand Coulee in December. With projected increases in winter inflow
513 (Section 4.1.2.4), Lake Roosevelt could store more inflow during system flood events, which
514 could decrease peak flood stages in Region D.

515 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

516 Streamflow in the lower Columbia River will be higher than the No Action Alternative in winter
517 due to the *Deeper Draft for Hydropower* measure at upstream projects. This measure could
518 further increase the projected increase in winter flows in the lower Columbia River.

519 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

520 See the No Action Alternative discussion above, as the effects are anticipated to be similar.

521 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

522 The effects of MO4 from the *Winter System FRM Space* measure are expected to be similar to
523 those effects described in MO1. This alternative also includes the *McNary Flow Target* measure
524 that increases outflow from Grand Coulee in May through July during dry years. This operation
525 may increase in frequency as streamflow volumes are projected to shift earlier in the year and
526 projected late spring/summer flow declines (Section 4.1.2.4). This operation results in greater
527 outflow early in the summer and less outflow during August to October compared to the No
528 Action Alternative. The *Lake Roosevelt Additional Water Supply* measure could further
529 exacerbate the effects of projected decreases in summer flow on meeting summer flow targets.

530 **4.2.2 River Mechanics**

531 Climate changes have the potential to substantially influence erosion, sediment transport, and
532 sediment deposition throughout river basins. Several key climate-influenced mechanisms linked
533 with geomorphological processes have been identified (Mauger et al. 2015) and are

534 summarized in Table 4-8. Qualitative assessments of how these drivers will change and their
 535 associated effects for the Columbia River Basin are discussed in subsequent sections. Potential
 536 effects of climate change are described for the No Action Alternative condition. These effects
 537 are assumed to be the same for each MO, unless a measure is expected to explicitly alter the
 538 response to climate change compared to the No Action Alternative.

539 **Table 4-8. Climate Influenced Processes and Mechanisms That Shape Geomorphological**
 540 **Change in River Basins**

Mechanism	Description
Temperature	Higher temperatures enhance thermal breakdown of rock. Warmer conditions can dry soils leading to higher stability of deeper soil layers. Warming can intensify warm and dry cycles, widening gaps in rock and soil.
Precipitation	Increased precipitation can increase soil water content and surface runoff. Intense rainfall can erode surface sediments.
Soil Water Content	Wetter soils have higher pore pressure and greater landslide susceptibility. Wetter soils absorb less precipitation and produce more subsurface flow, increasing runoff.
Snowpack and Glaciers	Snowpack loss in area and duration increases the amount of time underlying erodible soils are exposed to surface erosion. Receding glaciers expose loose, unconsolidated sediment that is susceptible to mobilization and increases sediment load downstream of deglaciated areas.
Streamflow	Higher streamflow can erode streambeds and banks, increasing transportation and deposition of sediment in alluvial reaches.
Vegetation	Vegetation can be influenced by climate change through its influence on frequencies of disturbance (wildfires, insects, disease) or water stress. Reduction in vegetative cover can increase surface erosion during rain events and elevate soil moisture. After wildfires, soils have the decreased ability to absorb water, leading to increased surface runoff, surface erosion, and sediment transport.
Sea Level Rise	Sea level rise could reduce stream velocities, trapping sediment in coastal rivers and deltas. Sea level rise could increase inland conveyance of wave energy, increasing shoreline erosion.

541 Note: Adapted from Mauger et al. (2015).

542 **4.2.2.1 Region A – Libby, Hungry Horse, and Albeni Falls Dams**

543 **NO ACTION ALTERNATIVE**

544 Surface erosion and sediment supply could increase in Region A. Primary mechanisms of
 545 sediment delivery to the upper Columbia River Basin within the United States are landslides and
 546 bank erosion (Section 3.3.2.3), which can increase after wildfires and from high-intensity
 547 precipitation events. The Northern Rocky Mountains have high wildfire potential, which could
 548 increase with climate change (Section 4.1.2.6). Furthermore, declining snowpack (Section
 549 4.1.2.3) and upland glacier area could increase the amount of land surface area exposed to
 550 erosion and increase the seasonal duration of exposure.

551 Bank erosion in the Kootenai River, Clark Fork, and Pend Oreille Rivers could increase during
 552 winter months as the phase of precipitation for storm events transitions from snowfall to
 553 rainfall, increasing winter flows (Section 4.1.2.4) and variability of local runoff response. Banks
 554 of these rivers, aside from those areas consisting of boulders and bedrock, are already highly
 555 susceptible to erosion (Section 3.3.2.9).

556 Conveyance of sediment from landslides or bank erosion to the riverine reaches could increase
557 during winter months with projected increases in median and high flows (Section 4.1.2.4).
558 However, only a small percentage of sediment—regardless of moderate rates of increase in
559 supply—will make it to the Columbia River mainstem, based on theoretical trapping efficiencies
560 of 91 and 71 percent at Libby Dam and Albeni Falls Dam, respectively (Section 3.3.2.3).
561 Depositional reaches in these systems, such as the Braided and the Meander Reach of the
562 Kootenai River and the mouth of Lightning Creek on the Clark Fork River, are expected to
563 remain depositional zones as sediment supply increases with rainier winters. Sediment
564 deposition near mainstem confluences could potentially influence fish passage, especially
565 during the warmer/drier summer season. Increased sedimentation will be monitored and
566 evaluated for maintenance activities. Transport reaches are expected to maintain or increase
567 sediment conveyance capability until reaching sediment sink zones such as Flathead Lake,
568 Kootenay Lake, and Lake Pend Oreille.

569 **MULTIPLE OBJECTIVE ALTERNATIVES 1, 2, 3, AND 4**

570 See the No Action Alternative discussion above, as the effects are anticipated to be similar.

571 **4.2.2.2 Region B – Grand Coulee and Chief Joseph Dams**

572 **NO ACTION ALTERNATIVE**

573 Surface erosion, sources of sediment, and landslides from reservoir margins could increase in
574 response to climate change in Region B. Upland forests of the eastern slopes of the Cascade
575 Range display high wildfire potential that is likely to continue to increase with climate change
576 (Section 4.1.2.6). Changes in wildfire potential for the lower elevation semi-arid ecosystems are
577 more uncertain (Section 4.1.2.6). Furthermore, sediment production could also increase from
578 upland areas following projected declines in snowpack (Section 4.1.2.3), which will increase the
579 land surface area exposed to erosion and increase the seasonal duration of exposure. The
580 conveyance of gains in sediment supply could increase with projected higher median and high
581 unregulated winter flow volumes (Section 4.1.2.4). Fluvial transported sediment through this
582 region will continue to be largely deposited in reservoir-impounded mainstem locations.

583 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

584 MO1 includes the *Winter System FRM Space* measure, providing additional space in Lake
585 Roosevelt for Grand Coulee system flood operations in December. With projected increased
586 frequency of system winter flood events and elevated winter inflow volumes (Section 4.1.2.4),
587 this space could be more frequently filled and evacuated during and after winter flood events.
588 This could result in greater reservoir fluctuations and associated bank sloughing and erosion in
589 non-bedrock shoreline areas.

590 **MULTIPLE OBJECTIVE ALTERNATIVES 2 AND 4**

591 See the MO1 discussion above, as the effects are anticipated to be similar.

592 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

593 See the No Action Alternative discussion above, as the effects are anticipated to be similar.

594 **4.2.2.3 Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice**
595 **Harbor Dams**

596 **NO ACTION ALTERNATIVE**

597 Mid-elevation forests of the Central Rockies could exhibit a strong response in wildfire (Section
598 4.1.2.6) to increased spring and summer temperatures (Section 4.1.2.1) and earlier snowmelt
599 (Section 4.1.2.3). The combined effect of warming, hydrological drought, wildfire, and intense
600 storms could enhance the potential for erosion and sediment delivery by altering land surface
601 vegetation which plays a primary role in modulating sediment dynamics in semi-arid landscapes
602 (e.g., Goode, Luce, and Buffington 2010). This increase in sediment supply could be coupled
603 with increased sediment transport in Region C rivers with projected increased median and high-
604 flow volumes during winter and early spring (Section 4.1.2.4).

605 **MULTIPLE OBJECTIVE ALTERNATIVES 1, 2, AND 4**

606 See the No Action Alternative discussion above, as the effects are anticipated to be similar.

607 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

608 MO3 includes breaching the lower four Snake River dam embankments. Without these
609 impoundments, the lower Snake River will no longer act as a sediment sink for watershed
610 contributions that predominately accumulate upstream of Lower Granite Dam. Increased
611 upstream sources of sediment and enhanced conveyance linked to projected hydrological
612 change could lead to increased sediment transport through this region to Region D,
613 downstream. Similar to non-climate change MO3 response, this additional bed material load
614 (coarser than 62 microns) is expected to accumulate within the upper 10 miles of the McNary
615 Reservoir between the Snake River confluence with the Columbia River and Wallula,
616 Washington. The routing of flood peaks from intense storms through the lower Snake River also
617 has potential to increase erosion and transport of higher-elevation residual sediment deposits
618 abandoned after the near-term dam breach activities. This could result in episodic increases in
619 localized suspended sediment concentrations.

620 **4.2.2.4 Region D – McNary, John Day, The Dalles, and Bonneville Dams**

621 **NO ACTION ALTERNATIVE**

622 Surface erosion and sources of sediment could increase in Region D. Forests of the central and
623 southern Cascade Range, which contribute to sediment loads in the rivers and reservoirs of
624 Region D, display moderate wildfire potential that could continue to increase with climate
625 change, whereas changes to fire potential in lower elevation semi-arid ecosystems display more
626 uncertainty (Section 4.1.2.6). Surface erosion could increase from upland areas following

627 projected declines in snowpack (Section 4.1.2.3), which could increase the land surface area
628 exposed to erosion and increase the seasonal duration of exposure. The conveyance of
629 increased sediment supply could also increase coincidentally with projected higher median and
630 high winter flow volumes (Section 4.1.2.4). McNary, John Day, The Dalles, and Bonneville Dams
631 will continue to act as a sink for the coarse fractions of this potential increased upstream
632 sediment yield.

633 Sea level rise is projected to influence water surface elevations downstream of Bonneville Dam
634 (Section 4.1.2.4). This could affect sediment dynamics, including conveyance, deposition, and
635 shoreline erosion processes. Potential effects will be strongest in downstream locations closest
636 to the estuary and confluence with the Pacific Ocean.

637 **MULTIPLE OBJECTIVE ALTERNATIVES 1, 2, AND 4**

638 See the No Action Alternative discussion above, as the effects are anticipated to be similar.

639 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

640 MO3 includes breaching the lower four Snake River dams, eliminating sediment sinks in the
641 Lower Snake reach. Increased sources of sediment and increased conveyance from the Snake
642 River linked to projected hydrological changes could lead to increased sediment supply being
643 delivered from Region C to this region. Deposition of the increased Snake River bed material
644 load sediments (fractions coarser than 62 microns) is expected to remain upstream of McNary,
645 while the flux of increased washload fractions (finer than 62 microns) will propagate further
646 downstream into the lower Columbia projects and estuary.

647 **4.2.3 Water Quality**

648 Many water quality issues are linked to water temperature. A recent assessment of water
649 temperature trends in the Columbia Basin (O'Connor 2020) found long-term warming trends in
650 water temperature on the order of 0.5 degree Fahrenheit (0.3 degree Celsius) per decade.
651 While water temperature trends vary between measurement sites, periods of analysis, and
652 season, this estimate is consistent with the range of the observed trends reported in other
653 studies (e.g., Quinn, Hodgson, and Peven 1997; Isaak et al. 2012; EPA 2019). Long-term (greater
654 than 20 years) increases in water temperature are primarily associated with increases in air
655 temperature. Cold water releases from storage dams have contributed to cooling trends at
656 some locations (O'Connor 2020). Cooling trends are identified on the mainstem of the
657 Columbia River above Grand Coulee Dam and at locations on the Clearwater River below
658 Dworshak Dam.

659 Changes to seasonal patterns in stream temperature occurred during the 1950 to 1970 period
660 as flow patterns changed with increased river regulation and dam construction. Construction of
661 dams in the Columbia River Basin resulted in an approximately 1 degree Fahrenheit (0.6 degree
662 Celsius) increase in water temperature, a shift in the timing of annual maximum temperatures,
663 and expanded the period of seasonally warm water. There were few detected trends relating to

664 these effects in the near-term period, suggesting that the effects experienced in the 1950 to
665 1970 period remain today and do not appear to contribute to near-term statistically significant
666 trends in water temperature (O'Connor 2019). Isaak et al. (2018) found that water temperature
667 trends of large regulated and unregulated river basins across the northwest are generally
668 consistent over recent periods of observation. The warming trend in global air temperatures is
669 expected to continue in the coming decades. Projecting river water temperature has been a
670 continued focus in the research community. Several studies have developed projections that
671 suggest that the Columbia River summer mainstem river temperature could increase 3.1 to 3.6
672 degrees Fahrenheit (1.7 to 2.0 degrees Celsius) by the end of the century (e.g., Yearsley 2009;
673 Isaak et al. 2018). Projected increases in summer water temperatures for Columbia River
674 tributaries by the end of the century span a wider range, 1.8 to 9.0 degrees Fahrenheit (1 to 5
675 degrees Celsius) (e.g., Cristea and Burges 2010; Mantua, Tohver, and Hamlet 2010; Wu et al.
676 2012; Beechie et al. 2013; Caldwell et al. 2013; Isaak et al. 2017).

677 **4.2.3.1 Region A – Libby, Hungry Horse, and Albeni Falls Dams**

678 **NO ACTION ALTERNATIVE**

679 Air temperature is projected to be warmer throughout Region A during the 2030s (Section
680 4.1.2.1). Warmer air temperature combined with projected decreased summer and fall flow
681 volumes (Section 4.1.2.4) could lead to increased riverine and reservoir surface water
682 temperature. This could exacerbate algal and nutrient problems (Appendix D, *Water and*
683 *Sediment Quality Technical Appendix*, Section 3.1.3.1) within the region's reservoirs and river
684 reaches. This warming could also increase the prevalence of invasive species.

685 Currently, selective withdrawal systems (SWSs) are used at Libby and Hungry Horse Dams to
686 manage downstream temperatures. These SWSs are operated to release warmer waters to
687 better reflect normative temperatures in the local river systems. Warmer air and water
688 temperature could allow SWS operations to meet temperature objectives for longer periods
689 throughout the spring and summer months. Fall water temperatures, however, are likely to be
690 negatively affected and remain warmer for longer. Deeper reservoir drafts for spring FRM at
691 Libby and Hungry Horse could result in warmer spring water temperatures downstream, which
692 may benefit downstream fish and in-river productivity.

693 The timing of the spring freshet inflow volume is projected to shift earlier in the year (Section
694 4.1.2.4), resulting in reservoirs filling earlier than historically. Depending on how early the refill
695 occurs, this could improve (make warmer) or exacerbate (make colder) temperature issues
696 downstream of Libby and Hungry Horse.

697 Inflow volumes to the reservoirs are projected to increase during winter and spring (Section
698 4.1.2.4). Higher inflow and outflow from these reservoirs could increase total dissolved gas
699 (TDG) and turbidity, and may result in suspended solids (nutrients, selenium) to move further
700 down into the reservoir and downstream of Libby Dam. Higher winter flows may also affect the
701 natural cooling of the downstream river.

702 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

703 Under MO1, the change to the *December Libby Target Elevation* measure allows for higher
704 winter (November to December) reservoir elevations at Libby Reservoir to mitigate for
705 potential over-drafting in years with a drier forecast. This is followed by the *Modified Draft at*
706 *Libby* measure, which creates higher outflows (aggressive drafting) in late winter/early spring
707 that could be exacerbated by anticipated higher winter flows under climate change. High winter
708 flows prevent the natural cooling of the Kootenai River in the winter downstream of Libby Dam.
709 Warmer winter water temperatures can be detrimental to fish, such as burbot, that require
710 near-freezing water temperatures to successfully spawn. Higher winter flows and runoff
711 anticipated under climate change (Section 4.1.2.4) may result in suspended solids (nutrients,
712 selenium) to move further down into the reservoir and downstream of Libby Dam as well.

713 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

714 Under MO2, the *Slightly Deeper Draft for Hydropower* measure calls for a deeper drawdown of
715 Libby Reservoir to provide additional hydropower generation. This drawdown may help to
716 ameliorate higher inflows anticipated in the winter under climate change (Section 4.1.2.4).
717 Deeper reservoir drafts and higher outflows may result in suspended solids (nutrients,
718 selenium) to move further down into the reservoir and downstream of Libby Dam and increase
719 downstream water temperature.

720 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

721 MO3 is similar to MO2 at Libby Reservoir and includes operational changes that could result in
722 changes to draft and refill operations when compared to the No Action Alternative. Anticipated
723 additional winter and early spring storage may help to ameliorate higher inflows anticipated in
724 the winter under climate change (Section 4.1.2.4). Deeper reservoir drafts and higher outflows
725 may result in suspended solids (nutrients, selenium) to move further down into the reservoir
726 and downstream of Libby Dam and increase downstream water temperature. These deeper
727 drafts may also affect in-reservoir food availability for resident fish.

728 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

729 Under MO4, in low water years, the *McNary Flow Target* measure would release an additional
730 600 thousand acre-feet from Libby, resulting in lower reservoir elevations, which could reduce
731 productivity in the reservoir and affect fish growth. This operation may increase in frequency as
732 streamflow volumes are likely to shift to occur earlier in the year, and late spring/summer flow
733 declines (Section 4.1.2.4).

734 **4.2.3.2 Region B – Grand Coulee and Chief Joseph Dams**

735 **NO ACTION ALTERNATIVE**

736 Air temperature is projected to be warmer throughout Region B (Section 4.1.2.1). Warmer air
737 temperature combined with reduced summer and fall flow volume (Section 4.1.2.4) could lead

738 to increased riverine and reservoir surface water temperature. Periods of higher temperatures
739 may occur earlier in the year and last longer than historically. This could exacerbate algal,
740 nutrient, pH, and dissolved oxygen (DO) issues (Appendix D, *Water and Sediment Quality*
741 *Technical Appendix*, Section 3.1.3.3) within the region's reservoirs and river reaches.

742 Flow volume is projected to increase during winter months (Section 4.1.2.4), which could result
743 in higher outflows. Periods of higher outflows from Grand Coulee and Chief Joseph could result
744 in higher spill. Increased inflow and spill volume is likely to result in higher TDG than historical
745 levels during winter. In the summer, TDG could decrease as a result of projected lower flow
746 volumes (Section 4.1.2.4).

747 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

748 MO1 includes the *Winter System FRM Space* measure, providing additional storage for flood
749 operations in December. With increased winter flow, this space may be filled and evacuated
750 during and after winter flood events more frequently, leading to greater reservoir fluctuations
751 and associated bank sloughing and turbidity, with higher spill and TDG in December. Increased
752 seasonal water surface elevations are anticipated to result in an increased amount of mercury
753 that is converted to methylmercury upon rewatering of shorelines. Methylmercury is the more
754 toxic form of mercury that bioaccumulates in fish tissue.

755 This alternative includes the *Lake Roosevelt Additional Water Supply* measure. This measure
756 reduces outflow from Grand Coulee. Reduced outflow could exacerbate warming of
757 downstream summer temperature.

758 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

759 See MO1 for discussion of the effects of FRM measures, as they are anticipated to be similar.

760 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

761 See MO1 for discussion of the effects of water supply measures, as they are anticipated to be
762 similar.

763 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

764 See MO1 for the effects of FRM measures, as they are anticipated to be similar. Additionally,
765 MO4 includes the *McNary Flow Target* measure, which increases outflow from Grand Coulee,
766 May through July, during dry years. This operation may increase in frequency as streamflow
767 volumes are likely to shift to occur earlier in the year, and late spring/summer flow declines
768 (Section 4.1.2.4). This operation results in greater outflow early in the summer, with less
769 outflow during August to October. Water temperatures downstream of Grand Coulee are
770 expected to continue to exceed water quality standards in late summer and early fall; this could
771 be exacerbated in dry years by the early release of flows and missed refill due to the *McNary*
772 *Flow Objective* measure.

773 **4.2.3.3 Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor**
774 **Dams**

775 **NO ACTION ALTERNATIVE**

776 Air temperature is projected to be warmer throughout Region C (Section 4.1.2.1). Warmer air
777 temperature combined with projected reduced summer and fall flow volume (Section 4.1.2.4)
778 will likely lead to increased riverine and reservoir surface water temperature. Periods of higher
779 temperature are projected to occur earlier in the year and last for longer durations than
780 historically. This could exacerbate cyanobacterial blooms, microbial activity at swim beaches,
781 increase pH, or reduce DO within the region’s reservoirs and river reaches (Appendix D, *Water*
782 *and Sediment Quality Technical Appendix*, Section 3.2.3.2).

783 Winter flows and the frequency of winter flood events are projected to increase in Region C
784 (Section 4.1.2.4). In response to this change, Dworshak Dam could store and evacuate inflow
785 volumes for system winter flood events more frequently than during the historical period. The
786 projected higher volumes and variability in flows could result in increased TDG and turbidity
787 during winter months.

788 During spring, the freshet volume is projected to occur earlier resulting in an earlier fill period
789 for Dworshak reservoir and higher outflows in April (Section 4.1.2.4). This could result in higher
790 TDG in spring and could increase reservoir productivity.

791 Projected decreases in summer flow volumes through the dams on the Lower Snake river could
792 make meeting downstream juvenile fish passage spill objectives more difficult since there could
793 be less total river flow to pass over the spillways of these dams and still provide minimum
794 turbine generation (Section 2.3.2.2).

795 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

796 The *Dworshak Temperature Control* measure results in significantly higher water temperature
797 than NAA in August and early September. These effects are greatest at Lower Granite and
798 decrease downstream. This measure could exacerbate potential warming water temperature
799 from climate change.

800 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

801 MO2 includes the *Slightly Deeper Draft for Hydropower* measure that will lead to lower pool
802 elevations of Dworshak reservoir during winter. Lower winter pool elevations could reduce the
803 increases in TDG resulting from projected increases in winter inflow and outflow for winter
804 flood operations due to climate change (Section 4.1.2.4).

805 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

806 MO3 includes breaching the lower four Snake River dams. Water quality effects of dams and
807 reservoirs would be eliminated with the breaching of the dams. Under MO3 water temperature

808 in the river will respond faster to seasonal changes in air temperature (Section 3.4, Appendix D)
809 which is projected to be warmer throughout the year, but with the highest degree of warming
810 in the spring and summer (Section 4.1.2.1; RMJOC, 2018). As compared to NAA, MO3 is
811 expected to result in warmer water temperature in the spring, similar water temperatures in
812 the summer, and cooler water temperatures in the fall with the overall duration of warm water
813 reduced. Furthermore, the shallower free flowing river condition of MO3 will lead to greater
814 diurnal fluctuations in water temperature, including night time cooling. Daily low temperatures
815 (occurring at night) are projected to warm faster than daily high temperatures. The effects of
816 projected increasing nighttime temperatures could reduce night time cooling of the river. The
817 effects of projected increased water temperature could result in increased periphyton growth
818 in the river.

819 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

820 MO4 includes the *Spill to 125% TDG* measure. Projected decreases in summer flow volumes
821 (Section 4.1.2.4) could make meeting this target more difficult since there would be less total
822 river flow to pass over the spillways of these dams and still provide minimum turbine
823 generation (Section 2.3.2.2).

824 **4.2.3.4 Region D – McNary, John Day, The Dalles, and Bonneville Dams**

825 **NO ACTION ALTERNATIVE**

826 Air temperature is projected to be warmer throughout Region D and upstream regions (Section
827 4.1.2.1). Warmer air temperature combined with reduced summer and fall flow volume
828 (Section 4.1.2.4) will likely lead to increased riverine and reservoir surface water temperature.
829 Periods of higher temperature are likely to occur earlier in the year and last for longer durations
830 than historically. This could exacerbate cyanobacterial blooms, microbial activity at swim
831 beaches, increase pH, or reduce DO within the region's reservoirs and river reaches.

832 Winter flows and the frequency of winter flood events are projected to increase in Region D
833 (Section 4.1.2.4). This could lead to increases in TDG through the winter and early spring
834 because TDG increases with higher flows.

835 Projected decreases in summer flow volumes (Section 4.1.2.4) through these dams could make
836 meeting downstream juvenile fish passage spill objectives more difficult since there could be
837 less total river flow to pass over the spillways of these dams and still provide minimum turbine
838 generation.

839 **MULTIPLE OBJECTIVE ALTERNATIVES 1, 2, AND 3**

840 See the No Action Alternative discussion above, as it is anticipated to be similar.

841 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

842 MO4 includes the *Spill to 125% TDG* measure. Projected decreases in summer flow volumes
843 could make meeting this target more difficult. MO4 also includes the *McNary Flow Target*
844 measure. This measure will provide more flow early in summer for dry years and potentially
845 lead to reduced flows in late summer and fall. This operation may increase in frequency as
846 streamflow volumes are projected to shift to occur earlier in the year and late spring/summer
847 flow declines (Section 4.1.2.4). Flow changes associated with this measure have the potential to
848 partially buffer early summer warming water temperature and exacerbate warming during late
849 summer and early fall.

850 **4.2.3.5 Anadromous Fish**

851 The Columbia River Basin hosts many anadromous fish species. These fish use freshwater
852 habitat for spawning and early juvenile life stages before migrating to marine waters to grow
853 and mature for part of their lifecycle. These species include 16 salmon and steelhead species or
854 ESUs as well as Pacific Eulachon, green sturgeon, Pacific lamprey, and American shad.

855 This section evaluates how the projected changes in regional climate may affect anadromous
856 fish. The structure of this section differs from other resource areas in that environmental
857 changes due to climate change can affect how project operations affect anadromous fish
858 differently as they migrate through multiple regions. Thus, expected effects on anadromous fish
859 species are discussed collectively rather than by separate regions.

860 Projected changes in air temperature, precipitation, hydrology and stream temperature have
861 negative implications for the freshwater, estuarine, and marine environments of many fish
862 species in the Pacific Northwest (Climate Impacts Group 2015; Scheuerell and Williams 2005;
863 Zabel et al. 2006; ISAB 2007).

864 **NO ACTION ALTERNATIVE**

865 For salmon and steelhead (*Oncorhynchus mykiss*) in the Columbia basin, climate change may
866 affect the timing of spawning, emergence and migration, cause changes in growth and
867 development, increase predation rates, and affect the availability of critical habitat. In turn,
868 these physiological changes could affect species productivity and abundance (Link, Griffis, and
869 Busch 2015). While habitat conditions may improve for some life stages in certain locations that
870 are currently colder than optimum (Zhang et al. 2019), overall effects on populations due to
871 climate changes that have already occurred in recent decades have been negative (Crozier and
872 Hutchings 2014). Many populations that are sensitive to non-climate threats are also most
873 vulnerable to climate change (Crozier et al. 2008; Crozier 2013). Overall, a warming climate
874 could cause moderate to severe declines in salmon and steelhead populations (Crozier 2015).

875 Increased variability in flows and reservoir levels could increase stranding/dewatering of larval
876 Pacific lamprey (*Entosphenus tridentatus*). Pacific eulachon (*Thaleichthys pacificus*) could
877 experience a mismatch in adult spawning triggers and larval dispersal if winter spawning

878 triggers remain similar but spring freshets peak sooner. Lower summer flows could decrease
879 foraging habitat for green sturgeon (*Acipenser medirostris*) in the estuary and lower Columbia
880 River.

881 There are several potential outcomes from climate change that could lead to consequences for
882 anadromous fish during the periods of their lifecycle where they reside in the inland water
883 bodies of the Columbia River and its tributaries:

884 • Warming water temperatures

885 Projected changes in stream and river temperatures (as described in Section 4.2.3) may
886 cause direct mortality due to heat stress and greater disease susceptibility if the range
887 of physiological tolerance is exceeded (Benda et al. 2015). For example, in the Columbia
888 Basin, Snake River sockeye salmon (*Oncorhynchus nerka*) are at high risk from heat
889 waves during their mid-summer adult migration (Keefer, Peery, and Caudill 2008;
890 National Marine Fisheries Service 2016). Historical water temperatures have already
891 approached lethal limits for adult steelhead in the upper Snake and middle Columbia
892 Rivers (Wade et. al 2013). Thus, even minor increases in thermal exposure put some of
893 these populations above lethal limits. Increases in water temperatures could result in
894 increased use of cold water refuges by adult salmon and steelhead (EPA, 2019).

895 Warming streams may also affect early life stage development of Chinook salmon
896 (*Oncorhynchus tshawytscha*), steelhead, and other salmon species, however effects are not
897 linear and can depend on specific life stage. For example, after modeling several climate
898 change scenarios for all West Coast populations of steelhead and Chinook salmon, Beer and
899 Anderson (2013) concluded that Chinook salmon could spawn later in the year. Juvenile
900 salmon in warm-region streams of the Columbia Basin will likely experience lower growth
901 rates if stream temperatures increase in the future, whereas fish in currently cold mountain
902 streams that will begin to warm could experience the same or higher growth by 2050 (Beer
903 and Anderson 2013). While warmer stream temperatures tend to increase production of
904 plankton and insects (food supply), they also increase fish metabolism and daily
905 requirements for food (Daly and Brodeur 2015; Haskell, Beauchamps, and Bollens 2017).
906 Overall, juvenile salmon weights are projected to be lower in the Columbia Basin by 2050
907 due to climate change, which could affect survival in the estuary and ocean (Faulkner et al.
908 2019). Effects of climate change on marine survival and growth of salmon will depend on
909 their natal rivers and movements at sea. But, salmon are becoming smaller and sometimes
910 younger when they return to freshwater, potentially as a result of decreasing pH and
911 increasing temperature (Bisson et al. 2018).

912 Where high temperature exposure is already an issue, increasing temperatures inside
913 fishways of dams could worsen thermal exposure for migrating adult sockeye, Chinook
914 salmon, and steelhead (Keefer and Caudill 2015). Temperature gradients up to 4
915 degrees Celsius within fish ladders at dams in the Columbia River appear to block
916 migration by causing adult fish to reverse movement in ladders and fall back

- 917 downstream (Caudill et al. 2013). Already a serious concern, temperature-related
918 fallback may increase if river temperatures continue to rise (Crozier 2013).
- 919 • Streamflow changes
- 920 Variability in streamflow, shifts in seasonal volume and the transitioning of snowmelt to
921 rain dominated streamflow regimes, could influence spawning, habitat occupancy, and
922 run timing (Ward et al. 2015; Beechie et al. 2006). Consequently, expected changes in
923 the timing and volume of flows (as described in Section 4.1.2.4) could alter run timing,
924 reduce spawning habitat access/availability, change egg and juvenile survival, and
925 change overwintering habitat for many juveniles. For example, Artaud et al. (2010)
926 found that higher tributary streamflow during spring was strongly positively correlated
927 with egg-to-smolt and egg-to adult survival rates for Chinook in the Lemhi River of
928 Idaho. Timing of smolt and adult migration may also change due to modified timing of
929 the spring freshet (Crozier and Hutchings 2014; Keefer, Peery, and Caudill 2008).
- 930 Lower flow during the late spring through fall (Section 4.1.2.4) increases travel time for
931 outmigrating juvenile species, making them more susceptible to predation by birds and
932 predatory fish.
- 933 • Invasive Species
- 934 Warming water temperatures lead to habit conditions that are favorable for non-native
935 warm-water adapted fish species, which compete with or prey upon native salmon
936 (Petersen and Kitchell 2001). Smallmouth bass (*Micropterus dolomieu*) have expanded
937 their range, increasing their overlap with subyearling Chinook rearing habitat in summer
938 (Lawrence, Olden, and Torgersen 2012; Kuehne, Olden, and Duda 2012). Also, invasive
939 non-native plankton species are now widespread and can dominate reservoir and the
940 estuary plankton communities (Emerson, Bollens, and Counihan 2015; Bowen et al.
941 2015). While Chinook salmon eat these species, they are not necessarily preferred prey.
- 942 American shad (*Alosa sapidissima*) has come to dominate the anadromous fish
943 migration in the lower Columbia River with abundances often exceeding 2 million in
944 recent years (Hinrichsen et al. 2013). The incursion of shad upstream past McNary Dam
945 in recent decades is correlated with higher water temperatures and lower flows (Crozier
946 2015). The influence of shad on the reservoir food web is complex; shad may compete
947 with juvenile salmon for invertebrate prey but juvenile shad are also an important food
948 source for adult fall Chinook in summer (Haskell, Beauchamp, and Bollens 2017).
- 949 Climate change is also projected to have consequences for the habitat of anadromous fish
950 during the period of their lifecycle where they reside in the Pacific Ocean and Columbia River
951 estuary. Several trends are expected:
- 952 • Reduction in thermal habitat for salmon

953 Future climate projections indicate there will be a reduction in thermal habitat
954 preferred by salmon in the ocean (Cheung et al. 2015). However, warming may not be
955 uniform across the northeast Pacific Ocean and the effects of localized wind and current
956 patterns make it challenging to project (Barth et al. 2007).

957 • Increasing ocean acidification

958 Increased concentrations of carbon dioxide in the atmosphere leads to increased
959 absorption by the oceans and results in ocean acidification. This has already been
960 detected both on the Washington and Oregon coast and in the Puget Sound (Feely et al.
961 2010; Harris et al. 2013; Hauri et al. 2013). Generally, acidification can change the food
962 web (reduce productivity) and have negative consequences on fish. For lower Columbia
963 River coho salmon (*Oncorhynchus kisutch*), for example, acidification affects their
964 olfactory senses, interfering with avoidance of predators, hunting of prey, and
965 navigating their return to spawning grounds.

966 • Changing estuarine and plume environments

967 The confluence of the Columbia River and the Pacific Ocean is critical habitat for
968 anadromous fish as they transition from fresh to salt water as juveniles. Changes in
969 water temperature and flows could bring changes in this habitat, the food web, and
970 predation (CRSO BiOp 2019). Sea level rise (see Section 4.1.2.5) has the potential to
971 convert shallow estuary rearing habitat into deeper channels (Flitcroft et al. 2013) and
972 alter habitat elevation bands as inundation patterns change. Lower freshwater flows in
973 late spring and summer may lead to upstream extension of the salt wedge, possibly
974 influencing the distribution of prey and predators (Bottom and Jones 1990); and
975 increased temperature of freshwater inflows and seasonal expansion of freshwater
976 habitats may extend the range of non-native, warm-water species in the estuary (CRSO
977 BiOp 2019). Multiple Objective Alternative 1

978 Improvements for juvenile anadromous salmon and steelhead in MO1, such as higher juvenile
979 survival rates, faster travel time, lower powerhouse encounter rates, and structural
980 improvements may be offset by the projected changes in flows and temperatures. Lower flows
981 could result in increased travel times and likely lower powerhouse encounter rates as juveniles
982 are better able to detect spillway routes in the forebay (McCann et al. 2017). Outmigrating
983 juveniles could experience increased predation risk as projected warmer water temperatures
984 throughout the Columbia River Basin may increase the proportion of non-native predatory fish
985 and their predation rates on juvenile salmon and steelhead.

986 MO1 includes measures to improve adult upstream passage that could be improved further by
987 lower flows and lower spill volumes, but the level of improvement could be reduced by
988 increased temperatures due to climate change. Temperatures in the Snake River under MO1
989 were found to be higher than under the No Action Alternative during August and early
990 September, which could cause delayed migration for summer steelhead, fall Chinook, or
991 lamprey; climate change could increase these temperatures even further. Throughout the
992 basin, increased fish ladder temperature differentials and more shad in fishways could also

993 decrease adult salmon migration success, offsetting gains in ladder improvements from
994 structural measures.

995 Climate change effects outside of the influence of the CRSO, such as decreased early life stage
996 survival due to tributary flows and habitat changes, as well as ocean conditions that reduce
997 survival in the adult ocean phase, could also diminish and likely overwhelm the minor increases
998 in survival in MO1.

999 In MO1 there are more years than in the No Action Alternative where chum flows would not be
1000 met without additional flow augmentation. The minor effects to eulachon caused by lower
1001 spring flows under MO1 could be reduced by climate change which could result in earlier and
1002 higher spring flow peaks. Higher spring flows in April could increase the distribution of
1003 eulachon larvae to feeding areas, but could also result in a mismatch between the temperature
1004 trigger for upstream adult migration and spawning and the spring freshet for larval distribution.
1005 If the freshet peaks and declines too soon, the slightly reduced larval distribution could be
1006 further impaired because larvae could miss the freshet. Lower summer flows could further
1007 decrease summer foraging habitat for green sturgeon. The seasonal changes in flow from MO1
1008 were found to have minor effects but could be compounded with climate change to become an
1009 issue for these species.

1010 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

1011 Climate change effects described in the No Action Alternative could further reduce juvenile
1012 survival and increase travel time. Due to higher water temperatures, juveniles could likely
1013 encounter higher predation rates, and more non-native fish in the river. In MO2, there is a
1014 measure that would potentially cease installation of fish screens to increase the efficiency of
1015 hydropower turbines at the Ice Harbor, McNary, and John Day Dams once improved Fish
1016 Passage turbines are installed. If this measure is implemented, then fewer fish screens could
1017 result in more juveniles passing through turbines rather than juvenile fish bypasses. Lower
1018 flows could improve the ability of juveniles to find spill routes in the forebay and could tend to
1019 decrease powerhouse passage (McCann et al. 2017).

1020 Adult migration under MO2 may be improved by lower spill, but the overall warming of the
1021 river water could offset this effect and result in poorer upstream migration and adult survival.
1022 Increased transportation of juveniles may benefit some adult returns to Bonneville Dam, but
1023 could also increase the incidence of fallback and straying of adult salmonids. Ocean and
1024 tributary life stage effects could reduce abundances of adult spawners.

1025 In the lower river, chum flows would be more difficult to meet under MO2. MO2 winter flows
1026 are 10 percent higher than the No Action Alternative during the month of December, which
1027 would increase minor effects to eulachon predation risk; climate change could make these
1028 flows even higher and may result in this effect being biologically detectable.

1029 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

1030 Increases in juvenile salmon and steelhead survival, decreases in travel time, and reductions in
1031 powerhouse encounters in MO3 could be reduced or offset by the effects of climate change. In
1032 MO3, the Snake River would be free-flowing (long-term) so powerhouse encounters in the
1033 Snake River would still be zero with climate change. Potential increased water temperature
1034 from MO3 in the spring could be further amplified by warming from climate change (Section
1035 4.2.3.3) and migration could initiate earlier. The benefits of decreased travel time through the
1036 lower Snake River could also be reduced or offset with lower summer flows (Section 4.1.2.4),
1037 and increased predator populations (warm water predators could increase with warmer water
1038 temperatures). The rate of powerhouse passage in the four lower Columbia dams should
1039 decrease under low-flow conditions, due to the increased ability of juveniles to detect spillway
1040 routes in the forebay (McCann et al. 2017).

1041 Analyses of adult migrations up the Snake River in MO3 showed the temperature effects of dam
1042 breaching under historical conditions (higher early summer) would be offset by the diel
1043 fluctuations providing nighttime refuge and by faster migration times with the dams breached.
1044 However, potential decreases in nighttime cooling from increasing air temperature could
1045 reduce the amount of cooling to protect upstream migrating adults from the faster increase in
1046 spring/early summer temperatures. Lower DO associated with warmer temperatures could also
1047 increase the magnitude of short-term effects noted in MO3 to all fish. Fall Chinook salmon
1048 habitat increases in MO3, but may be reduced by climate change effects. Predictions of Fall
1049 Chinook rearing strategies due to dam breach may be altered with warmer temperatures. In
1050 the Columbia River, slower adult migrations under MO3 may be further slowed by increased
1051 water temperatures and ladder differential issues.

1052 In the lower River, chum flows could be met more often than the No Action Alternative under
1053 MO3, and climate change could increase the frequency of meeting chum objectives further
1054 with projected increases in winter flow volumes. Winter flows would be slightly higher than in
1055 the No Action Alternative in MO3 and could be further increased; this may increase eulachon
1056 predation risk. Summer foraging for green sturgeon could be decreased further with climate
1057 change. These are minor effects in the alternative that may become biologically noticeable with
1058 climate change.

1059 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

1060 MO4 includes several measures to increase juvenile survival and decrease travel time and
1061 powerhouse encounters. Lower flows in late spring/summer with climate change could reduce
1062 the effectiveness of these measures for most migrants. Earlier spring runoff could shift the
1063 timing of outmigrations earlier and reduce the effectiveness of flow augmentation. Water
1064 temperatures downstream of Chief Joseph Dam are expected to continue to exceed water
1065 quality standards in late summer and early fall, this could be exacerbated in dry years by the
1066 early release of flows and missed refill due to the *McNary Flow Objective* measure. This could
1067 reduce survival of later migrants. The flow operation that causes this effect may increase in
1068 frequency as streamflow volumes are likely to shift to occur earlier in the year and late

1069 spring/summer flow declines. This alternative was the only one with substantial increases in
1070 TDG effects; these could be reduced with lower spill volumes due to lower flows due to climate
1071 change (Geldert, Gulliver, and Wilhelms 1998).

1072 Adult upstream migrations would be challenged by MO4 flow and spill conditions and may be
1073 further complicated by the effects of climate change. The additional flow augmentation
1074 (*McNary Flow Target* measure) delivery would increase flows in spring but then reduce them
1075 later in summer, resulting in increased water temperature in the Columbia River from Chief
1076 Joseph downstream. These temperatures could be further elevated with climate change and
1077 could increase delays and fallback. Temperatures would be elevated in MO4, which could make
1078 Upper Columbia River sockeye more frequently encounter conditions in the lower Columbia
1079 River where it is too warm to migrate, and where there is a thermal block downstream of
1080 spawning habitat in the Wenatchee or Okanogan Rivers (Hyatt, Stockwell, and Rankin 2003).
1081 Similarly, Pacific lamprey could experience even more days over their thermal stress threshold
1082 (temperature above which the fish experience stress) in the Columbia River from Chief Joseph
1083 Dam to McNary Dam, where temperatures would be elevated in MO4.

1084 In the lower Columbia River, MO4 would increase the risk of not meeting chum operations
1085 without flow augmentation, which could be even more difficult with climate change. May
1086 outflows in dry water years would be 10 percent higher than the No Action Alternative and
1087 could be even higher with a climate change shift in peak flows; this could increase predation
1088 risk for eulachon. Forage habitat for green sturgeon could be decreased or disrupted by lower
1089 summer flows and flow fluctuations in July and August, and this could be enhanced by climate
1090 change effects.

1091 ***4.2.3.6 Resident Fish, Aquatic Invertebrates, and Aquatic Habitat***

1092 Resident fish species that remain in one location or display limited migrations between
1093 reservoirs and tributaries must be able to tolerate the annual range of temperatures and flows
1094 within a small areal range. A warming climate could affect the distribution and abundance of
1095 many resident fish, increasing the range of some species while reducing the range of others, as
1096 well as resulting in isolated populations in separated, deeper water habitats.

1097 Like anadromous fish, projected changes in air temperature, precipitation, hydrology and
1098 stream temperature have negative implications for the freshwater, estuarine, and marine
1099 environments of many fish species in the Pacific Northwest (Climate Impacts Group 2015;
1100 Scheuerell and Williams 2005; Zabel et al. 2006; ISAB 2007).

1101 **REGION A - LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

1102 **No Action Alternative**

1103 Potentially lower pool elevations in late summer through October in Hungry Horse Reservoir
1104 could reduce the productive zone for phytoplankton and zooplankton production, dewater
1105 benthic insect production faster, and reduce the surface area available for fish to feed on

1106 terrestrial insects in the summer. If fall elevations are lower due to changes in runoff (Section
1107 4.2.2.1) it could also increase varial zone effects to bull trout (*Salvelinus confluentus*). These
1108 effects could be reduced on spring-spawning fish such as westslope cutthroat trout as spring
1109 levels could be higher. Faster recovery of storage through the winter could increase habitat
1110 available for spring benthic insect production, but deeper drafts and more variability in
1111 outflows and pool elevations could result in more dewatering of this food resource. Likewise, if
1112 the reservoir were drafted deeper in spring for FRM because of higher runoff volumes (Section
1113 4.2.2.1), it could also increase dewatering of benthic production. More potential variability in
1114 outflows could also disrupt the production of aquatic invertebrates in the rivers below these
1115 projects, and if outflows were to increase through winter months there could be more
1116 entrainment of fish and zooplankton, and a decrease in suitable winter habitat for bull trout
1117 and other fish. Potentially lower summer outflows could decrease entrainment risk in summer.
1118 Minimum flows would likely maintain habitat in the rivers below these reservoirs.

1119 At Albeni Falls dam, higher, more variable pool elevations and flows could disrupt food
1120 production in winter. More variability through the winter could disrupt the spawning and
1121 rearing success of kokanee (non-anadromous form of the sockeye salmon) as eggs could be
1122 deposited at a higher location and then dewatered if the reservoir drops. In Lake Pend Oreille,
1123 kokanee avoid predatory lake trout, which occupy deeper areas, by migrating closer to the
1124 surface. If surface temperatures become too warm during the summer period of stratification,
1125 they may no longer be able to use this refuge (Stockwell and Johnson 1999). Lower and more
1126 variable lake elevations could decrease the spawning success of warm water gamefish. Higher
1127 and earlier spring freshet flows could increase entrainment of invasive northern pike (*Esox*
1128 *lucius*) from Clark Fork River reservoirs into Lake Pend Oreille. Lower summer and fall flows with
1129 warming temperatures could favor non-native fish species in the Pend Oreille River.

1130 Libby Reservoir may experience similar effects as Hungry Horse Reservoir, with elevations and
1131 flows combining for lower productivity of food resources for fish, increased varial zone effects
1132 to bull trout but lower effects to spring spawning species. Earlier spring peaks may change the
1133 spawn timing of Kootenai River white sturgeon (*Acipenser transmontanus*) with unknown
1134 spawning success effects, but warmer water temperatures in spring may increase recruitment
1135 success, depending on the timing between higher spring flows to trigger spawning and warmer
1136 water for egg and larvae development (Paragamian and Kruse 2001).

1137 Potentially warmer water in these reservoirs could reduce the suitability of these habitats for
1138 native fish such as bull trout, westslope cutthroat trout (*Oncorhynchus clarki lewisi*), and
1139 mountain whitefish (*Prosopium williamsoni*). Hungry Horse Reservoir is protected from invasion
1140 of non-native fish by Hungry Horse Dam, but Lake Pend Oreille could see a shift to more non-
1141 native species with warmer temperatures. Downstream habitats may see benefits of the
1142 selective withdrawal structures being usable for longer periods and be at optimum
1143 temperatures sooner in the spring with warmer flows, but warmer fall temperatures could limit
1144 habitat for cold water fish (Section 4.2.3). Higher winter temperatures (Section 4.2.3) may be
1145 detrimental for certain fish species, such as burbot (*Lota lota*), which require near freezing river
1146 temperatures (<2°C) to spawn. Higher TDG and turbidity could increase effects to fish.

1147 In the spawning tributaries above Columbia River System projects, bull trout may be especially
1148 vulnerable to climate change given that spawning and early rearing are constrained by cold
1149 water temperatures, creating a patchwork of preferred headwater habitats across river
1150 networks. Climate warming could increase fragmentation of remaining bull trout habitats and
1151 accelerate decline of this species. In fact, predicted warming could result in losses of 18 to 92
1152 percent of thermally suitable habitat area (Rieman et al. 2007). Even with no further habitat
1153 loss, existing fragmentation could contribute to continuing local extinctions due to the
1154 expansion of introduced species (Rieman, Lee, and Thurow 1997).

1155 **Multiple Objective Alternative 1**

1156 At Hungry Horse Reservoir, lower late September lake elevations from the Water Supply
1157 measure coupled with projected decreases in summer inflow (Section 4.1.2.4) could increase
1158 varial zone effects to bull trout. Entrainment risk could be increased with higher spring flows,
1159 but reduced in summertime when MO1 outflows would be increased; this would likely offset
1160 the entrainment risk to bull trout in summer. MO1 would reduce summer habitat suitability in
1161 the South Fork and mainstem Flathead Rivers, which could be alleviated somewhat with lower
1162 summer flows projected under climate change (Section 4.1.2.4), but the tradeoff with lower
1163 reservoir elevations would be considerable. Habitat channel maintenance that would be slightly
1164 reduced in MO1 could be enhanced with higher spring flows. Hungry Horse Reservoir is critical
1165 habitat for bull trout; therefore, effects on bull trout in the reservoir would have a greater
1166 effect than downstream.

1167 In the Pend Oreille basin, MO1 had only minor effects to resident fish so the effects of climate
1168 change would be similar to the No Action Alternative.

1169 In the Kootenai basin, reduced summer productivity described in the No Action Alternative due
1170 to climate change could offset slight increases seen in MO1 analyses. Winter production of
1171 benthic insects would be disrupted in MO1 and this effect could be exacerbated by increased
1172 fluctuations in winter and potentially deeper drafts (Section 4.2.1.1). Under MO1, the *Modified*
1173 *Draft at Libby* measure increases outflow from Libby Dam in late winter and early spring,
1174 potentially increasing downstream water temperature in the Kootenai River. This could
1175 exacerbate negative effects of warming winter water temperatures (Section 4.2.3.1) on burbot
1176 spawning. MO1 would slightly reduce sturgeon spawning success but this could be offset with
1177 enhanced sturgeon recruitment opportunities if climate change produces higher spring freshets
1178 (Section 4.1.2.4) and warmer spring temperatures in the Kootenai River. Burbot success could
1179 be lower, however, with warming temperatures.

1180 **Multiple Objective Alternative 2**

1181 Hungry Horse Reservoir summer elevation and food production would be similar to the No
1182 Action Alternative; therefore, the climate change effects would be the same as described in the
1183 No Action Alternative. In winter, however, the production of benthic insects would be
1184 decreased with deeper, steeper drops in elevation that could be even deeper, steeper, and
1185 more variable with climate change. Varial zone effects would be similar to the No Action

1186 Alternative. In the South Fork and mainstem Flathead Rivers, MO2 would limit winter habitat
1187 for bull trout with much higher outflows that could be further damaging with higher flows
1188 under climate change. MO2 was the only alternative where effects to Flathead Lake bull trout
1189 were noted; bull trout entrainment would increase and could be increased even further with
1190 projected increases in winter flows (Section 4.1.2.4). The lower Flathead River (below Flathead
1191 Lake) would also see reduced habitat for bull trout and other native fish under MO2 that could
1192 be worsened by increased winter flows due to climate change.

1193 Under MO2, the *Slightly Deeper Draft for Hydropower* measure calls for a deeper drawdown of
1194 Libby Reservoir to provide additional hydropower generation. Increasing outflow from Libby
1195 Dam could increase downstream water temperature in the Kootenai River. This could
1196 exacerbate negative effects of warming winter water temperatures on burbot spawning.

1197 MO2 effects in the Pend Oreille basin were similar to the No Action Alternative so the climate
1198 change effects would be similar to those described for climate change in the No Action
1199 Alternative.

1200 In MO2, Libby Reservoir levels are lower than the No Action Alternative in winter, reducing
1201 productivity. Kootenai River effects of MO2 include lower spring flows and fewer days of
1202 potential sturgeon spawning trigger flows. Sturgeon recruitment potential under MO2 would
1203 be diminished; it could be enhanced with projected potentially higher and earlier spring
1204 freshets (Section 4.1.2.4), but this likely would not be enough to incite successful recruitment.

1205 **Multiple Objective Alternative 3**

1206 Effects in Hungry Horse Reservoir, South Fork Flathead River, the mainstem Flathead River,
1207 Flathead Lake, and Clark Fork Rivers would all be similar to those described in MO1. One
1208 difference would be that MO3 would lift ramping rate restrictions that could increase
1209 disruption of benthic production in the South Fork Flathead and mainstem Flathead Rivers; this
1210 could be exacerbated with increased variability in outflows during winter (Section 4.2.1.1).

1211 MO3 effects in the Pend Oreille River Basin would be similar to the No Action Alternative, so
1212 climate change effects would also be similar to those described in the No Action Alternative.

1213 In the Kootenai River Basin, MO3 would have lower elevations and higher draft rates than the
1214 No Action Alternative through the winter, which decrease benthic production. This could be
1215 further reduced with potentially deeper drafts and more variability (Section 4.2.1.1). Fewer
1216 days of optimal sturgeon recruitment conditions in MO3 could be ameliorated by better
1217 recruitment caused by higher projected spring flows, and an earlier freshet coupled with
1218 warmer water in the Kootenai River in spring. MO3 could improve burbot spawning conditions
1219 with cooler temperatures potentially partially ameliorating the increased winter water
1220 temperature from climate change (Section 4.2.3.3).

1221 **Multiple Objective Alternative 4**

1222 In Hungry Horse Reservoir, in wet and average years the effects of MO4 would be similar to
1223 MO1 effects and climate change would either enhance or offset those effects as described in
1224 MO1. MO4 also includes the *McNary Flow Target* measure, which would cause effects through
1225 similar mechanisms as those in MO1, but the magnitude would be higher in the summer
1226 months due to higher outflows and deeper reservoir drawdowns. These could be exacerbated
1227 further with the potentially lower summer elevations under climate change inflows (Section
1228 4.2.1.1). Food productivity effects could be even higher and varial zone effects that would
1229 reduce access to tributaries and increase predation risk for bull trout, westslope cutthroat
1230 trout, and other native species could be increased with climate change. Furthermore, these dry
1231 year effects could happen more frequently as climate change could increase the frequency that
1232 the trigger for the *McNary Flow Target* measure would be met.

1233 In Libby Reservoir, MO4 would cause decreases in reservoir productivity with lower elevations.
1234 Reservoir elevations could be further reduced due to projected decreases in late summer and
1235 fall flow (Section 4.1.2.4). Reductions in suitable habitat under MO4 for bull trout in the
1236 Kootenai River could be further reduced with projected higher flows in early summer. MO4
1237 would reduce the volume of the spring freshet; however, projected higher, earlier spring flows
1238 resulting from climate change could increase the habitat maintenance flows naturally occurring
1239 in the river. Kootenai River white sturgeon would experience fewer days of spawning and
1240 recruitment potential under MO4 (see Section 3.5.2, *Hydrology and Hydraulics*), but this could
1241 be offset somewhat with potentially earlier and higher spring freshets. Potentially warmer
1242 temperatures under climate change scenarios could offset the higher pool elevations that cool
1243 water temperatures in MO4.

1244 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

1245 **No Action Alternative**

1246 In the Columbia River from the U.S.-Canada border to Lake Roosevelt, projected earlier and
1247 higher flows of the spring freshet (Section 4.1.2.4) may provide stronger spawning cues for
1248 white sturgeon and increase opportunities for recruitment if water temperatures could remain
1249 suitable. Projected decreases in streamflow by June and July coupled with potential increases in
1250 water temperatures (Section 4.2.3.2) could reduce spawning success.

1251 In Lake Roosevelt, projected increases in winter inflow could decrease retention time, resulting
1252 in higher entrainment of fish in winter. Projected lower summer flows could result in longer
1253 retention times and therefore less entrainment of fish and zooplankton in the summer. Lower
1254 elevations in fall could increase varial zone effects to kokanee in the late fall and redband
1255 rainbow trout (*Oncorhynchus mykiss gairdneri*) in spring as these fish move from the reservoir
1256 to spawning tributaries and could be exposed to higher predation and experience potential
1257 access issues. The net pens in Lake Roosevelt (operated in spring) could become dewatered or
1258 experience higher temperatures and lower DO before the current average release date for
1259 hatchery rainbow trout in late spring. Potentially higher early spring lake elevations could

1260 increase the time boat ramps would be useable for boat-based northern pike suppression
1261 efforts, but projected overall changes in temperatures and elevations could increase northern
1262 pike populations, thus negating the suppression efforts.

1263 Potentially lower summer outflows could reduce fish entrainment in summer and reduce fish in
1264 Lake Rufus Woods. Potentially higher TDG in winter (Section 4.2.3.2) could cause more injury or
1265 mortality to fish from gas bubble trauma at times when it currently is near the threshold for
1266 effects.

1267 From Chief Joseph Dam to McNary Dam, resident fish would experience lower summer flows
1268 and higher temperatures that could further increase the ratio of non-native fish that thrive in
1269 warmer water. White sturgeon in this reach could be cued to spawn earlier, resulting in a
1270 longer recruitment window, but one that could result in a mismatch with temperatures and
1271 reduce success.

1272 **Multiple Objective Alternative 1**

1273 Projected earlier and higher freshet flows would increase the risk of entrainment of fish and
1274 zooplankton out of Lake Roosevelt in late winter and early spring. Redband rainbow trout
1275 access to tributaries and varial zone effects from MO1 could be enhanced with climate change.
1276 MO1 would cause elevation changes in the winter that could increase stranding of kokanee and
1277 burbot eggs; potentially more variable winter elevations (Section 4.2.1.2) could increase this
1278 effect. Early spring northern pike suppression efforts that are reduced under MO1 could be
1279 offset with higher elevations, but overall warming and reservoir habitat could increase these
1280 non-native predators. MO1 effects to fish in Lake Rufus Woods and the river from Chief Joseph
1281 Dam to McNary Dam would be similar to the No Action Alternative so the effects of climate
1282 change would be the same as described in the No Action Alternative.

1283 **Multiple Objective Alternative 2**

1284 The effects to fish in the Columbia River from the U.S.-Canada border to Lake Roosevelt would
1285 be the same as the No Action Alternative so climate change effects would be the same. In Lake
1286 Roosevelt, MO2 would increase winter zooplankton and fish entrainment in winter; this effect
1287 could be increased with additional outflows and lower retention time in winter and early spring
1288 that could result from the projected changes in streamflow (Section 4.2.1.2). In some years,
1289 varial zone effects to fish in Lake Roosevelt as they access tributaries for spawning that would
1290 occur under MO2 operations could be increased by climate change. Increased stranding of
1291 kokanee eggs in MO2 could be exacerbated by climate change variability in winter elevations.
1292 Northern pike are tolerant of temperatures up to 28°C and could benefit from warming due to
1293 climate change (Eaton and Scheller 1996). The increased entrainment of pike caused by higher
1294 outflows in May under MO2 could be offset by potential lower summer outflows. MO2 effects
1295 to fish in Lake Rufus Woods and the Columbia River between Chief Joseph Dam to McNary Dam
1296 would be similar to the No Action Alternative.

1297 **Multiple Objective Alternative 3**

1298 MO3 effects to white sturgeon in the Columbia River above Lake Roosevelt would be the same
1299 as MO1. Increased winter entrainment out of Lake Roosevelt in MO3 could be further increased
1300 with the projected higher winter flows (Section 4.1.2.4). Varial zone effects to migrating
1301 kokanee and redband rainbow trout, stranding/dewatering risk, northern pike suppression
1302 efforts, and net pen fish would all be similar to the No Action Alternative so the climate change
1303 effects would be the same as described in the No Action Alternative section. Fish in Lake Rufus
1304 Woods may see an increase in population from entrained fish out of Lake Roosevelt under
1305 MO3. This could be further increased by the projected higher winter flows in the future. Fish in
1306 the Columbia River from Chief Joseph Dam to McNary Dam would be similar to the No Action
1307 Alternative, with the notable exception that white sturgeon in the McNary Reservoir would be
1308 affected short term by increased turbidity but in the long term would likely experience
1309 increased reproduction success and reconnection with Snake River populations with the breach
1310 of the Snake River dams (Hatten et al. 2018). The enhanced success of these fish in MO3 could
1311 be decreased with projected higher temperature effects. Additionally, higher temperatures and
1312 changes in the timing of flows due to climate change could decrease spawning cues due to
1313 climate change.

1314 **Multiple Objective Alternative 4**

1315 White sturgeon recruitment effects would be the same as MO1. MO4 would increase
1316 entrainment risk of zooplankton and fish in the summer months when they are most
1317 susceptible (*McNary Flow Target* measure). Potentially lower retention time with climate
1318 change effects could reduce this risk somewhat. MO4 also would increase entrainment in
1319 winter and when climate change could potentially further increase entrainment. Potential
1320 climate change effects could exacerbate these risks with lower summer/fall elevations and
1321 more winter variability (Section 4.2.1.2). MO4 would also increase the risk of northern pike
1322 invasion downstream with much higher entrainment risk at times when juveniles would be
1323 most susceptible to entrainment. The projected changes in flow volumes and resulting
1324 operations (Sections 4.1.2.4, 4.2.1.2) could reduce the risk slightly in summer but increase it in
1325 early spring. MO4 could cause water quality effects to net pen fish that could be increased by
1326 changes to lake elevation and water quality issues linked with climate change.

1327 In the Columbia River from Chief Joseph Dam to McNary Dam, water temperatures would
1328 increase in late July as compared to the No Action Alternative. This would negatively affect
1329 most native fish in this reach and especially be harmful to white sturgeon. Potential warming
1330 with climate change (Section 4.2.3.2) could exacerbate this effect.

1331 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
1332 **HARBOR DAMS**

1333 **No Action Alternative**

1334 In Dworshak reservoir, higher winter elevations and higher releases could increase the loss of
1335 kokanee from the reservoir, and more variability in winter elevations could cause stranding of
1336 kokanee eggs and fry. Lower summer lake elevations could hamper the migration of bull trout
1337 to their spawning tributaries in late June and early July.

1338 Warmer temperatures in the Clearwater and Snake Rivers could shift the fish community
1339 further towards dominance by non-native fish, reducing native fish populations that need
1340 cooler water. Bull trout, specifically, require very cold water and are often challenged to find
1341 suitable refugia in the Snake River and could become more stressed with projected increases in
1342 water temperatures (Section 4.2.3.3). While higher, early spring flows may cue white sturgeon
1343 to spawn earlier, projected elevated water temperatures and lower summer flows may reduce
1344 successful larval recruitment in these populations.

1345 **Multiple Objective Alternative 1**

1346 The *Modified Dworshak Summer Draft* measure was intended to increase cooling water earlier
1347 in the season and later in the season. Water quality modeling showed the result would have
1348 negligible benefits to early cooling. This would be harmful to native fish in the Snake River,
1349 particularly white sturgeon, and would be beneficial to non-native warm water species. This
1350 temperature effect could be increased with potential warming under climate change.

1351 **Multiple Objective Alternative 2**

1352 Under MO2, Dworshak releases increase in winter, resulting in much higher loss of kokanee
1353 from the reservoir; climate change could potentially increase this loss even further as releases
1354 could increase due to projected increased winter inflow and operations for system winter flood
1355 events (Section 4.2.1.3). Dworshak elevations from May through July would be lower and result
1356 in potential access issues for bull trout migrating to their tributaries to spawn. This effect could
1357 be ameliorated by projected shifts in inflow timing as the reservoir could refill earlier, leading to
1358 higher pool elevations in May and June than historical levels (Section 4.2.1.3). Potential
1359 warming of the reservoir could also decrease the annual period when bull trout can migrate to
1360 tributaries.

1361 On the Snake River, MO2 operations would result in less spill and resident fish may increase
1362 their passage through turbines where they are more subject to injury or mortality. Potential
1363 thermal issues due to projected warmer water temperatures (Section 4.2.3.3) may increase the
1364 susceptibility of injured fish to disease, resulting in higher mortality.

1365 **Multiple Objective Alternative 3**

1366 Over time, as the river would clear itself and work back towards equilibrium, the potential flow
1367 and water quality changes under climate change could favor the recolonization and success of
1368 non-native macroinvertebrates and fish. Long term, the return of the river to a more
1369 naturalized river and less reservoir habitat could result in more native species. Bull trout and
1370 white sturgeon populations would become more connected populations rather than isolated
1371 groups, but potential warming due to climate change may result in suboptimal conditions for
1372 adults in the mainstem in summer. Additionally, the increase in spring flows may provide earlier
1373 spawning cues for white sturgeon, but likely would not be sustained long enough to provide
1374 adequate conditions for recruitment success due to reduced summer flows and higher
1375 temperatures (Counihan and Chapman 2018).

1376 MO3 would result in major changes to the temperature regime as the thermal mass of
1377 reservoirs would converted to free-flowing river. The river would heat up sooner in the summer
1378 and cool down sooner in the fall, but experience wider fluctuations between day and night. Fish
1379 could be negatively affected by the earlier warming, but this would be mitigated by the
1380 nighttime cool refuge. Climate change could potentially warm the river more and earlier to the
1381 point that nighttime refugia may not be enough to offset the earlier seasonal warming.

1382 **Multiple Objective Alternative 4**

1383 The key effect of MO4 on Snake River resident fish would be the increase in TDG exposure in
1384 spring and early summer. Additionally, increased spill may delay bull trout as they are moving
1385 out of the system to avoid warming temperatures in May and June. Potential reductions in spill
1386 and TDG due to climate change (Section 4.2.3.3) could offset TDG and spill effects, but
1387 increased temperatures could exacerbate the early season warming water temperature and
1388 hamper bull trout migrations even more.

1389 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

1390 **No Action Alternative**

1391 Overall potential warming, higher winter flows, and lower late spring and summer flows could
1392 increase the success of warm water, non-native fish and further challenge native fish to survive
1393 in Region D. Bull trout use the mainstem Columbia River intermittently as thermal conditions
1394 allow; with potential warming they could be able to use it less and become more isolated.
1395 White sturgeon in Region D are limited to occasional high water year events where recruitment
1396 would be successful. Higher, earlier spring freshets could potentially provide better spawning
1397 cues, but could result in a mismatch of spawning and recruitment conditions more often than
1398 without climate change. Potentially reduced early summer flows and warmer temperatures
1399 could result in more temperature stress events on white sturgeon populations.

1400 **Multiple Objective Alternative 1**

1401 See No Action Alternative discussion above, as effects are anticipated to be similar.

1402 **Multiple Objective Alternative 2**

1403 See No Action Alternative discussion above, as effects are anticipated to be similar.

1404 **Multiple Objective Alternative 3**

1405 **See No Action Alternative discussion above, as effects are anticipated to be similar. Multiple**
1406 **Objective Alternative 4**

1407 The *McNary Flow Target* measure would increase river flows in May and June of dry years, but
1408 reduce flows later in June and July, compared to the No Action Alternative. Potential climate
1409 change effects could further enhance early spring flows but reduce summer flows (Section
1410 4.1.2.4); though the potential change to resident fish is difficult to discern. White sturgeon
1411 success and bull trout use of the mainstem river would likely remain similar to the No Action
1412 Alternative. TDG would be higher under MO4 but if spill were lowered, then exposure to TDG
1413 could reduce this effect. Flows would increase in July with additional flow augmentation about
1414 3 percent higher than the No Action Alternative; this change was not found to have discernable
1415 effects to resident fish, but the augmentation could be more beneficial under projected
1416 decreases in summer flows (Section 4.1.2.4). In dry years, warmer water temperatures could
1417 reduce native fish reproductive success and favor non-native fish. Potential effects of climate
1418 change on water temperature (Section 4.2.3.4) could exacerbate this effect and shift the fish
1419 community further towards non-native, warm-water fish.

1420 **4.2.4 Vegetation, Wildlife, Wetlands, and Floodplains**

1421 Projected changes in climate, such as warmer air temperatures and changes to hydrology, will
1422 likely affect the ecosystem. Warming air temperatures coupled with changing rainfall amounts
1423 and timing will likely affect soil conditions, plant communities, insects, and wildlife. Warm
1424 weather is projected to occur earlier in the spring and stay later into the fall (Section 4.1.2.1).
1425 This will likely lead to longer plant-growing seasons (USGCRP 2018) and changes in timing of
1426 phenological events (such as when plants begin to grow, bloom, and set seed). Precipitation
1427 amounts and timing are also projected to change, with a tendency for increased winter
1428 precipitation and decreased summer precipitation (Section 4.1.2.2), which could affect soil and
1429 growing conditions. To the extent drought conditions become more frequent and severe,
1430 (USGCRP 2018), it could stress⁵ and alter plant communities and ecosystems that are more
1431 sensitive to drought conditions.

1432 As the climate warms, the symbiotic relationships between plants, insects, and wildlife may
1433 become out of sync and be at risk due to climate change (Bellard et al. 2012; United Nations

⁵ Drought is an environmental stressor for many species and makes them vulnerable to other stressors or even normal environmental events, such as wildlife or insect outbreaks (USFS 2019c).

1434 Environmental Programme 2018). Life cycles of insects, including pollinators, and wildlife, such
1435 as birds which depend on insects and help keep them in check, have evolved over time with
1436 each other. Insects rely on plants for food; plants rely on insects and other pollinators to
1437 fertilize flowers; and wildlife depend on plants and insects for food. Phenological events, such
1438 as when a pollinator or migrating bird arrives to an area, may not mesh with changes in plants,
1439 or vice versa, resulting in increased environmental stress that cause ecosystem changes
1440 (MacMynowski et al. 2007; Van Buskirk, Mulvihill, and Leberman 2009; Case, Lawler, and
1441 Tomasevic 2015; Wadgyamar et al. 2018). These include changes in compositions of plant and
1442 animal communities, such as reductions in population or disappearance from regions of species
1443 that are particularly sensitive to soil and climatic conditions or depend on particular niches
1444 (USGCRP 2018). Some plants may be able to adapt more quickly to changing environmental
1445 conditions (soil, air temperature, precipitation), while others may not. For example, cheat grass
1446 flourishes in many different environments, whereas bluebunch wheatgrass (*Pseudoroegneria*
1447 *spicata*), a native grass, is more sensitive to climatic conditions and its range, and may shrink in
1448 response to changing precipitation patterns and warmer air temperatures (Ganksopp and
1449 Bedell 1979; Bradley, Curtis, and Chambers 2016; Kray 2019).

1450 Changes to timing and volumes of streamflow will likely affect riparian area extent and species
1451 composition: aspen, willow, cottonwood, and herbaceous communities dependent on water
1452 availability during the growing season may decline along with the ecosystem services they
1453 provide (USFS 2019a). Changes to vegetative cover can affect streamflow and water quality,
1454 reducing the ability for ecosystems to improve water quality and regulate water flows (USGCRP
1455 2018; USFS 2019a). Changes in hydrology will affect the lifestyle, survival, and reproductive
1456 success of aquatic and semi-aquatic invertebrate and amphibian species (USFS 2019a). For
1457 example, shallow water areas or pools that typically provide habitat for amphibians, such as
1458 frogs, may dry out earlier or faster and cause tadpoles to die. This could affect local populations
1459 of amphibians.

1460 At the same time, climate change may enhance the expansion of invasive species by giving non-
1461 native species an advantage over stressed native species (USGCRP 2018; USFS 2019b).
1462 Increased outbreaks of insects and other pests are likely to become more common and
1463 widespread. Disturbances such as wildland fire will also increase in frequency and severity
1464 (Section 4.1.2.6). The effects of wildland fire on wildlife habitat can be exacerbated in areas
1465 stressed by drought, insect outbreak, or dominated by invasive species.

1466 Climate change can also have positive effects. A longer growing season (USGCRP 2018) may
1467 benefit some plant species and allow for greater productivity and nutrient cycling (USFS 2019b).
1468 Warmer air temperatures combined with earlier winter and spring flows (Section 4.1.2.4) could
1469 allow wetlands to recharge earlier in the growing season and could increase riparian and
1470 wetland vegetation along reservoir shorelines and rivers. This could increase available habitat
1471 for some wildlife species. For example, if a wetland area has greater productivity and provides
1472 cooler and cleaner water, this could enhance amphibian and waterfowl habitat. Additionally,
1473 species are adapting and responding to climate change by altering individual characteristics, the
1474 timing of biological events, and geographic ranges (USGCRP 2018).

1475 The projected changes in precipitation (Section 4.1.2.2) coupled with warming temperatures
1476 (Section 4.1.2.1) could result in increased winter flood frequency and magnitude (Section
1477 4.1.2.4). Increases in winter precipitation can also lead to increased snowmelt flooding in the
1478 spring, particularly in high elevation regions where winter temperatures will remain below
1479 freezing even with moderate amounts of warming (Hamlet et al. 2013; Salathé et al. 2014;
1480 RMJOC 2018; Chegwidden et al. 2019). Floodplains could experience increased frequency,
1481 duration, and extent of inundation due to these projected increases in flooding.

1482 **4.2.4.1 Region A - Libby, Hungry Horse, and Albeni Falls Dams**

1483 **NO ACTION ALTERNATIVE**

1484 Potential higher winter inflows and increased frequency of systemwide winter flood events
1485 could lead to more variable reservoir outflows and pool elevations during winter (Section
1486 4.2.1.1). This could lead to bank sloughing and increased erosion, which would erode wildlife
1487 habitat adjacent to the reservoir thus reducing nearby wildlife habitat. Downstream of Libby,
1488 projected increases in winter rains and spring flows could increase erosion/frozen bank
1489 sloughing (Section 4.2.2.1), which could discourage cottonwood establishment and impair
1490 wildlife habitat.

1491 Lower inflows and lower reservoir levels are projected during the summer and early fall
1492 (Section 4.2.1.1). This could lead to the establishment of invasive species (e.g., flowering rush
1493 [*Butomus umbellatus*]). At Hungry Horse, the lower inflows and deeper pool levels may
1494 influence habitat, including wetland communities that border the reservoir. Wetland habitats
1495 may become drier and shift downslope of current elevations, and gradually transition to plant
1496 communities more tolerant of drought conditions or more traditionally upland communities
1497 like conifers.

1498 At Libby, shallow water habitat may become unvegetated mudflats due to decreased inflows
1499 (Section 4.1.2.4). As described above, this could affect insects and amphibians. Lower water
1500 surface elevations or levels surrounding reservoirs may lead to changes in shallow water
1501 habitat. Increased exposure and reduced water levels could cause the habitat to transition to
1502 mudflats.

1503 Floodplains in Region A could experience increased frequency, duration, and extent of
1504 inundation due to projected increases in flooding.

1505 **MULTIPLE OBJECTIVE ALTERNATIVES 1 AND 3**

1506 Same as the No Action Alternative discussion above, as effects are anticipated to be similar.

1507 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

1508 Same as the No Action Alternative, except for at Hungry Horse. Projected increases in winter
1509 flow could reduce the need for deeper drafts at Hungry Horse and Libby (section 4.2.1.1),
1510 potentially reducing the exposure of the barren zone (the area where small animals become

1511 prey because of lack of cover) by increasing the duration and the extent (or width) of the
1512 exposed barren zone.

1513 **MULTIPLE OBJECTIVE ALTERNATIVES 4**

1514 MO4 includes measure that provide deeper drafts during dry years at Libby and Albeni Falls and
1515 in all years at Hungry Horse. These deeper drafts could exacerbate the effects of climate change
1516 on vegetation and wildlife discussed under NAA.

1517 **4.2.4.2 Region B – Grand Coulee and Chief Joseph Dams**

1518 **NO ACTION ALTERNATIVE**

1519 Vegetation and wildlife habitat surrounding the reservoirs and streams coming into the
1520 reservoirs could experience higher inflows during the winter (Section 4.2.1.2) that could
1521 increase surface erosion. Increased erosion could decrease riparian vegetation and habitat as
1522 banks fall into the reservoirs.

1523 Projected warmer air temperatures (Section 4.1.2.1) combined with projected lower summer
1524 and fall reservoir levels (Section 4.2.1.2) could favor invasive species along banks and shallow
1525 water areas vulnerable to drying. Likewise, there could be subsequent effects to amphibians
1526 and other species if shallow water habitat is reduced.

1527 Floodplains in Region B could experience increased frequency, duration, and extent of
1528 inundation due to projected increases in flooding.

1529 **MULTIPLE OBJECTIVE ALTERNATIVE 1 AND 2**

1530 The *Winter System FRM Space* measure may be used more frequently, leading to greater
1531 reservoir fluctuations and associated bank sloughing. Increased erosion from this measure
1532 being activated more frequently could erode wildlife habitat adjacent to the reservoir, thus
1533 reducing nearby wildlife habitat locally.

1534 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

1535 See No Action Alternative discussion above, as effects are anticipated to be similar.

1536 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

1537 The McNary Flow Target, which could increase in frequency as streamflow volumes shift earlier
1538 in the year, could result in greater outflow earlier in the summer and reduced outflow from
1539 August to October (Section 4.2.1.2). Combined with additional projected deeper drafts in the
1540 fall for navigation (Section 4.2.1.2) and more frequent use of the Winter System FRM (see
1541 MO1), this could lead to bank sloughing and increased erosion. This would erode wildlife
1542 habitat adjacent to the reservoir, thus reducing nearby wildlife habitat. It could also provide

1543 additional opportunity for the establishment of invasive species in areas where there is
1544 drawdown.

1545 **4.2.4.3 Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor**
1546 **Dams**

1547 **NO ACTION ALTERNATIVE**

1548 At Dworshak, projected higher inflows (Section 4.1.2.4) and pool levels in the winter could
1549 decrease extent and duration of exposure of the barren zone, allowing for increased survival of
1550 small prey animals. Projected warmer air temperature (Section 4.1.2.1) combined with earlier
1551 spring inflows (Sections 4.1.2.4, 4.2.3.3) will likely allow for wetlands to recharge earlier in the
1552 growing season. This could allow for the establishment of riparian and wetland vegetation
1553 along the shoreline, including cottonwoods. Warmer air temperature and lower releases on the
1554 lower Snake River projects during the summer could lead to establishment of invasive
1555 vegetation (i.e., flowering rush) in areas with drawdown. Shallow water habitat may become
1556 unvegetated mudflats more frequently, allowing for colonization of invasive species. Amphibian
1557 eggs may desiccate if pools dry up faster.

1558 Floodplains in Region C could experience increased frequency, duration, and extent of
1559 inundation due to projected increases in winter and spring flooding.

1560 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

1561 Same as the No Action Alternative discussion above, as effects are anticipated to be similar.

1562 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

1563 Deeper drafting in the winter at Dworshak reservoir increases the barren zone (area where
1564 small animals become prey because of lack of cover). In the spring, pool levels at Dworshak may
1565 be lower (Section 4.2.1.3). This may delay recharge of wetlands in the spring, allowing for
1566 establishment of vegetation species adapted to drier conditions.

1567 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

1568 Breaching the lower Snake River dams will lead to perched habitat and exposed sediment and
1569 shoreline (Section 3.6.3.5). The exposed shoreline would be at increased risk of invasion by
1570 invasive plant species. Climate change could exacerbate shifts in wetland and riparian habitats
1571 by allowing vegetation to colonize earlier in the growing season, thereby increasing the
1572 likelihood of invasive species. The stage of the un-impounded river could be more responsive to
1573 local inflow as compared to the NAA. Variability of local inflows could increase during winter
1574 months as more precipitation falls as rain (Section 4.1.2.2) and outflow of Dworshak Dam could
1575 become more variable (Section 4.2.1.3). This could cause a larger band of riparian vegetation to
1576 establish and possibly a larger barren zone than what could occur with the No Action
1577 Alternative.

1578 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

1579 Same as the No Action Alternative discussion above, as effects are anticipated to be similar.

1580 **4.2.4.4 Region D – McNary, John Day, The Dalles, and Bonneville Dams**

1581 **NO ACTION ALTERNATIVE**

1582 Increased likelihood of heavy precipitation events in the fall and winter, mostly in the form of
1583 rain, may lead to higher flows in Region D (Section 4.2.3.4). This could lead to more flood
1584 storage in adjacent wetlands and floodplains. Wetlands could act as a stormwater retention
1585 area and stay wetter longer during the spring growing season. Additionally, earlier inflows in
1586 the spring could allow for wetlands to recharge earlier in the growing season. This could allow
1587 for establishment of riparian and wetland vegetation along the shoreline, including
1588 cottonwoods. Longer periods of low flows in the summer could lead to the establishment of
1589 invasive vegetation in areas where there is drawdown. Shallow water habitat could become
1590 unvegetated mudflats, allowing for colonization of invasive species and may lead to amphibian
1591 habitat drying up and killing eggs and tadpoles.

1592 Floodplains in Region D could experience increased frequency, duration, and extent of
1593 inundation due to projected increases in winter flooding.

1594 **MULTIPLE OBJECTIVE ALTERNATIVES 1 TO 4**

1595 Same as the No Action Alternative discussion above, as effects are anticipated to be similar.

1596 **4.2.5 Power Generation and Transmission**

1597 **4.2.5.1 Power Generation**

1598 Projected future changes in temperature, precipitation, snowpack, and streamflow will likely
1599 impact hydropower generation and load in the basin. Climate change is likely to add
1600 uncertainty to the annual magnitude of generation, and significant uncertainty to the monthly
1601 magnitude of the effect of the MOs relative to the No Action Alternative due to the increase in
1602 variability of streamflow (Section 4.1.2.4). However, climate change is not likely to change the
1603 general conclusions from the power analysis of the relative effect of one MO versus another.
1604 The projected changes in climate are likely to affect hydropower generation in all alternatives
1605 relative to the No Action Alternative roughly the same on an annual basis (though with a little
1606 more variability on a monthly basis). More detailed analyses on the projected effect of climate
1607 change on power is in the hydropower appendix (Appendix H).

1608 **NO ACTION ALTERNATIVE**

1609 The projected changes in streamflow (section 4.1.2.4) will affect hydropower generation. For
1610 the No Action Alternative, climate change adds uncertainty to the annual magnitude of
1611 generation, and significant uncertainty to the monthly shaping of generation with longer

1612 periods of low generation in the summer. Additionally, rising temperatures will likely decrease
1613 winter and increase summer energy demand in the region, which is likely to decrease winter
1614 shortfalls and increase summer shortfalls.

1615 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

1616 MO1 produces less energy than the No Action Alternative on average under historical
1617 hydrological conditions. MO1 has a higher spill operation than No Action, thus the projected
1618 increased runoff (Section 4.1.2.4) in the spring (mid-April to June) does not reduce generation
1619 in MO1 as much as in No Action. Projected increases in runoff could somewhat offset the
1620 higher spill operation effects and result in an increase in generation under climate change for
1621 MO1 as compared to No Action. Lower summer flows (first half of August; Section 4.1.2.4) may
1622 cause similar or exacerbate the already lowered generation when compared to the No Action
1623 Alternative.

1624 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

1625 MO2 produces more energy than the No Action Alternative under historical hydrological
1626 conditions. Projected changes in runoff timing with potentially more flow in the winter and less
1627 in the spring (Section 4.1.2.4) combined with the measures in MO2 may somewhat reduce the
1628 magnitude of the increase in annual generation under historical conditions. This is because
1629 generation in MO2 is more sensitive to decreases in spring flows since MO2 includes more
1630 spring generation than the No Action Alternative or the other MOs. Monthly generation is more
1631 uncertain and may experience more variability under climate change. MO2 is projected to
1632 provide the most resiliency for meeting projected energy demand increases in the summer.

1633 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

1634 MO3 produces less average energy than in the No Action Alternative under historical
1635 hydrological conditions, largely due to the measure that breaches the lower Snake River dams
1636 and ends generation at those projects. Projected increases in winter and spring runoff (Section
1637 4.1.2.4) will likely lead to increased generation from the Lower Snake River dams during that
1638 time period Breaching of the lower Snake River dams eliminates the potential opportunity for
1639 increased seasonal generation gains, particularly in March and April. Thus, climate change may
1640 result in MO3 having even less generation compared to the No Action Alternative than what
1641 was modeled with the historical conditions. In the summer, when the loss of generation from
1642 the lower Snake River dams contributes to significant reliability concerns, climate change could
1643 exacerbate these concerns given the decrease in potential generation over the summer with
1644 lower flows.

1645 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

1646 MO4 produces considerably less energy than the No Action Alternative under historical
1647 hydrological conditions, largely in the spring and summer with large reliability concerns
1648 especially in August (Section 3.7.3.6). Projected decreases in summer flows (Section 4.1.2.4)

1649 with climate change may further decrease summer generation under MO4. Monthly generation
1650 is more uncertain and may experience more variability under climate change.

1651 **4.2.5.2 Energy Demand (Loads)**

1652 Projected warming regional temperatures (Section 4.1.2.1) are expected to affect energy
1653 demand (load) as well. By the 2030s, loads are likely to increase in the June through August
1654 period, and possibly into September as well, due to increasing air conditioning demand and a
1655 longer air conditioning season. In the winter months (roughly December through February),
1656 loads are likely to decrease as increasing regional temperatures lower the need for heating. This
1657 change in energy demand has important potential implications for reliability.

1658 The power shortages (Section 3.7.3) in December through February under all alternatives are
1659 likely to be reduced into the 2030s as loads in those months decrease (absent other changes).
1660 Conversely, the summer power shortages that increase in MO1, MO3, and MO4 as compared to
1661 the No Action Alternative are likely to be further exacerbated as temperatures and load in
1662 those months increase. Under MO2, climate change could somewhat decrease the increases in
1663 power reliability in summer months (section 3.7.3.4). Recent research supports these
1664 conclusions. A Northwest Power and Conservation Council and Pacific Northwest National
1665 Laboratories study found that combined climate change effects on loads and hydropower may
1666 lead to decreases in winter shortfalls and increases in summer shortfalls as increases in peak
1667 loads for cooling coincide with decreases in hydropower generation (Voisin et al. 2019).

1668 **4.2.5.3 Coal Plant Retirement**

1669 Changes in economics and GHG emissions reduction policy in the region are resulting in
1670 increased and accelerated retirements of coal plants serving Pacific Northwest loads (Section
1671 3.7.3.1). These retirements will change the Loss of Load Probability of No Action Alternative and
1672 MOs as well as resources required to maintain regional reliability (Section 3.7.3). Summer
1673 power shortages are projected for MO1, MO3, and MO4 and are likely to increase with climate
1674 change due to increased loads. This will be further exacerbated with the retirement of baseload
1675 coal generation. The retirement of coal generation could also lead to reliability concerns with
1676 MO2 with climate change as well.

1677 **4.2.6 Air Quality and Greenhouse Gases**

1678 While the relationship between meteorological factors and air pollutants is complex, studies
1679 indicate that climate change-related weather patterns are a driving force in establishing
1680 conditions that are conducive to ozone formation and accumulation, including abundant
1681 sunshine, high temperatures, more frequent stagnation, less frequent rainfall, reduced
1682 ventilation, and increased biogenic emissions (e.g., from air conditioning) due to temperature
1683 (Leung et al. 2004; Leung and Gustafson 2005; Steiner et al. 2006; Grambsch, Hemming, and
1684 Weaver 2009; Jacob and Winner 2009). The Pacific Northwest, and the Columbia River Basin in
1685 particular, already experiences an isolated, sometimes stagnant atmosphere as a result of
1686 topographic features (Ferguson 1998; Leung et al. 2004; Zhang et al. 2008). This could be

1687 enhanced under projected climate conditions. Specifically, the development of a low-level
1688 thermal trough and upper-level ridge are climatologically significant factors that could increase
1689 summer ozone concentrations over time in the Pacific Northwest (McKendry 1994; Leung et al.
1690 2004).

1691 The relationship of meteorological factors to particulate matter (PM) concentrations is not as
1692 well understood as the relationship to ozone. However, wildland fires fueled by projected
1693 changes to climate (Section 4.1.2.6) could become an increasing source of PM emissions
1694 (Grambsch, Hemming, and Weaver 2009; Jacob and Winner 2009). This could affect air quality
1695 across the basin.

1696 Beyond the more direct effects on air pollutant concentrations, climate change may also affect
1697 activities that generate emissions across the region, including power generation and navigation
1698 and transportation (e.g., by affecting reservoir levels and stream flows). For example, to the
1699 extent climate change results in changes in hydropower generation (Section 4.2.7; Appendix H),
1700 it could therefore result in changes in emissions from power generation: GHGs and ozone
1701 precursors (i.e., nitrogen oxides, carbon monoxide, and volatile organic compounds). The
1702 following sections describe how climate change may influence how the CRSO EIS alternatives
1703 affect air quality and GHG emissions, and due to the nature of airsheds, effects on the resource
1704 are discussed collectively rather than by region.

1705 **4.2.6.1 No Action Alternative**

1706 Climate change may degrade air quality by increasing ground-level ozone concentrations (see
1707 previous section) and potentially increasing PM and GHG emissions from wildland fires (Section
1708 4.1.2.6). Climate change will add uncertainty to the annual and monthly magnitude of
1709 hydropower generation in the region (Section 4.2.7, Appendix H).

1710 Projected increasing temperatures will likely also affect electricity demand (Section 4.2.5.2). In
1711 the winter, decreased heating demands due to projected higher temperatures could reduce
1712 generation needs, and therefore emissions, from fossil-fuel plants. Conversely, increased air
1713 conditioning loads in summer months due to projected increased temperatures could increase
1714 emissions from fossil-fuel combustion.

1715 Potentially offsetting this effect to some degree, both with and without climate change, the
1716 region could increasingly rely on power generation from renewable sources and reduce
1717 generation from fossil fuel combustion, which would curtail emissions of ozone precursors, PM,
1718 and GHGs. Existing coal and natural gas plants are concentrated in Region D (as well as areas
1719 across the Pacific Northwest outside of the CRSO regions) (section 3.8.3, figure 3-156; Oregon
1720 Department of Energy, 2020); therefore, Region D may experience improvements in air quality.

1721 Further, climate change is not likely to affect emissions from navigation/transportation, or
1722 construction activities.

1723 **4.2.6.2 Multiple Objective Alternative 1**

1724 MO1 produces less hydropower than the No Action Alternative under historical hydrological
1725 conditions, but projected increased runoff with climate change may increase generation (see
1726 Section 4.2.5.1) compared with No Action. The increased hydropower generation may reduce
1727 reliance on, and associated air pollutant and GHG emissions from, existing fossil fuel plants. Air
1728 quality improvements would most likely occur in Region D, where the existing fossil fuel plants
1729 are concentrated, and in other areas across the Pacific Northwest, outside of the CRSO regions.

1730 **4.2.6.3 Multiple Objective Alternative 2**

1731 MO2 results in more hydropower generation than the No Action Alternative under historical
1732 hydrological conditions, but projected changes in seasonal streamflow timing may reduce the
1733 magnitude of the increased hydropower generation relative to No Action (Section 4.2.5.1).
1734 MO2 would still be beneficial to air quality relative to the No Action Alternative by reducing
1735 reliance on fossil fuel power plants (currently concentrated in Region D, as well as areas across
1736 the Pacific Northwest outside of the CRSO regions).

1737 **4.2.6.4 Multiple Objective Alternative 3**

1738 MO3 produces less hydropower generation than the No Action Alternative under historical
1739 hydrological conditions, and projected changes in runoff could further reduce generation under
1740 MO3 (Section 4.2.7.1). This would further increase the need for additional power resources to
1741 replace the reduced hydropower generation. While the type (i.e., mix of renewables and
1742 natural gas) and location of additional power resources is uncertain, increased generation from
1743 existing fossil fuel plants in Region D, and any added natural gas capacity across the CRSO
1744 regions would further degrade air quality relative to the No Action Alternative if these existing
1745 fossil fuel plants replace the reduced hydropower generation.

1746 **4.2.6.5 Multiple Objective Alternative 4**

1747 Hydropower generation under MO4 is less than under the No Action Alternative under
1748 historical hydrological conditions, but projected changes in runoff could slightly lessen the
1749 difference (Section 4.2.5.1) based on various influences that increase or decrease generation in
1750 different months. The effects of this alternative on air quality would likely still be adverse due
1751 to the potential increased reliance on high-emitting fossil fuel generation as compared to the
1752 No Action Alternative if these existing fossil fuel plants replace the reduced hydropower
1753 generation. However, the effects of climate change could slightly lessen these effects.

1754 **4.2.6 Flood Risk Management**

1755 Winter flooding and large accumulations of snowfall, which contribute to snowmelt flooding
1756 during spring, are associated with atmospheric rivers (ARs). ARs are enhanced water vapor
1757 plumes in the atmosphere from extratropical cyclones sourced from tropical latitudes. These
1758 typically only last several days, but deliver a significant amount of intense precipitation, wind,
1759 and often warm temperatures. The frequency and severity of landfalling atmospheric rivers in
1760 the Pacific Northwest is projected to increase (Warner, Mass, and Salathé 2015; Hagos et al.

1761 2016). The projected changes in precipitation (Section 4.1.2.2) coupled with warming
1762 temperatures (Section 4.1.2.1) could result in increased winter flood frequency and magnitude
1763 (Section 4.1.2.4). Increases in winter precipitation can also lead to increased snowmelt flooding
1764 in the spring, particularly in high elevation regions where winter temperatures will remain
1765 below freezing even with moderate amounts of warming (Hamlet et al. 2013; Salathé et al.
1766 2014; RMJOC 2018; Chegwiddden et al. 2019).

1767 **4.2.7.1 Region A – Libby, Hungry Horse, and Albeni Falls Dams**

1768 **NO ACTION ALTERNATIVE**

1769 Historically, flood mechanisms in this region have been driven by snowmelt. This flood
1770 hydrological regime is expected to continue through the 2030s.

1771 An earlier shift in flood freshet volumes is projected for the headwaters of the Kootenai River
1772 (Section 4.1.2.4); however extreme peak freshet volumes (95th percentile volume) are
1773 expected still to occur in June. The projections show both increases and decreases in the peak
1774 volume magnitude, indicating future uncertainty (Libby Dam inflow, Section 4.1.2.4). Increased
1775 flow volume in winter is unlikely to affect local FRM at Bonner’s Ferry, Idaho; however,
1776 increased peak local inflows from spring snowmelt linked to increased precipitation and
1777 warmer spring temperatures could elevate local flood risk at Bonner’s Ferry.

1778 An earlier shift in flood freshet volumes is projected for the headwater regions of the Flathead
1779 River and Clark Fork tributaries, with peaks occurring in both May and June (Hungry Horse
1780 inflow, Section 4.1.2.4). A large fraction of the projections indicate peak snowmelt volumes that
1781 are larger than historical values for unregulated headwater areas. These are likely to elevate
1782 local flood risk of the Flathead River at Columbia Falls, Montana, and of the Clark Fork River
1783 near Plains, Montana.

1784 On average, the center of timing of the peak spring freshet at Albeni Falls Dam is projected to
1785 occur a month earlier, in May, where nearly all projections indicate increasing peak monthly
1786 volumes in median (50th percentile) and extreme (95th percentile) flows conditions (Section
1787 4.1.2.4). The timing of flood risk on Lake Pend Oreille is likely to shift earlier, however, there are
1788 not clear trends to indicate directional changes in the probability of exceeding flood stage at
1789 this Lake.

1790 **MULTIPLE OBJECTIVE ALTERNATIVES 1, 2, 3, AND 4**

1791 See the No Action Alternative discussion above, as the effects are anticipated to be similar.

1792 **4.2.7.2 Region B – Grand Coulee and Chief Joseph Dams**

1793 This region includes one flood risk consequence area, “Below Priest Rapids.” Flood risk was
1794 determined to be negligible at this location in the historical period analysis (Section 3.9.3.2).
1795 Effects of climate change on flood risk at this location are not expected under any of the MOs
1796 or the No Action Alternative.

1797 **4.2.7.3 Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor**
1798 **Dams**

1799 **NO ACTION ALTERNATIVE**

1800 Historically, flood mechanisms in this region have been driven by snowmelt. This hydrological
1801 flooding regime is expected to continue through the 2030s.

1802 An earlier shift in unregulated flood freshet volumes is projected for drainages in the lower
1803 Snake River. Extreme peak freshet volumes (95th percentile volume) are projected to occur in
1804 May. The projections indicate potential increases and decreases in the spring freshet peak
1805 volume (Dworshak Dam inflow, Ice Harbor natural flow, Section 4.1.2.4). Increased local flood
1806 risk for the Clearwater River at Orofino and Spalding, Idaho, and the Snake River at Anatone,
1807 Idaho, is possible. In the Clearwater River, seasonal extremes in winter flow volume are
1808 indicated by nearly all projections (section 4.1.2.4). Increased winter volumes could impose
1809 challenges in meeting draft requirements for spring FRM operations, potentially elevating
1810 spring flood risk on the Clearwater River at Spalding.

1811 **MULTIPLE OBJECTIVE ALTERNATIVES 1 TO 4**

1812 See the No Action Alternative discussion above, as the effects are anticipated to be similar.

1813 **4.2.7.4 Region D – McNary, John Day, The Dalles, and Bonneville Dams**

1814 **NO ACTION ALTERNATIVE**

1815 Historically, flood mechanisms in this region have been driven by both winter rainfall and spring
1816 snowmelt events. Both hydrological flooding regimes are expected to persist through the
1817 2030s.

1818 Potential increases in winter rainfall driven events effecting the coastal ranges, Southern
1819 Cascades range, and lower Columbia are projected (RMJOC 2018). Potential increases in intense
1820 rainfall events associated with atmospheric rivers, coupled with increasing winter flow volumes
1821 from the mainstem of the Columbia River (Section 4.1.2.4) are likely to elevate flood risk at
1822 flood consequences areas in this region.

1823 An earlier shift in flood freshet volumes is projected for the Columbia River. The extreme peak
1824 freshet volumes (95th percentile) are expected to still occur in the May to June period. The
1825 projections show both increases and decreases in the peak volume, indicating future
1826 uncertainty (The Dalles natural flow, Section 4.1.2.4).

1827 Sea level rise could elevate flood stages at locations below Bonneville Dam (Section 4.1.2.5,
1828 USGS 2019). The influence of sea level rise increases with proximity to the outlet of the
1829 Columbia River at the Pacific Ocean.

1830 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

1831 MO1 includes the *Winter System FRM Space* measure, providing additional flood storage for
1832 system flood operations through the winter. This additional space allows Grand Coulee to
1833 reduce outflows and store inflow volume during December flood events. This measure could
1834 partially buffer projected increases in winter flood risk for consequence locations affected by
1835 flow on the Columbia River in this region.

1836 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

1837 See the No Action Alternative discussion above, as the effects are anticipated to be similar.

1838 **MULTIPLE OBJECTIVE ALTERNATIVES 2 AND 4**

1839 See the MO1 discussion above, as the effects are anticipated to be similar.

1840 **4.2.7 Navigation and Transportation**

1841 Navigation and transportation could be affected by climate change through changes in seasonal
1842 patterns and variability of streamflow and the consequences for riverbed profiles. The water
1843 surface elevation of rivers and reservoirs, and channel depths affect access to shoreline
1844 transportation infrastructure and drafts of freight vessels.

1845 **4.2.7.1 Region A – Libby, Hungry Horse, and Albeni Falls Dams**

1846 No effects from climate change to Navigation and Transportation are identified in this region.
1847 The region does not include significant riverine navigation and transportation activities or
1848 infrastructure.

1849 **4.2.7.2 Region B – Grand Coulee and Chief Joseph Dams**

1850 **NO ACTION ALTERNATIVE**

1851 When the Lake Roosevelt forebay elevation falls below 1,229 feet National Geodetic Vertical
1852 Datum of 1929 (NGVD29), the Inchelium-Gifford Ferry is inoperable (Section 3.10.3.2). The
1853 projected shift toward earlier freshet timing (Section 4.1.2.4) could result in refill being initiated
1854 earlier more frequently, reducing the amount of time that Lake Roosevelt is drafted to this
1855 inoperable range.

1856 **MULTIPLE OBJECTIVE ALTERNATIVES 1 TO 4**

1857 See the No Action Alternative discussion above, as the effects are anticipated to be similar.

1858 **4.2.7.3 Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor**
1859 **Dams**

1860 **NO ACTION ALTERNATIVE**

1861 Lower unregulated flows are projected June through October (Section 4.1.2.4). This could result
1862 in an increased frequency of shallow river conditions that may affect navigation at some
1863 locations. Projected higher flows and higher extreme flows November through March could
1864 slow or interrupt barge traffic more frequently in this region.

1865 **MULTIPLE OBJECTIVE ALTERNATIVES 1, 2, AND 4**

1866 See the No Action Alternative.

1867 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

1868 This alternative includes the *Breach Snake Embankments* measure. This measure could increase
1869 the conveyance of sediment downstream in the lower Snake River (Section 3.3.3.5). The
1870 potential supply of sediment from the land surface could increase as a consequence of
1871 projected hydrological changes (Section 4.2.2.3) and could result in increases in dredging for
1872 maintenance of ports (e.g., berthing areas) in the lower Snake River.

1873 **4.2.7.4 Region D – McNary, John Day, The Dalles, and Bonneville Dams**

1874 **NO ACTION ALTERNATIVE**

1875 Lower unregulated flows are projected June through October (Section 4.1.2.4). This could result
1876 in an increased frequency of shallow river conditions that may affect navigation at some
1877 locations. Projected higher flows and higher extreme flows November through March could
1878 slow or interrupt barge traffic more frequently in this region.

1879 Projected sea level rise could affect river surface elevations downstream of Bonneville Dam
1880 (4.2.2.5). The effects of sea level rise on river elevations could provide a marginal benefit for
1881 navigation of the channel below Bonneville and have limited effects on shoreline transportation
1882 infrastructure.

1883 **MULTIPLE OBJECTIVE ALTERNATIVES 1 TO 3**

1884 See the No Action Alternative discussion above, as effects are anticipated to be similar.

1885 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

1886 MO4 also includes the *McNary Flow Target* measure. This measure will provide more flow early
1887 in summer for dry years and potentially lead to reduced flows in late summer and fall. This
1888 operation may increase in frequency as streamflow volumes are projected to shift to occur
1889 earlier in the year and late spring/summer flow declines (Section 4.1.2.4). Flow changes

1890 associated with this measure have the potential to exacerbate low flow conditions effecting
1891 navigation in late summer.

1892 **4.2.8 Recreation**

1893 Recreational opportunities could be affected by climate change primarily by changing seasonal
1894 access for in-water activities. Projected effects to other resources could also influence visitation
1895 related to specific recreational activities. For instance, potential effects to fish and wildlife
1896 (Section 4.2.4, 4.2.5) could influence sport fishing and hunting opportunities. Potential effects
1897 to water quality (Section 4.2.3) could affect swimming opportunities.

1898 **4.2.8.1 Region A – Libby, Hungry Horse, and Albeni Falls Dams**

1899 **NO ACTION ALTERNATIVE**

1900 The timing of the spring freshet inflow volume is projected to shift earlier in the year (Section
1901 4.1.2.4), resulting in headwater reservoirs, Libby Dam/Lake Koochanusa and Hungry Horse Dam
1902 and reservoir, filling earlier than historically. The seasonal period for recreational activities that
1903 depend on high lake levels for water access (fishing, boating, paddling, and camping) could
1904 begin earlier in the year. Decreased summer and fall flow volume (Section 4.1.2.4) will likely
1905 lead to lower lake levels in the late summer and fall resulting in less recreational access during
1906 this time of year.

1907 The operations of Albeni Falls Dam/Lake Pend Oreille follow a fixed seasonal draft; changes in
1908 seasonal inflow patterns will not affect draft and refill timing. However, increased frequency of
1909 system wide winter flood events (Section 4.2.1.1) will result in flood volumes being stored and
1910 evacuated more frequently during winter. This potential increase in fluctuations of Lake Pend
1911 Oreille could negatively affect winter recreational activities that use the lakeshore and ice
1912 surface (ice fishing). Projected increases in winter temperature could decrease the duration and
1913 frequency of periods where ice conditions suitable for ice fishing. Increases in summer water
1914 temperature (Section 4.2.3.1) could increase visitation for in-water activities.

1915 Sport fishing opportunities may increase for resident species that may benefit from warming
1916 water temperature at some headwater locations, and warm water adapted invasive species.
1917 Opportunities could decrease for potentially negatively affected resident species (Section
1918 4.2.3.6).

1919 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

1920 Under MO1, the *December Libby Target Elevation* measure allows for higher winter (November
1921 to December) reservoir elevations at Libby Reservoir to mitigate for potential over-drafting in
1922 years with a drier forecast. Projected changes in inflow timing combined with this measure
1923 could support higher spring and summer pool elevations (Section 4.2.1.1) that would support
1924 increased periods of water access.

1925 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

1926 See the No Action Alternative discussion above, as effects are anticipated to be similar.

1927 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

1928 Similar to effects of MO1 however through the combined influence of different measures.

1929 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

1930 Under MO4, in low water years, the *McNary Flow Target* measure would release an additional
1931 water from Libby, Hungry Horse, and Albeni Falls, resulting in lower reservoir elevations on
1932 April 10, which could affect refill during dry water years. Projected decreases in summer inflow
1933 volume with climate change may further exacerbate the effects of refill during drier years.
1934 Projected increases in winter flows could aid in storage recovery.

1935 **4.2.9.2 Region B – Grand Coulee and Chief Joseph Dams**

1936 **NO ACTION ALTERNATIVE**

1937 The timing of the spring freshet inflow volume is projected to shift earlier in the year (Section
1938 4.1.2.4), resulting in Lake Roosevelt filling earlier than historically. The seasonal period for
1939 recreational activities that depend on high lake levels for water access (fishing, boating, and
1940 camping) could begin earlier in the year. Decreased summer and fall flow volume (Section
1941 4.1.2.4) will likely lead to lower lake levels in the late summer and fall resulting in less
1942 recreational access during this time of year. Increases in water temperature (Section 4.2.3.2)
1943 could increase visitation for in-water activities. However, it could also increase algal growth,
1944 including at recreational areas where cyanobacteria is currently present (Lake Roosevelt, Rufus
1945 Woods Lake). Potential negative effects of climate change to native anadromous fish (Section
1946 4.2.3.5) could lead to decreased sport fishing opportunities. Sport fishing opportunities for
1947 warm water adapted species may increase.

1948 **MULTIPLE OBJECTIVE ALTERNATIVES 1, 2, AND 3**

1949 See the No Action Alternative discussion above, as the effects are anticipated to be similar.

1950 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

1951 MO4 includes the *McNary Flow Target* measure that increases outflow from Grand Coulee from
1952 May through July during dry years. This operation may increase in frequency as streamflow
1953 volumes are projected to shift to occur earlier in the year and late spring/summer flow declines
1954 (Section 4.1.2.4). This operation could result in lower elevations of Lake Roosevelt during the
1955 summer recreation period, thus effecting recreational access.

1956 **4.2.9.3 Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice**
1957 **Harbor Dams**

1958 **NO ACTION ALTERNATIVE**

1959 The timing of the spring freshet inflow volume is projected to shift earlier in the year (Section
1960 4.1.2.4), resulting in Dworshak filling earlier than historically. This means the seasonal period
1961 for recreational activities that depends on high lake levels for water access (fishing, boating,
1962 and camping) could begin earlier in the year. Projected decreased summer and fall flow volume
1963 (Section 4.1.2.4) will likely lead to lower lake levels at Dworshak in the late summer and fall,
1964 resulting in less recreational access during this time of year. Projected increases in summer
1965 water temperature (Section 4.2.3.3) could increase visitation for in-water activities, which could
1966 potentially be offset by potential increases in harmful water quality conditions (e.g., harmful
1967 algae blooms). Potential negative effects of climate change to native anadromous fish (Section
1968 4.2.3.5) could lead to decreased sport fishing opportunities. Sport fishing opportunities for
1969 warm water adapted species could increase.

1970 **MULTIPLE OBJECTIVE ALTERNATIVES 1, 2, AND 4**

1971 See the No Action Alternative discussion above, as the effects are anticipated to be similar.

1972 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

1973 This alternative includes the *Breach Snake Embankments* measure. Recreational activities
1974 would change after dam breaching (Section 3.11.3.5). Projected increased spring water
1975 temperature amplified by MO3 could increase the period for in-water activities, starting earlier
1976 in the year. River flows through the affected lower Snake River mainstem reach will more
1977 closely mimic and be more responsive to inflow patterns. Projected increased variability in
1978 winter flow volumes and lower summer volumes (Section 4.1.2.4) could negatively affect
1979 recreational boating opportunities and activities that rely on consistent shoreline water access.

1980 **4.2.9.4 Region D – McNary, John Day, The Dalles, and Bonneville Dams**

1981 **NO ACTION ALTERNATIVE**

1982 Inflow volumes may be stored and evacuated more frequently within the series of the four
1983 lower Columbia River dams and reservoirs for winter system flood events (Section 4.2.1.4). The
1984 projected variability of winter pool elevations and outflow from Bonneville Dam could restrict
1985 winter recreational activities. Sea-level rise is not expected to affect recreational activities.
1986 Potential negative effects of climate change to native anadromous fish (Section 4.2.4.1) could
1987 lead to decreased sport fishing opportunities. Sport fishing opportunities for warm water
1988 adapted species may increase.

1989 **MULTIPLE OBJECTIVE ALTERNATIVES 1 TO 4**

1990 Similar to the No Action Alternative discussion above, as effects are anticipated to be similar.

1991 **4.2.9 Water Supply (Irrigation, Municipal, Industrial, Groundwater, and Aquifers)**

1992 Climate change has the potential to disrupt hydrological processes that in turn may affect
1993 current water supply practices. These changes could affect surface and groundwater users,
1994 including users that use free flowing or natural/live⁶ flow systems.

1995 Climate change has the potential to affect water supply for irrigation, municipal, and industrial
1996 uses from surface water sources. Changes in natural/live flow to the system that reduces
1997 summer and fall stream flows may reduce the amount of available supply. These live flow rights
1998 will be regulated based on states water law. This is true for all the CRSO regions in the No
1999 Action Alternative and MOs.

2000 An example of water supply that may be affected is the State of Washington “interruptible
2001 water rights.” This group of water rights is curtailed (not allowed to divert) when the March 1,
2002 April to September Dalles forecast⁷ drops below 60 million acre-feet. From the ResSim, No
2003 Action Alternative model, there is a 2.4 percent probability of the 5,000-year simulations where
2004 The Dalles forecast drops below 60 million acre-feet, therefore causing these rights to be
2005 curtailed. Using the RMJOC-II inflow projections, there is not a clear indication of a directional
2006 change in the relative frequency of The Dalles forecast volumes below the curtailment
2007 threshold.

2008 Effects to groundwater from climate change are not as well understood as potential effects to
2009 surface water. However, some studies have suggested that the projected decrease in snowpack
2010 and higher intensity winter storms may decrease groundwater recharge (Doll 2009). In addition,
2011 it is possible that the decreased ability to rely on surface water may cause some to rely more on
2012 groundwater, thus decreasing supplies (Reclamation 2016).

2013 **4.2.9.1 Region A – Libby, Hungry Horse, and Albeni Falls Dams**

2014 **NO ACTION ALTERNATIVE**

2015 Under the No Action Alternative and MOs, water supply in these reaches could potentially be
2016 affected by changes in live/natural flow. Specifically, water supply uses that rely on the
2017 live/natural flow water rights for delivery may experience increased shortage in the summer or
2018 fall as flows are projected to decrease during this period (Section 4.1.2.4). Changes to

⁶ Live or natural flow is water appropriated by the individual states and is distributed in priority or by other rules defined by the states.

⁷ This is the volume of runoff forecasted to flow past the Dalles between April and September and is calculated on March 1 each year.

2019 operations should not affect live/natural flow distributions as they are based on state prior
2020 appropriation law under all alternatives, including No Action Alternative.

2021 **MULTIPLE OBJECTIVE ALTERNATIVES 1 TO 3**

2022 See the No Action Alternative discussion above, as effects are expected to be similar.

2023 ***4.2.9.2 Region B – Grand Coulee and Chief Joseph Dams***

2024 **NO ACTION ALTERNATIVE**

2025 Water supply is pumped from Lake Roosevelt for irrigation, municipal, and industrial needs in
2026 the Columbia Basin Project. Water flowing into Lake Roosevelt could be affected by climate
2027 change, both in volume and timing. Changes to operations should not affect live/natural flow
2028 distributions as they are based on state prior appropriation law under all alternatives, including
2029 No Action Alternative.

2030 **MULTIPLE OBJECTIVE ALTERNATIVES 1 TO 4**

2031 See the No Action Alternative discussion above, as effects are expected to be similar.
2032 Additionally, pumping costs at the John W Keys pumping plant may change if climate change
2033 causes further decreases in Lake Roosevelt water surface elevation.

2034 ***4.2.9.3 Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor***
2035 ***Dams***

2036 **NO ACTION ALTERNATIVE**

2037 Water supply is available out of the pools behind Lower Granite, Little Goose, Lower
2038 Monumental, and Ice Harbor. Water is available using live/natural flow rights and is accessible
2039 to water users due to the elevated pool levels for navigation and power production. These run-
2040 of-the-river dams do not provide water storage for water rights holders, but make is easier for
2041 users to access the water. Projected changes in climate are unlikely to affect the elevation in
2042 these pools and therefore the availability of water is unlikely to change.

2043 **MULTIPLE OBJECTIVE ALTERNATIVE 1, 2 AND 4**

2044 See the No Action Alternative discussion above, as effects are anticipated to be similar.

2045 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

2046 Under MO3, water supply is not expected to continue from the pools in Region C with the
2047 breaching of the dams. This would not be affected by climate change.

2048 **4.2.9.4 Region D – McNary, John Day, The Dalles, and Bonneville Dams**

2049 **NO ACTION ALTERNATIVE**

2050 Water supply is available out of the pool behind McNary and John Day using live/natural flow
2051 rights and is accessible to users due to elevated pool levels for navigation and power
2052 production. In the John Day pool, the elevation is held higher though the irrigation season to
2053 allow pumps to operate. Projected changes in climate are unlikely to change the elevation in
2054 these pools and therefore the ability to supply the current level of water is not expected to
2055 change.

2056 **MULTIPLE OBJECTIVE ALTERNATIVE 1, 2 AND 3**

2057 See the No Action Alternative discussion, as effects are anticipated to be similar.

2058 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

2059 In MO4, the John Day pool is operated 1.5 feet lower than current irrigation season elevations,
2060 which may limit the ability of some pumps to operate. It is unlikely that climate change will
2061 have an effect on this operation.

2062 **4.2.7 Visual**

2063 Climate change is not expected to ameliorate or exacerbate effects to visual resources.

2064 **4.2.8 Noise**

2065 Climate change is not expected to ameliorate or exacerbate effects to noise resources.

2066 **4.2.9 Fisheries**

2067 Although fish abundance is only one of many considerations with respect to determining
2068 allowable fish harvest, this analysis evaluates potential impacts on fisheries by referencing the
2069 potential effects on relevant fish populations only. The anadromous and resident fish resources
2070 of the Columbia River Basin are caught in commercial and ceremonial and subsistence fisheries
2071 within the Basin and in the ocean off the coasts of Washington, Oregon, California, British
2072 Columbia, and Alaska.⁸ Commercial salmonid catch within the Columbia River Basin includes
2073 Chinook salmon, coho salmon, sockeye salmon, and steelhead. Other anadromous fish,
2074 including certain white sturgeon populations, American shad, and Pacific eulachon, are also
2075 caught commercially in the Columbia River Basin. Resident fish are not targeted in the Basin
2076 commercially, though some are caught incidentally and sold in tribal fisheries. To the extent
2077 that climate change effects ameliorate or exacerbate the effects of the Multiple Objective
2078 Alternatives on fish in a way that increases or decreases abundance of target species,

2079 commercial and ceremonial and subsistence fishing opportunities, and the economic, social,
2080 and cultural values associated with them, then fisheries could be affected. Climate change may
2081 also affect fisheries if it results in a change in distribution of fish populations that increases the
2082 cost associated with fishing, or limits access in some way.

2083 **4.2.9.1 No Action Alternative**

2084 As described in Section 4.2.4, the effects of climate change are expected to have an adverse
2085 effect overall on anadromous fish populations, which could lead to moderate to severe declines
2086 in salmon and steelhead populations. Available information also suggests that species such as
2087 Pacific lamprey, Pacific eulachon, and green sturgeon may also experience adverse impacts
2088 from the effects of climate change. Changes in air temperature, precipitation, stream flows,
2089 and water temperatures may also have adverse implications for resident fish, including changes
2090 in their distribution and abundance (see Section 4.2.3.6). Decreased abundance of anadromous
2091 and resident species of importance in commercial and ceremonial and subsistence fisheries
2092 could result in a decreased opportunity for harvest, and a decrease in the economic, social, and
2093 cultural values associated with fishing. Additionally, changes in the distribution of species
2094 associated with the effects of climate change could mean a loss of access to certain species, or
2095 increased costs associated with harvesting those species, which could adversely affect those
2096 fisheries.

2097 **4.2.9.2 All Multiple Objective Alternatives**

2098 Under all Multiple Objective Alternatives, climate change has the potential to exacerbate or
2099 ameliorate the full range of predicted effects of the alternative on fish that differ by species,
2100 region, and life history stage, and the resulting effects may work in competing directions. Thus,
2101 it is difficult to discern how the effects of climate change and the MO itself would collectively
2102 influence the abundance of a population overall. Sections 4.2.4. and 4.2.3.6. describe how fish
2103 may be affected by climate change under each of the MOs. Where these effects result in an
2104 overall change in abundance of a given population of commercial or ceremonial and
2105 subsistence value, the fisheries that depend upon them could be affected. The potential for
2106 redistribution of fish populations resulting in an increased cost of harvest or loss of access
2107 remains the same as under the No Action Alternative.

2108 **4.2.10 ITAs, Tribal Perspectives and Tribal Interests**

2109 No direct or indirect effects to Indian Trust Assets were identified for any of the alternatives,
2110 including the Preferred Alternative. Trust lands identified during the geospatial database query
2111 and tribal outreach are located outside of any direct or indirect effects identified in the
2112 alternatives. These include lands from the Confederated Tribes of Warm Springs Reservation,
2113 the Yakama Nation, and the Kootenai Tribe of Idaho, as well as the following Indian
2114 reservations: The Confederated Tribes of the Colville Indian Reservation; Spokane Tribe of
2115 Indians; Kootenai Tribe of Idaho; Nez Perce Tribe; and The Confederated Salish & Kootenai
2116 Tribes of the Flathead Reservation.

2117 “Climate change impacts have the potential to affect the entire Basin and resources the Tribes
2118 stewarded from time immemorial. The change has the potential to impact both aquatic systems
2119 across the Basin and the generation of electricity from the System.” (The Shoshone-Bannock
2120 Tribes Tribal Perspective Submittal, See 3.17.2.2)

2121 The Tribes of the Pacific Northwest are focused on the challenges posed by the projected
2122 changes in climate. These changes have the potential to adversely affect tribal culture given the
2123 relationship these cultures have with the natural environment. For many tribes, their culture of
2124 stewardship is an effort to restore the ecosystem to its natural condition. This is considered an
2125 essential element in their fight against, and to counteract the effects of climate change. Climate
2126 change presents a threat to critical cultural resources, thereby also threatening the lifeways and
2127 wellbeing of the Tribes. Some tribes view the CRS, particularly reservoirs and loss of riverine
2128 ecosystem structure and function, as a contributor to climate change.

2129 “Climate change impacts have the potential to affect the entire Basin and resources the Tribes
2130 stewarded from time immemorial. The change has the potential to impact both aquatic systems
2131 across the Basin and the generation of electricity from the System.” (The Shoshone-Bannock
2132 Tribes Tribal Perspective Submittal, See 3.17.2.2)

2133 The Tribes of the Pacific Northwest are focused on the challenges posed by the projected
2134 changes in climate. These changes have the potential to severely affect tribal culture given the
2135 relationship these cultures have with the natural environment. The Tribes' view of their culture
2136 of stewardship, which speaks to this relationship, means that for many of the tribes they see
2137 their work as an effort to restore the ecosystem to its natural condition as an essential element
2138 in the fight against, and to counteract, the effects of climate change because its "impacts have
2139 the potential to affect the entire Basin and resources the Tribes stewarded from time
2140 immemorial." Climate change presents a threat to critical cultural resources, thereby also
2141 threatening the lifeways and well-being of the Tribes. Some Tribes' view the CRSO, particularly
2142 through effects from slack-water reservoirs and a loss of riverine ecosystem structure and
2143 function, as contributors to climate change.

2144 **4.2.10 Cultural Resources**

2145 Cultural resources around reservoirs experience erosion-driven decay when exposed during
2146 drawdown periods of storage reservoirs. Exposed to the elements (not inundated), sites
2147 undergo more erosion from heavy rainfall events and wave action. Exposed sites are also
2148 subject to looting and recreation-related damage. Stability of environmental conditions is also
2149 important for preservation of organic remains in sites, which decay faster under increased
2150 variability, especially rapid changes in soil moisture and acidity.

2151 Increased reservoir fluctuations associated with changes in operations or changes in climate are
2152 likely to have increasing effects on cultural resources. Climate change projections for the region
2153 include increases in winter precipitation and earlier and potentially larger spring runoff volumes
2154 (4.1.2.4). Atmospheric rivers are also projected to increase. These intense storms often produce

2155 gulley erosion on exposed drawdown zones, which can quickly diminish the integrity of cultural
2156 resources.

2157 The extent to which the Action Alternatives accelerate the erosion and decay of cultural
2158 resources is largely tied to the extent that they would increase the exposure of sites. For most
2159 of the Action Alternatives, the changes in operations from the No Action Alternative are
2160 minimal, and this means that the alternatives do not have the potential to worsen the effects
2161 driven by climate change.

2162 There are numerous locations in the Columbia River Basin that tribes consider as “sacred sites”.
2163 Sacred sites can be affected by climate change through its influence on environmental drivers
2164 of landscape change (e.g., erosion, deposition) and potential to impede access to the sites. The
2165 tribes contacted as a part of the compilation of this EIS identified two locations that fall in line
2166 with the definition of “sacred sites” in Presidential Executive Order 13007: Kettle Falls, which is
2167 located behind Grand Coulee Dam on Lake Roosevelt in northeast Washington State, and Bear
2168 Paw Rock, which is located on Lake Pend Oreille behind Albeni Falls Dam.

2169 **4.2.10.1 Region A – Libby, Hungry Horse, and Albeni Falls Dams**

2170 **NO ACTION ALTERNATIVE**

2171 Projected changes to reservoir operations (Section 4.2.1.1) such as more variable reservoir
2172 elevations and also deeper reservoir drafts could expose more cultural resources. Additionally,
2173 the lack of water coverage means that the sites could undergo more erosion from heavy rainfall
2174 events and wave action. The exposed sites could also be more subject to looting and
2175 recreation-related damage.

2176 The only sacred site identified in Region A is Bear Paw Rock at Albeni Falls Dam. Changes in
2177 operations related to projected changes in climate under this alternative would have negligible
2178 effects on this sacred site.

2179 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

2180 Projected changes in climate could further increase the drawdowns (Section 4.2.1.1) that could
2181 already be happening as a response to MO1 at Libby and Hungry Horse. This could amplify the
2182 effects on cultural resources.

2183 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

2184 Same as MO1, except with an even greater, extended drawdown risk and subsequent resource
2185 exposure at Libby due to increased spring draft requirements for projected increases in spring
2186 inflow volume (Section 4.1.2.4). The effects at Hungry Horse and Albeni Falls would be more
2187 muted as draft patterns are not anticipated to change significantly in response to projected
2188 changes in flow volumes (Section 4.2.1.1).

2189 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

2190 Under MO3, operations at Hungry Horse would result in increased exposure of cultural
2191 resources (Section 3.16.2.6), and the deeper drawdowns associated with climate change
2192 (Section 4.2.1.1) could likely to exacerbate these effects.

2193 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

2194 MO4 causes deep drafts at Hungry Horse (Section 3.2.2.7), and the addition of climate change
2195 driven drafts of the reservoir could exacerbate these effects.

2196 **4.2.10.2 Region B – Grand Coulee and Chief Joseph Dams**

2197 **NO ACTION ALTERNATIVE**

2198 Changes in Lake Roosevelt pool elevations in the winter could be further exacerbated by
2199 changes in inflow due to changes in climate (Section 4.2.1.2). This could result in more cultural
2200 resources being exposed and thus subjected to accelerated decay due to erosion and amplified
2201 wetting and drying cycles.

2202 The only sacred site identified in Region B is Kettle Falls. Changes in operations related to
2203 climate change may cause increased exposure to landforms associated with the Kettle Falls
2204 sacred site (especially Hayes Island), which is not expected to impede access to the site, but
2205 may cause adverse effects at the site.

2206 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

2207 The changes in operations anticipated from MO1 (section 3.2.2.4) could be amplified by the
2208 changes in climate potentially resulting in longer and deeper drawdowns at Grand Coulee than
2209 were seen in the No Action Alternative. Changes in the operations for FRM result in deeper
2210 drafts in the winter and spring, increasing the potential impacts to cultural resources from
2211 exposure, including accelerated decay due to erosion and amplified wetting and drying cycles.

2212 The changes in operations anticipated in MO1 from FRM, which result in deeper drafts in the
2213 winter and spring, could be amplified by projected changes in climate, potentially resulting in
2214 longer and deeper drawdowns at Grand Coulee than in the No Action Alternative. The
2215 projected increases in exposure under climate change is not expected to impede access to the
2216 site, but may cause adverse effects at the site.

2217 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

2218 In MO2 deeper drafts for hydropower would result in increased exposure. Cultural resources
2219 may be exposed to a greater degree during a period that also coincides with projected
2220 increased precipitation, so this exposure may not occur. However, if the exposure occurs, it
2221 means that sites may be more subject to erosion, especially from intense winter rain events.

2222 In MO2 deeper drafts for hydropower would result in increased exposure of some of the
2223 landforms associated with Kettle Falls. The projected increases in exposure under climate
2224 change are not likely to impede access to the site, but may cause adverse effects at the site.

2225 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

2226 See the No Action Alternative discussion above.

2227 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

2228 Under MO4, the lack of refill during the summer in driest years (due to the flow augmentation
2229 for the *McNary Flow Target* measure) could result in more exposure of cultural resources
2230 during the season when the most people are using the Lake Roosevelt National Recreation
2231 Area. This will likely be exacerbated by projected hydrological changes. This will lead to an
2232 increase in damage related to camping on the cultural resources (especially archaeological
2233 sites) and resultant casual looting would amplify these effects.

2234 Under MO4, the lack of refill during the summer in the driest years (due to the *McNary Flow*
2235 *Target* measure) will result in more exposure of the Kettle Falls sacred site during that season,
2236 when the most people are using the Lake Roosevelt National Recreation Area. The projected
2237 increases in exposure under climate change are not likely to impede access to the site, but may
2238 cause adverse effects at the site.

2239 **4.2.10.3 Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice**
2240 **Harbor Dams**

2241 **NO ACTION ALTERNATIVE**

2242 It is important to note first that the operations of Dworshak, a storage reservoir, will not follow
2243 the same pattern as the other four projects in Region C, as they are all run-of-river projects that
2244 would be operated to maintain fairly consistent reservoir levels.

2245 No sacred sites were identified in Region C.

2246 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

2247 Deeper drafts during the spring at Dworshak will expose more archaeological sites and will
2248 increase the rates of erosion, particularly gulley formation resulting from rain and melting
2249 snow. There would be little change relative to the No Action Alternative for the lower four
2250 Snake projects.

2251 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

2252 See the MO1 discussion above. Additionally, operations under MO2 at Dworshak would tend to
2253 expose cultural resources to a greater degree than under the No Action Alternative due to

2254 increase reservoir drawdown, and the operational changes in response to climate change could
2255 amplify these effects. At the run-of-river projects, no changes are expected.

2256 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

2257 MO3 would result in significant changes in flow and stage in the lower Snake River. Dam breach
2258 would have varied effects on cultural resources, especially over the short term. Increased
2259 aridity during the summer months may make it harder to re-establish vegetation over the
2260 exposed draw down zones of the four reservoirs. This lack of plant cover means that sites
2261 would continue to be exposed for a longer period and, as a result, would decay more quickly, or
2262 be more susceptible to looting/pothunters.

2263 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

2264 Operational effects to cultural resources under MO4 for Dworshak would closely follow MO1.
2265 At the run-of-river projects, MO4 would tend to result in slightly higher reservoir elevations,
2266 which may slightly reduce decay related to exposure. Climate change is not expected to alter
2267 these conditions.

2268 **4.2.10.4 Region D – McNary, John Day, The Dalles, and Bonneville Dams**

2269 **NO ACTION ALTERNATIVE**

2270 In general, it appears that changes in operations driven by climate change in the four lower
2271 Columbia River projects would be minimal because the storage in the reservoirs does not
2272 undergo large changes in response to changing inflows.

2273 No sacred sites were identified in Region C.

2274 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

2275 Operations under MO1 would generally follow the same patterns as under the No Action
2276 Alternative, but this alternative calls for slightly higher median pool elevations in April and May.
2277 These higher elevations would not alter conditions driven by climate change.

2278 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

2279 Operations under MO2 would not differ from the No Action Alternative to any significant
2280 degree, especially when focusing on median reservoir elevations. Climate change implications
2281 are not expected to be amplified.

2282 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

2283 Conditions under MO3 are expected to closely follow those found under MO1.

2284 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

2285 Operations under MO4 would feature lower elevations in spring and summer months,
2286 increasing the degree of cultural resource exposure during low flow years.

2287

2288 **4.2.11 Environmental Justice**

2289 Climate change can exacerbate effects on minority populations, low-income populations, and
2290 Indian tribes. All the tribes expressed in meetings with the lead agencies their concern and
2291 focus on climate change and what it means for tribal culture and resources. The Shoshone-
2292 Bannock Tribes encapsulated these concerns in their tribal perspective “Projected changes in
2293 temperature, precipitation, hydrology, and ocean chemistry threaten not only the lands,
2294 resources, and economies of the Shoshone-Bannock Tribes (Tribes), but also tribal homelands,
2295 ceremonial sites, burial sites, tribal traditions, and cultural practices that have relied on native
2296 plants, fish, and animal species since time immemorial” (Tribal Perspective Submittal from the
2297 Shoshone-Bannock Tribes, Page 12. See Appendix P). At the same time, these populations are
2298 often less able to adapt or recover from these effects (EPA 2016a). This section evaluates
2299 whether there would be disproportionately high and adverse effects on minority populations,
2300 low-income populations, or Indian tribes considering how projected changes in climate may
2301 affect resources given effects from the CRSO EIS alternatives.

2302 For the following resources, the environmental justice analysis compares effects to the general
2303 population and effects to minority populations, low-income populations, and Indian tribes by
2304 region and by alternative.

2305 • **Navigation and transportation.** Changes to in-river and reservoir conditions under the CRSO
2306 EIS alternatives could affect the availability of ports for commercial navigation activities
2307 (including commercial shipping barges, cruise ships, and ferries) (Section 3.15.3). Inchelium-
2308 Gifford Ferry operations on Lake Roosevelt could also be affected by operational measures
2309 in some CRSO alternatives that would result in additional reservoir fluctuations, including
2310 drawdowns in some years. This ferry is operated by the Confederated Tribes of the Colville
2311 Reservation and primarily serves the tribal population. Climate change could affect
2312 navigation and transportation through changes to seasonal patterns and variability of
2313 streamflow and consequences for riverbed profiles (Section 4.2.7). The water surface
2314 elevation of rivers and reservoirs, and channel depths affect access to shoreline
2315 transportation infrastructure and drafts of freight vessels (Section 4.2.7).

2316 • **Cultural resources.** The CRSO EIS alternatives have the potential to affect cultural resources
2317 (including archaeological resources, traditional cultural properties, and historic built
2318 resources) as a result of changes in reservoir elevations or construction activities (Section
2319 3.15.3.2). As discussed in the Cultural Resources section in chapter 3, ongoing effects of
2320 inundation and reservoir fluctuation would continue to have substantial adverse effects on
2321 traditional cultural properties under the No Action Alternative. Implementation of the
2322 action alternatives could negatively affect cultural resources through increasing exposure
2323 and erosion associated with increased reservoir level fluctuations and, thus creating the
2324 potential for effects associated with public access including looting, vandalism, creation of
2325 trails, and unauthorized activities (Section 3.15.3.2). Projected changes in climate could
2326 exacerbate these effects by increasing decay through operations resulting in deeper
2327 drawdowns, changes in precipitation (as more snow falls as rain), and increased variability
2328 (especially rapid changes in soil moisture and acidity).

- 2329 • **Fish.** Warming water temperatures, streamflow changes, increased pervasiveness of
2330 invasive species, and changing ocean conditions (reduction in thermal habitat for salmon,
2331 increasing ocean acidification, changing estuarine and plume environments) are projected
2332 to have negative implications for the freshwater, estuarine, and marine environments of
2333 many fish species in the Pacific Northwest (section 4.2.3). The CRSO EIS alternatives have
2334 the potential to affect the availability of fish for harvest for low-income populations,
2335 minority populations, and Indian tribes participating in these activities (section 3.15.3.2).
2336 The environmental justice analysis in chapter 3 concludes that, while the construction of
2337 the dams and current system operations have ongoing effects on tribal culture, lifeways
2338 (e.g., customs and practices), and traditions, site-specific information is not available to
2339 identify precisely where these subsistence activities occur, and whether plant or wildlife
2340 species that are important for ceremonial or subsistence use would be affected by the
2341 changing water levels (section 3.15.3). Climate change does not alter that conclusion.
2342 Therefore, this resource is not analyzed in further detail for this analysis.
- 2343 • **Vegetation, wetlands, and wildlife.** In general, the analyses of effects to vegetation,
2344 wetlands, and wildlife, identified negligible to minor effects to these resources across most
2345 CRSO EIS alternatives (Section 3.15.3.1) with no expected disproportionality high and
2346 adverse human health or environmental effects on minority populations, low-income
2347 populations, or Indian tribes. Climate change is projected to have minimal effects on these
2348 conclusions; therefore, no change is expected in effects from the alternatives.
- 2349 • **Air quality.** There are a number of uncertainties surrounding the likelihood, volume and
2350 specific location of future emissions that render making a determination of effects to
2351 specific communities speculative (Section 3.15.3.1). Climate change adds additional
2352 uncertainties that make further evaluation even more difficult and uncertain, so it is too
2353 speculative to know whether there would be expected disproportionate high and adverse
2354 human health or environmental effects on minority populations, low-income populations,
2355 or Indian tribes.
- 2356 • **Power generation.** Projected changes in climate are not likely to change the general
2357 conclusions from the power analysis of the relative effect of one MO versus another
2358 because the projected changes in climate are likely to affect hydropower generation in all
2359 alternatives relative to the No Action Alternative roughly the same on an annual basis
2360 (though with a little more variability on a monthly basis) (Section 4.2.5). Therefore,
2361 climate change does not alter the relative conclusions of the environmental justice
2362 analysis identified in Chapter 3.15.3.
- 2363 • **Flood risk management.** The flood risk analysis in this EIS does not anticipate changes to
2364 flood risk from any of the proposed CRSO EIS alternatives therefore no additional
2365 environmental justice analysis is necessary (Section 3.15.3.1). Climate change is projected
2366 to have minimal effects on these conclusions; therefore, this resource is not analyzed in
2367 detail in this section.
- 2368 • **Recreation.** The analyses of effects to recreation identified negligible to minor effects to the
2369 resources across most CRSO EIS alternatives (Section 3.15.3.1). The adverse effects on

2370 resources identified in Region C under MO3 do not appear likely to disproportionately affect
2371 minority populations, low-income populations, or Indian tribes (Section 3.15.3.1). Climate
2372 change does not alter this conclusion.

- 2373 • **Water supply.** Effects to water sources are focused on a need to extend pumps under MO4
2374 to allow for continued water supply and the potential loss of irrigation under MO3 because
2375 the pumps that supply this water would no longer be operational once the dams are
2376 breached and the nearby groundwater elevations could be adversely affected (Section
2377 3.15.3). These effects are relatively small and are not expected to result in
2378 disproportionately high and adverse effects on minority populations, low-income
2379 populations, or Indian tribes (Sections 3.15.3.7, 3.15.3.8). Moreover, projected changes in
2380 climate are unlikely change the supply of water in regions A, B, C, and D (Sections 4.2.9.3,
2381 4.2.9.4).
- 2382 • **Sacred sites.** The effects to sacred sites (Bear Paw Rock and Kettle Falls) created by
2383 construction of the Federal dams are not expected to increase markedly as a result of the
2384 CRSO EIS alternatives (Section 3.15.3.1). Climate change is projected to have minimal to
2385 negligible effects on these conclusions (Section 4.2.13); therefore, this resource is not
2386 discussed further in this section.

2387 **4.2.11.1 Region A – Libby, Hungry Horse, and Albeni Falls Dams**

2388 **NO ACTION ALTERNATIVE**

- 2389 • **Navigation and transportation.** Commercial navigation, cruise ships, and ferries do not
2390 occur in Region A. This would not change under the No Action Alternative (Section
2391 3.15.3.4).
- 2392 • **Cultural resources.** Numerous types of cultural resources have been identified in the
2393 vicinity of the projects in Region A, including sites of particular importance in the vicinity of
2394 the storage reservoirs: Albeni Falls, Hungry Horse, and Libby. Cultural resources would
2395 continue to be adversely affected under the No Action Alternative due to ongoing
2396 operations and maintenance of the Columbia River System (Section 3.15.3.4). Projected
2397 changes to operations in response to changes in climate (Section 4.2.1.1) could expose
2398 more cultural resource sites, potentially leading to more erosion from heavy rainfall events
2399 and wave action. In addition, the exposed sites could potentially be subject to looting and
2400 recreational-related damage (Section 4.2.10.1).

2401 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

- 2402 • **Navigation and transportation.** See No Action Alternative discussed above.
- 2403 • **Cultural resources.** Effects on cultural resources are anticipated to be negligible in Region A
2404 under MO1, with the exception of moderate effects to archaeological resources at Hungry
2405 Horse Reservoir (Section 3.15.3.5). Projected changes in climate could further increase the
2406 drawdowns that would already be happening as a response to MO1 at Libby and Hungry

2407 Horse (section 4.2.1.1), thereby further increasing those effects to archaeological resources
2408 at Hungry Horse Reservoir.

2409 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

- 2410 • **Navigation and transportation.** See No Action Alternative discussed above.
- 2411 • **Cultural resources.** Implementation of MO2 could negatively affect cultural resources
2412 through increasing exposure and erosion associated with increased reservoir level
2413 fluctuations at Libby and Hungry Horse (Section 3.15.3.6). Projected changes in climate
2414 could further increase the drawdowns that could already be happening as a response to
2415 MO2 at Libby, while effects at Hungry Horse could be more muted due to smaller changes
2416 in projected spring inflow volumes and FRM draft requirements (section 4.2.1.1).

2417 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

- 2418 • **Navigation and transportation.** See No Action Alternative discussed above.
- 2419 • **Cultural resources.** Implementation of MO3 could negatively affect archaeological
2420 resources through increasing exposure and erosion associated with increased reservoir level
2421 fluctuations at Libby Dam and Hungry Horse Reservoir (Section 3.15.3.7). Deeper
2422 drawdowns at Hungry Horse associated with climate change would likely exacerbate these
2423 effects (Section 4.2.10.1).

2424 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

- 2425 • **Navigation and transportation.** See No Action Alternative discussed above.
- 2426 • **Cultural resources.** Implementation of MO4 would increase the exposure of archaeological
2427 resources at Hungry Horse Reservoir (Section 3.15.3.8), and projected changes in climate
2428 could further increase drawdowns and exposure of those archaeological resources (Section
2429 4.2.10.1). Climate change is not projected to alter conclusions for sites at Libby Dam,
2430 where effects to archaeological resources are expected to be negligible (Section 3.15.3.8),
2431 or at Albeni Falls, where MO4 would not increase the exposure of archaeological resources
2432 (Section 3.15.3.8).

2433 **4.2.11.2 Region B – Grand Coulee and Chief Joseph Dams**

2434 **NO ACTION ALTERNATIVE**

- 2435 • **Navigation and Transportation.** When the Lake Roosevelt forebay elevation falls below
2436 1,229 feet NGVD29, the Inchelium-Gifford Ferry is inoperable (section 3.10.3.2). With
2437 climate change, refill could be initiated earlier more frequently, reducing the amount of
2438 time that Lake Roosevelt is drafted to inoperable range, thus potentially reducing the
2439 effects identified in (Section 3.10.3.2), including effects to the Confederated Tribes of
2440 the Colville Reservation (section 4.2.7.2).

- 2441 • **Cultural Resources.** Numerous types of cultural resources have been identified in the
2442 vicinity of the projects in Region B, including sites of particular importance near the historic
2443 location of Kettle Falls. Cultural resources could continue to be adversely affected under the
2444 No Action Alternative due to ongoing operations and maintenance of the Columbia River
2445 System (Section 3.15.3.4). Changes in Lake Roosevelt pool elevations in the winter could be
2446 further exacerbated by changes in inflow due to changes in climate, resulting in more
2447 cultural resources being exposed and thus subjected to accelerated decay, which could
2448 further heighten the effects to these resources and the tribal populations that consider
2449 these resources culturally important (Section 4.2.10.2).

2450 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

- 2451 • **Navigation and Transportation.** MO1 is expected to disproportionately and adversely affect
2452 environmental justice populations due to effects on navigation and transportation
2453 resources, with effects primarily falling on the Confederated Tribes of the Colville
2454 Reservation community (Section 3.15.3). The Inchelium-Gifford Ferry is expected to have 9
2455 fewer operational days during wet years under MO1. With climate change, refill could be
2456 initiated earlier more frequently, reducing the number of days that Lake Roosevelt is
2457 drafted to inoperable range (Section 4.2.7.2) and at least partially alleviating the effects to
2458 environmental justice populations.
- 2459 • **Cultural resources.** Implementation of MO1 could negatively affect cultural resources
2460 through increasing exposure and erosion of reservoir areas associated with increased
2461 reservoir level fluctuations, particularly at Grand Coulee Dam (Lake Roosevelt) (Section
2462 3.15.3.5). Climate change could amplify the changes in operations anticipated from MO1,
2463 potentially resulting in longer and deeper drawdowns at Grand Coulee as compared to the
2464 No Action Alternative (Section 4.2.1.2).

2465 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

- 2466 • **Navigation and Transportation.** See MO1 discussion above.
- 2467 • **Cultural resources.** Implementation of MO2 could negatively affect cultural resources
2468 through increasing exposure and erosion associated with increased reservoir level
2469 fluctuations, specifically at Grand Coulee (Section 3.15.3.6). Cultural resources may be
2470 exposed to a greater degree during a period that also coincides with projected increases
2471 in precipitation, thus potentially subjecting the site to more erosion (Section 4.2.10.2).

2472 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

- 2473 • **Navigation and Transportation.** Under MO3, the Inchelium-Gifford Ferry is expected to
2474 operate approximately 2 days more than anticipated under the No Action Alternative
2475 (Section 3.15.3.7). With climate change, refill could be initiated earlier more frequently,
2476 reducing the amount of time that Lake Roosevelt is drafted to inoperable range
2477 (Section 4.2.7.2). Thus, this effect could potentially result in lessening the effects
2478 described in Section 3.15.3.7.

- 2479 • **Cultural resources.** Effects on cultural resources are anticipated to be negligible in Region B
2480 under MO3 (section 3.15.3.7). Climate change could further exacerbate changes in Lake
2481 Roosevelt pool elevations in the winter, potentially resulting in more cultural resources
2482 being exposed and thus subjected to accelerated decay, which could have
2483 disproportionately high and adverse effects on Indian tribes who find these resources
2484 culturally important (Section 4.2.10.2).

2485 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

- 2486 • **Navigation and Transportation.** See MO1 discussion above.
- 2487 • **Cultural resources.** Implementation of MO4 could negatively affect cultural resources
2488 through increasing exposure and erosion associated with increased reservoir level
2489 fluctuations, specifically at Grand Coulee (Section 3.15.3.8). Climate change could
2490 exacerbate this by resulting in Lake Roosevelt not being able to refill in early July,
2491 leaving sites exposed during times of heavy use (Section 4.2.10.2). Thus, climate change
2492 could further exacerbate the effects to cultural resource sites near Grand Coulee valued
2493 by the Confederated Tribes of the Colville Reservation and the Spokane Tribe.

2494 **4.2.11.3 Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice**
2495 **Harbor Dams**

2496 **NO ACTION ALTERNATIVE**

- 2497 • **Navigation and transportation.** This region includes low-cost barge transportation, ports,
2498 and a growing cruise ship industry, bringing development and commercial activity to the
2499 region (Section 3.15.3.4). Climate change could result in increased frequency of shallow
2500 river conditions that may affect navigation at some locations, and projected higher flows
2501 and higher extreme flows November through March could slow or interrupt barge
2502 traffic more frequently in this region (Section 4.2.7.3).
- 2503 • **Cultural resources.** Numerous types of cultural resources have been identified in the
2504 vicinity of the projects in Region C. Cultural resources would continue to be adversely
2505 affected under the No Action Alternative due to ongoing operations and maintenance of the
2506 Columbia River System (Section 3.15.3.4). Climate change is projected to have minimal
2507 effects to operations at Dworshak or the four lower Snake River projects so increased
2508 effects to cultural resources are not expected (Section 4.2.10.3).

2509 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

- 2510 • **Navigation and transportation.** Effects on navigation and transportation are anticipated to
2511 be negligible in Region C under MO1 (section 3.15.3). Climate change is not projected to
2512 alter these conclusions. As such, disproportionate and adverse effects to low-income,
2513 minority or Indian tribes are not anticipated.
- 2514 • **Cultural resources.** See No Action Alternative discussion above.

2515 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

2516 See MO1 discussion above.

2517 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

- 2518 • **Navigation and Transportation.** Dam breach would result in regional economic effects of
2519 changes in navigation mode from river to rail and truck, as well as likely lead to some
2520 displacement of workers. While some laborers are likely to be low-income, minority, or
2521 members of Tribal communities, these effects do not appear likely to be concentrated in
2522 one group or area (Section 3.15.3.7). Climate change is not projected to alter these
2523 conclusions. As such, disproportionate and adverse effects to low-income, minority or
2524 Indian tribes are not anticipated.
- 2525 • **Cultural resources.** Following dam breach, the Ice Harbor, Lower Monumental, Little Goose,
2526 and Lower Granite projects would experience significant effects to archaeological sites
2527 associated with sediment erosion and deposition (Section 3.15.3.7). Climate change is
2528 not projected to amplify or diminish these effects (Section 4.2.10.3).

2529 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

2530 See MO1 discussion above.

2531 **4.2.11.4 Region D – McNary, John Day, The Dalles, and Bonneville Dams**

2532 **NO ACTION ALTERNATIVE**

- 2533 • **Navigation and transportation.** This region benefits from low-cost barge transportation,
2534 deep water ports located along the Lower Columbia River below Bonneville Dam, and cruise
2535 ships that board in the Portland Area and travel both downstream and upstream on the
2536 mainstem Columbia (Section 3.15.3.4). Climate change could increase the frequency of
2537 shallow river conditions that may affect navigation at some locations (Section 4.2.7.4). The
2538 effects of sea level rise on river elevations could provide a marginal benefit for navigation of
2539 the channel below Bonneville Dam and have limited effects on shoreline transportation
2540 infrastructure (Section 4.2.7.4).
- 2541 • **Cultural resources.** Numerous types of cultural resources have been identified in the
2542 vicinity of the projects in Region D. Cultural resources would continue to be adversely
2543 affected under the No Action Alternative due to ongoing operations and maintenance of the
2544 Columbia River System (Section 3.15.3.4). Climate change is projected to have minimal
2545 effects to changes in operations in the four lower Columbia River projects (Section 4.2.10.4).

2546 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

- 2547 • **Navigation and Transportation.** Effects on navigation and transportation are anticipated to
2548 be negligible in Region D under MO1 (Section 3.15.3). Climate change is not projected to

2549 alter these conclusions. As such, effects to low-income, minority or Indian tribes are not
2550 anticipated.

- 2551 • **Cultural Resources.** Effects to cultural resources are anticipated to be negligible. As such,
2552 effects to low-income, minority or Indian tribes are not anticipated (Section 3.15.3).
2553 Climate change is projected to have minimal effects to changes in operations in the four
2554 lower Columbia River projects (Section 4.2.10.4) and does not change this conclusion.

2555 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

2556 See MO1 discussion above.

2557 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

- 2558 • **Navigation and transportation.** Dam breach would result in regional economic effects of
2559 changes in navigation mode from river to rail and truck, as well as likely lead to some
2560 displacement of workers. While some laborers are likely to be low-income, minority, or
2561 members of Tribal communities, these effects do not appear likely to be concentrated in
2562 one group or area (Section 3.15.3.7). Climate change is not projected to alter these
2563 conclusions. As such, effects to low-income, minority or Indian tribes are not anticipated.

- 2564 • **Cultural Resources.** Effects to cultural resources are anticipated to be negligible. As such,
2565 effects to low-income, minority or Indian tribes are not anticipated (section 3.15.3). Climate
2566 change is projected to have minimal effects to changes in operations in the four lower
2567 Columbia River projects (Section 4.2.10.4).

2568 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

2569 See MO1 discussion above.

CHAPTER 5 - MITIGATION

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5.1 INTRODUCTION

When preparing an environmental impact statement (EIS), the Council on Environmental Quality (CEQ) regulations state that Federal agencies shall include appropriate mitigation measures to address environmental impacts, if not already included in the alternatives (40 Code of Federal Regulations [C.F.R.] §§ 1502.14(f) and 1502.16(h)). This chapter provides an overview of possible mitigation measures being considered to avoid, minimize, and reduce impacts to the human environment associated with the four Multiple Objective Alternatives (MOs). Mitigation associated with the Preferred Alternative is described in Chapter 7; however, it relies on the same measures for avoidance and mitigation identified in this process. The Records of Decision, which conclude the National Environmental Policy Act (NEPA) process, will identify the co-lead agencies' preferred alternative and associated mitigation measures.

5.1.1 Overview of Mitigation

As part of the NEPA process, Federal agencies consider appropriate mitigation measures to avoid, minimize, rectify, reduce or eliminate, and/or compensate for specific impacts (CEQ 2011). The mitigation measures summarized in this chapter are intended to reduce the duration and severity of impacts from implementing a specific action.

CEQ defines mitigation as the following (40 C.F.R. 1508.20):

- Avoiding the impact altogether by not taking a certain action or parts of an action.
- Minimizing impacts by limiting the degree or magnitude of the action and its implementation.
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
- Compensating for the impact by replacing or providing substitute resources or environment.

Avoidance and minimization measures include operational and construction measures such as standard operating procedures, best management practices (BMPs) such as minimizing ground disturbance, and industry standards. When physical or functional impacts to a resource cannot be avoided or minimized, agencies can implement specific measures to mitigate adverse impacts. Where possible in the mitigation analysis, the co-lead agencies identified in-kind and in-place mitigation to address impacted resources at the location of impact. However, if there were no feasible options to mitigate impacted resources at the project location, out-of-kind or out-of-place mitigation was proposed for unavoidable environmental impacts. Mitigation falls into four categories of actions to restore, replace, substitute, or supplement resources:

- 36 1. In-kind and in-place mitigation, which consists of actions to offset an impacted resource at
37 the location of impact or an area immediately adjacent to the project site.
- 38 2. In-kind and out-of-place mitigation, which consists of actions that address the impacted
39 resource at a different location.
- 40 3. Out-of-kind and in-place mitigation, which consists of actions that address a different
41 resource at the location of impact or an area immediately adjacent to the project site.
- 42 4. Out-of-kind and out-of-place mitigation, which consists of actions that addresses a different
43 resource at a different location.

44 NEPA requires that all relevant, reasonable mitigation measures that could diminish the
45 adverse impacts of the project be identified in the document, even if they are outside the
46 jurisdiction of the lead agency or the cooperating agencies. See 40 C.F.R. §§ 1502.16(h) and
47 1505.2(c); 46 Fed. Reg. 18026. The inclusion of mitigation measures in this chapter is not
48 intended to indicate that the co-lead agencies, or the Federal government as a whole, has the
49 authority to perform all of the measures listed. If the measures are outside the jurisdiction of
50 the co-lead agencies, those measures will not be included in the Preferred Alternative or
51 Records of Decision (ROD). Their inclusion in this chapter serves to alert other agencies,
52 officials, and the public who can implement the measures to the potential benefits of the
53 measure.

54 Implementation and effectiveness monitoring should be used to evaluate mitigation actions in
55 accordance with CEQ regulations (40 C.F.R. §§1505.2(c) and 1505.3). Implementation
56 monitoring ensures that mitigation is carried out as described in the NEPA documents and
57 committed as part of the decision as documented in the ROD. Where implementation and
58 effectiveness monitoring are planned in conjunction with mitigation, these actions are
59 described in Section 5.5, *Monitoring and Adaptive Management*; Appendix R, part 1,
60 *Monitoring and Adaptive Management*; and discussed in the co-lead agencies' RODs, as
61 appropriate.

62 **5.1.2 Avoidance and Minimization Measures**

63 This section describes avoidance and minimization measures that were incorporated as a
64 component of the proposed MOs, as well as the decision framework used to identify which
65 effects need mitigation.

66 The co-lead agencies would avoid and minimize impacts to the environment by implementing
67 BMPs (such as minimizing ground disturbance) and industry standards, as required, to comply
68 with applicable federal and state regulations.

69 Generalized avoidance or minimization actions, standard BMPs, and industry standards that
70 would likely be required for the proposed MOs are listed below. The list provided below is not
71 intended to be complete; rather, it reflects the most predictable actions that would be
72 implemented as integral components of the MOs. Other, site-specific avoidance and
73 minimization actions may be identified and discussed in any future NEPA documents.

74 Standard BMPs would include the following:

- 75 • Use water and other dust suppressants to control fugitive dust and minimize erosion during
76 construction.
- 77 • Develop and implement storm water prevention, erosion and sediment control, and spill
78 prevention control and countermeasure plans.
- 79 • Implement secondary containment for fuel and hazardous chemicals used in conjunction
80 with construction and operational implementation of measures.
- 81 • Adhere to fish passage guidelines during in-water work and construction of ladders, weirs,
82 and other in-water structures and coordinate with NOAA Fisheries and the U.S. Fish and
83 Wildlife Service if ESA-listed species are impacted.
- 84 • Implement dam safety requirements for construction and operation of new structures
85 associated with Federal hydroelectric projects (term used to encompass a dam, reservoir,
86 and all associated infrastructure).
- 87 • Implement standard fish handling techniques to minimize stress, and acquire the necessary
88 federal and state scientific take permits for fish handling.
- 89 • Minimize spread and establishment of invasive species by implementing control measures
90 for construction equipment.

91 **5.1.3 Conservation Recommendations per Fish and Wildlife Coordination Act of 1934**

92 In developing mitigation for the effects of the alternatives, the co-lead agencies also considered
93 the conservation recommendations included in the U.S. Fish and Wildlife Service's (USFWS) Fish
94 and Wildlife Coordination Act Report (CAR). The Fish and Wildlife Coordination Act (FWCA) of
95 1934, as amended (16 U.S.C. §§ 661–667e) provides authority for USFWS and NMFS
96 involvement in evaluating impacts to fish and wildlife from proposed water resource
97 development projects and requires them to provide conservation recommendations for the
98 project. The draft CAR is included in Appendix U and provides analysis of effects of the
99 alternatives, landscape findings, and conservation recommendations. The USFWS will be
100 preparing a final CAR with emphasis on the Preferred Alternative for inclusion in the final EIS.
101 Coordination between the co-lead agencies and the USFWS is ongoing for the final CAR.

102 **5.1.4 Affected Resources**

103 Mitigation measures were developed to offset impacts to affected resources that are protected
104 by Federal laws, regulations, and Executive Orders, such as the following:

- 105 • Waters of the U.S. - Clean Water Act and EO 11990 Protection of Wetlands
- 106 • Threatened and endangered species -Endangered Species Act and Lacey Act
- 107 • Raptors, waterfowl, and migratory birds -Migratory Bird Treaty Act and Bald and Golden
108 Eagle Protection Act

- 109 • Tribal, Cultural and Historic Resources - Native American Graves Protection and Repatriation
110 Act and National Historic Preservation Act
- 111 • Invasive Species -Executive Order (EO) 13751 – Invasive Species
- 112 • Floodplains -EO 11988 – Floodplain Management

113 Additional information describing these regulations and others relevant for this EIS can be
114 found in Chapter 8.

115 **5.2 DECISION FRAMEWORK AND SELECTION PROCESS**

116 Mitigation measures were proposed as comments received during the public scoping period
117 and by technical teams during evaluation of the alternatives. These preliminary mitigation
118 features were further developed, compared, and then vetted through a robust selection
119 process. The process started with the co-lead agencies, with input from cooperating agencies
120 on the technical teams, considered potential mitigation measures from scoping comments and
121 the technical teams' expertise. Then, the co-lead agencies used the decision framework
122 (described below) to identify if mitigation was warranted based on the adverse effects of
123 implementing a measure in the MOs and an evaluation of the severity of the impact on a
124 resource. The areas of analysis were divided into four regions (regions A, B, C, D) to assess
125 regional and localized impacts. During the last round of the selection process, those screened
126 mitigation measures were matched to mitigate adverse effects based on ability to reduce
127 specific impacts. They were then further developed, refined, and screened, which resulted in
128 the proposed mitigation as shown in Section 5.4.

129 Mitigation was only developed for adverse impacts; if an action resulted in negligible effects or
130 the effect was beneficial, then no additional mitigation was proposed. For resources with minor
131 effects, the co-lead agencies generally practice avoidance where practical through operations
132 and implement BMPs, but did not propose taking additional mitigation actions. For purposes of
133 meeting compliance with different federal laws, regulations, and EOs, the co-lead agencies have
134 proposed mitigation measures, where appropriate, even if effects are minor, such as for
135 wetland impacts. Conversely, if a proposed operational or structural measure would result in a
136 moderate or major impact to any resource, then a range of mitigation measures were
137 developed to address the impacted resource or resources. To differentiate among minor,
138 moderate, and major effects as described in Section 3.1, the effect descriptors were used to
139 evaluate the intensity of the impact in relation to significance (see 40 C.F.R. § 1508.27). The
140 rationale for why an effect is considered to fall under one of the preceding intensity descriptors
141 is included in each resource section and summarized in Chapter 3.

142 The full suite of proposed mitigation measures were assessed based on five criteria developed
143 by the co-leads with cooperating agencies input, which helped to identify the likelihood that a
144 measure would be adopted by the co-lead agencies:

- 145 Category type: in-kind and in-place mitigation measures were preferred over out-of-kind
146 or out-of-place measures.

147 Effectiveness: a qualitative assessment of the mitigation measure’s effectiveness in
148 reducing the impact from the alternative.

149 Scale: a qualitative assessment of the spatial (i.e., site-specific or regional) and temporal
150 scale (i.e., short-term or long-term, seasonal or annual, or temporary or permanent) of
151 the mitigation measure relative to the severity and duration of the impact.

152 Feasibility: a qualitative assessment of the feasibility of implementing a measure based
153 on technical and economic factors. For example, a mitigation measure may not be
154 feasible if there are other technical actions that would effectively reduce the severity or
155 duration of impact. Similarly, if the expense of implementing a measure would be
156 unreasonable, then the measure would not be feasible.

157 Jurisdiction: an assessment of the co-lead agencies’ jurisdiction or authority to
158 implement the measures

159 Finally, the suite of proposed mitigation measures were evaluated to determine if each
160 measure would fully reduce or minimize the impact or if residual impacts would exist after
161 implementation. The co-lead agencies identified where effects would remain after
162 implementing the mitigation measure. The full suite of prescreened mitigation measures are
163 available in Appendix R - Mitigation, Monitoring and Adaptive Management, Part 3.

164 **5.2.1 Existing Programs That Include Mitigation Under The No Action Alternative**

165 Under the No Action Alternative, mitigation currently being implemented would continue. With
166 implementation of any of the proposed MOs, there are nine mitigation programs that the co-
167 lead agencies currently implement that would be incorporated, with certain modifications, in
168 the respective alternatives. These mitigation programs are the Bonneville Power Administration
169 (Bonneville) Fish and Wildlife Program (F&W Program), the Lower Snake River Compensation
170 Plan, the U.S. Army Corps of Engineers’ (Corps’) Columbia River Fish Mitigation Program, U.S.
171 Bureau of Reclamation’s (Reclamation) Columbia River Tributary Habitat Program, the Federal
172 Columbia River Power System Cultural Resources Program, Predator Management, Invasive
173 Species Management, Pest Management Programs, and Nutrient Supplementation Program.
174 Outside of the specific mitigation measures that have been identified in the CRSO EIS, changes
175 to mitigation programs, like the Bonneville F&W Program, are not being made through this EIS
176 process. Rather, for example, future program adjustments for the Bonneville F&W Program
177 would be made in consultation with the region through Bonneville's budget-making processes
178 and other appropriate forums and consistent with existing agreements. In determining
179 appropriate mitigation measures to implement, the co-lead agencies considered the extent to
180 which mitigation is already occurring or planned under the No Action Alternative.

181 In their management and operation of the Columbia River System, Bonneville, the U.S. Army
182 Corps of Engineers, and the Bureau of Reclamation have together fulfilled the other primary
183 fish and wildlife mitigation mandate in the Northwest Power Act, providing fish and wildlife
184 “equitable treatment” with the other congressionally authorized purposes of the FCRPS (16 USC

185 § 839b(h)(11)(A)(i)). Since the 1990s, the federal agencies have overhauled system operations
186 and infrastructure, achieving juvenile dam passage survival that meets or exceeds performance
187 standards of 96% and 93% for spring and summer migrants respectively,¹ a marked
188 improvement as compared to when Congress passed the Act and the estimated average
189 juvenile mortality at each mainstem dam and reservoir project was 15%–20% with losses
190 recorded as high as 30%.² Travel time improved for yearling Chinook and juvenile steelhead
191 through the system, even in low flow years such as 2015,³ and total In-River survival has
192 improved for migrating juvenile salmon and steelhead. Comparing two time periods reported in
193 NOAA’s reach study⁴, (1997–2007 and 2008–2016), there has been a 10% survival increase for
194 hatchery and wild sockeye salmon, a 2% increase in hatchery and wild Chinook (4% for wild),
195 and a 25% survival increase for hatchery and wild steelhead (13% for wild).

196 **5.2.1.1 Bonneville Power Administration Fish and Wildlife Program**

197 The Bonneville F&W Program funds hundreds of projects each year to mitigate the impacts of
198 the development and operation of the federal hydropower system on fish and wildlife.
199 Bonneville began this program to fulfill mandates established by Congress in the Pacific
200 Northwest Electric Power Planning and Conservation Act of 1980 (Northwest Power Act), 16
201 USC § 839b(h)(10)(A), to protect, mitigate, and enhance fish and wildlife affected by the
202 development and operation of the FCRPS. Each year Bonneville funds projects with many local,
203 state, tribal, and federal entities to fulfill its Northwest Power Act fish and wildlife
204 responsibilities and to implement offsite mitigation actions listed in various Biological Opinions
205 for ESA-listed species. Offsite protection and mitigation actions typically address impacts to fish
206 and wildlife not caused directly by the CRS, but they are actions that can improve the overall
207 conditions for fish to help address uncertainty related to any residual adverse effects of CRS
208 management. For example, the Bonneville F&W Program funding improves habitat in the
209 mainstem as well as tributaries and the estuary, builds hatcheries and boosts hatchery fish
210 production, evaluates the success of these efforts, and improves scientific knowledge through
211 research. This work is implemented through annual contracts, many of which are associated
212 with multi-year agreements like the Columbia River Basin Fish Accords, the Accord extensions,
213 or wildlife settlements.

214 **HABITAT ACTIONS**

215 Bonneville works with states, tribes, and watershed groups to protect, mitigate, and enhance
216 spawning and rearing habitat, targeting factors that limit fish survival throughout the Columbia
217 River Basin. Bonneville has funded hundreds of projects across the basin to restore natural

1 See Endangered Species Act Federal Columbia River Power System 2016 Comprehensive Evaluation – Section 1, at 17, t.2 (Jan. 2017).

2 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)).

3 2016 Comprehensive Evaluation at page 20.

4 James R. Faulkner, Daniel L. Widener, Steven G. Smith, Tiffani M. Marsh, and Richard W. Zabel. 2017. *Survival Estimates for the Passage of Spring-Migrating Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs, 2016*. Report of research for Bonneville Power Administration, Contract 40735, Project 199302900.

218 stream channels, reconnect estuarine tidal channels, enhance flow volume and timing, expand
219 cold water refuges and open access to habitat (www.cbfish.org). These habitat improvement
220 actions provide both near-term and long-term benefits, including those that will help address
221 the effects of climate change. Actions that improve connectivity and stream flow will provide a
222 buffer against the effects of climate change.

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

226 **HATCHERY ACTIONS**

227 Bonneville constructed and now funds the operation and maintenance of over 20
228 compensation, conservation, and supplementation hatchery programs throughout the
229 Columbia and Snake River basins to preserve, rebuild, and reduce extinction risk for ESA-listed
230 fish species as well as to meet Northwest Power Act objectives to protect, mitigate, and
231 enhance fish and wildlife affected by the FCRPS. The conservation hatchery programs help
232 rebuild and enhance the naturally reproducing ESA-listed fish in their native habitats using
233 locally-adapted broodstock, while maintaining genetic and ecologic integrity, and supporting
234 harvest where and when consistent with conservation objectives. These hatchery programs
235 include captive propagation for critically endangered Snake River sockeye, Snake River
236 spring/summer Chinook supplementation, Snake River fall Chinook supplementation,
237 reintroduction of spring Chinook in the Okanagan Basin, coho reintroduction and
238 supplementation in the Mid and Upper Columbia basins, reconditioning of Mid and Upper
239 Columbia and Snake River steelhead kelts, Kootenai River White sturgeon, burbot and
240 westslope cutthroat trout.

241 **PREDATION**

242 Bonneville's F&W Program funds efforts to address the mortality of ESA-listed and non-listed
243 fish caused by predators including birds, fish, and mammals. Certain types of fish in rivers are
244 voracious consumers of juvenile salmon and steelhead. Predation by introduced fish species in
245 reservoirs is also a concern. Other predators are known to consume substantial numbers of
246 adult spring Chinook salmon and winter steelhead below Bonneville Dam and injure adult fish
247 that migrate upstream. Bonneville funds projects to reduce the impact of these predator
248 species on native fish.

249 **LAMPREY**

250 Several lamprey species, both anadromous and resident, are native to the Columbia River
251 Basin, which historically supported productive populations. Much of the research and
252 mitigation effort in the Basin is currently focused on the anadromous Pacific Lamprey due to its
253 cultural importance to tribes and vital role in the ecosystem. At present Bonneville funds six
254 lamprey projects to improve our understanding of Pacific Lamprey status and limiting factors,
255 implement high-priority habitat restoration actions, increase populations through

256 reintroduction and translocation efforts, and conduct artificial propagation research with plans
257 to release hatchery juveniles in select areas pending an environmental assessment.

258 **WILDLIFE MITIGATION FOR CONSTRUCTION, INUNDATION, AND OPERATIONS**

259 When the CRS dams were built and the reservoirs behind them filled, they inundated about
260 308,996 acres, much of it important fish and wildlife habitat. To calculate the area affected by
261 FCRPS development—dam construction and inundation by the reservoirs behind them—
262 Bonneville relied on either the amounts agreed upon in negotiated mitigation agreements with
263 state and tribal entities or the loss assessments prepared by Federal, state, and tribal wildlife
264 managers.⁵

265 To date, Bonneville has implemented wildlife habitat projects on over 689,000 acres to address
266 the impact of the development of the FCRPS, many of which were permanently acquired for
267 wildlife habitat. Bonneville also provides operations and maintenance funding for these
268 projects.

269 The loss assessments relating to dam construction and inundation considered all habitat losses
270 up to and including full reservoir pool levels. As such, mitigation for those losses can also serve
271 to address the effects of reservoir operations on wildlife habitat, to the extent that such
272 operational impacts occur below full pool level.

273 While much of the mitigation work has been implemented through annual contracts, Bonneville
274 and its partners negotiated “settlement agreements” to complete the wildlife mitigation for
275 construction and inundation impacts, and some operational impacts, for Dworshak, Libby,
276 Hungry Horse Projects and part of the impacts from the Albeni Falls Dam. These settlements
277 allowed Bonneville and the affected states or tribes to agree on an appropriate amount of
278 mitigation to be done and the funding or other consideration Bonneville would provide.

279 • **Albeni Falls Dam.** In the 2018 Albeni Falls Dam Wildlife Mitigation Agreement, Bonneville
280 and the State of Idaho established that 14,087 acres had already been mitigated through
281 the efforts of the state and three tribes (6,617 acres were impacted as a result of the
282 construction and inundation of Albeni Falls dam).[1] In addition, Bonneville agreed to fund
283 the State of Idaho to protect and enhance 1,279 acres of wetland habitat at the Clark Fork
284 Delta and an additional 99 acres at the Priest River Delta to address the upriver effects of
285 Albeni Falls operations. This is in addition to the 624 acres of wetland protected and
286 enhanced on the Clark Fork Delta by IDFG, which was funded by Bonneville through a letter
287 agreement in 2012.

5 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. See, e.g., U.S. Fish and Wildlife Service, Wildlife Impact Assessment Bonneville, McNary, The Dalles, and John Day Projects (Oct. 1990).

- 288 • **Dworshak Dam.** The 1992 Dworshak wildlife mitigation agreement with the State of Idaho
289 and the Nez Perce Tribe, frequently referred to as the “Dworshak Settlement,” mitigated
290 the impacts to wildlife from developing that dam estimated at 16,970 acres.⁶ To determine
291 acreage protected, Bonneville relied on the Dworshak Wildlife Agreement reports from the
292 tribe. The tribe’s 2018 annual report indicates it has purchased 7,576 acres and still has over
293 \$9.5 million remaining in its mitigation fund established under the agreement.⁷ The State of
294 Idaho also has a \$3 million fund provided by Bonneville to manage the 60,000 acre Peter T.
295 Johnson Unit of the Craig Mountain Wildlife Management Area (formerly known as Craig
296 Mountain), which Bonneville purchased and transferred to Idaho.⁸ All told, Bonneville has
297 already funded 67,576 acres of mitigation for Dworshak Dam.
- 298 • **Montana Dams.** As with Dworshak, Bonneville addressed the construction and inundation
299 mitigation for Libby and Hungry Horse dams wildlife using a comprehensive long-term
300 agreement. To determine acreage protected, Bonneville relied on reports from Montana
301 Fish, Wildlife, and Parks. Under the 1989 Montana Wildlife Mitigation Trust Agreement,⁹
302 Montana has protected or enhanced 272,104 acres¹⁰ (substantially more than the Council’s
303 program called for, which was a total of 55,837 acres for Libby and Hungry Horse dams split
304 between 29,171 acres of enhancement and 26,666 acres of protection).¹¹

305 **5.2.1.2 Lower Snake River Compensation Plan**

306 Congress authorized the Lower Snake River Compensation Plan (LSRCP) as part of the Water
307 Resources Development Act of 1976 (90 Stat. 2917) to offset fish and wildlife losses caused by
308 construction and operation of the four lower Snake River dams. A major component of the
309 authorized plan was the design and construction of fish hatcheries and satellite facilities. The
310 U.S. Corps of Engineers and Bonneville implement separate portions of this program.

311 **U.S. Corps of Engineers’ Lower Snake River Compensation Plan**

312 The Corps’ LSRCP includes construction of fish hatcheries and acclimation facilities in Idaho,
313 Oregon, and Washington. In addition, the Corps developed over 23,000 acres of land as wildlife
314 habitat (shrub-steppe and riparian) to replace habitat that was inundated and to provide fishing
315 and hunting access.

6 Crediting Forum, Final Report 3.

7 Nez Perce Tribe, Dworshak Wildlife Mitigation Annual Report (2018) (on file with Bonneville).

8 Idaho Dept. of Fish and Game, Craig Mountain Wildlife Management Area 2014-2023 Wildlife Management Plan 9 (Dec. 2014), <https://idfg.idaho.gov/sites/default/files/2014-2023-CraigMtnWMA-Plan-Final.pdf>

9 Montana Fish, Wildlife and Parks, Montana’s Wildlife Mitigation Settlement (Power Point presented to Bonneville by MFWP wildlife managers on Nov. 19, 2013) (on file with Bonneville).

10 Montana Fish, Wildlife and Parks, Montana Wildlife Mitigation Program FY 2019, 1 (Oct. 2, 2019).

11 See, Council, 1987 Columbia River Basin Fish and Wildlife Program § 1000 138–39 tbl.4, <https://www.nwcouncil.org/media/6843101/1987Program.PDF>; see also, Montana Fish, Wildlife and Parks, Program for Mitigating Wildlife Impacts Caused by construction of Libby and Hungry Horse Dams: Five-Year Operating Plan 3 (July 1, 2009) (citing Yde and Olsen (1984)), <http://fwp.mt.gov/fwpDoc.html?id=53780> [hereinafter Program for Libby and Hungry Horse].

316 **BONNEVILLE’S LOWER SNAKE RIVER COMPENSATION PLAN**

317 In addition to the hatchery operations that are funded through its F&W Program, Bonneville
318 directly funds the U.S. Fish and Wildlife Service (USFWS) for annual operations and
319 maintenance of the LSRCP fish hatcheries and facilities. The LSRCP hatcheries and satellite
320 facilities produce and release more than 19 million salmon, steelhead, and resident rainbow
321 trout as part of the program’s mitigation responsibility. The 25 LSRCP hatcheries and satellite
322 facilities are operated by Idaho Fish and Game (IDFG), Washington Department of Fish and
323 Wildlife (WDFW), Oregon Department of Fish and Wildlife (ODFW), USFWS, the Nez Perce Tribe
324 (NPT), Confederated Tribes of the Umatilla River (CTUIR), and Shoshone-Bannock Tribes (SBT).
325 LSRCP would be continued, consistent with the NAA, under all of the MOs except for MO3.

326 **5.2.1.3 U.S. Corps of Engineers’ Columbia River Fish Mitigation Program**

327 The Columbia River Fish Mitigation Program (CRFM) is the Corps' construction account for
328 studying, designing, and constructing new anadromous fish passage improvements at CRS
329 dams. Nearly all fish passage improvements required for compliance with past Biological
330 Opinions issued by the NMFS have been constructed, and few new anadromous fish
331 improvements requiring construction have been identified. Therefore it is assumed that for CRS
332 dams, requirements for new construction will be completed within the next 10 years.

333 Examples of CRFM funded activities include installing turbine intake screens and bypass
334 systems, modifying spillways (e.g., flow deflectors, surface spill weirs, and modified surface spill
335 structures), and installing improved fish passage turbines. Additional modifications to fish
336 ladders have also been underway to increase passage of adult lamprey, including the
337 installation of specialized lamprey passage structures at Bonneville, The Dalles, and McNary
338 dams.

339 **5.2.1.4 Bureau of Reclamation’s Columbia River Tributary Habitat Program**

340 Reclamation has a Columbia-Snake salmon program to help meet its ESA obligations for the
341 Grand Coulee and Hungry Horse projects. The program funds, designs, and implements
342 tributary habitat improvements in specified Columbia River sub-basins, and also funds avian
343 predation management.

344 **5.2.1.5 Direct Funding Agreements with the Corps and Reclamation**

345 In addition to Bonneville’s fish and wildlife mitigation program described above, there are also
346 fish and wildlife mitigation costs that are direct funded by Bonneville to the Corps and
347 Reclamation for mitigation activities, such as hatchery operations, fish stocking, elk habitat
348 maintenance, cultural resource compliance and others.

349 **5.2.1.6 Federal Columbia River Power System Cultural Resource Program**

350 The co-lead agencies implement the Federal Columbia River Power System Cultural Resource
351 Program (Cultural Resource Program) (Bonneville 2019) to comply with Section 106 of the
352 NHPA.

353 When a historic property is adversely affected by a Federal undertaking, agencies consult with
354 consulting parties to seek ways to avoid, minimize, or mitigate for the adverse effects. To
355 effectively manage historic properties within the study area (see Chapter 1 for map), the co-
356 lead agencies developed the Cultural Resource Program in 1997 to address compliance with
357 Section 106 for the undertaking that resulted from the System Operation Review (SOR) EIS –
358 the operation and maintenance of the Federal Columbia River Power System for the multiple
359 congressionally authorized project purposes. Activities implemented as part of the program are
360 guided by the 2009 Systemwide Programmatic Agreement for the Management of Historic
361 Properties Affected by the Multipurpose Operations of Fourteen Projects of the Federal
362 Columbia River Power System (Systemwide PA) (Bonneville 2009). Through the Cultural
363 Resources Program and the Systemwide PA, the co-lead agencies also partner with other
364 Federal agencies, states, and tribal technical staff who specialize in Columbia River Plateau
365 archaeology, historic and cultural importance to tribes, the built environment, and other
366 cultural resources to share information and assist in defining priorities and solutions to
367 appropriately manage cultural resources in the study area.

368 Under the Systemwide PA, the Cultural Resources Program manages historic properties through
369 a standard process of surveys, evaluation, assessments, and resolution of adverse effects. In
370 addition, the program evaluates potential historic properties to determine if they are eligible
371 for listing in the National Register of Historic Places. Annual operation and maintenance
372 activities affect some of the historic properties. Operations and maintenance can affect cultural
373 resource sites and areas of traditional importance, sometimes exposing artifacts that could
374 potentially be looted or vandalized. The PA assesses the effects from changes in configuration,
375 and operations and maintenance activities, and develops options to resolve adverse effects.
376 Through the assessment of effects, the program can monitor the status of site conditions and
377 fund limited law enforcement activities, where appropriate.

378 If a cultural resource is eligible for listing in the National Register of Historic Places, the Cultural
379 Resource Program works with the consulting parties to determine how to prioritize activities to
380 mitigate the adverse effects. Examples of mitigation include protection and restoration; bank
381 stabilization for erosional areas; data recovery, and analysis; public education through the
382 production of brochures, exhibits, interpretive trails, or presentations; and creative offsite
383 mitigation. Offsite mitigation options can include, but are not limited to rehabilitating
384 structures that have a cultural tie to the impacted areas or funding educational opportunities
385 and activities for tribal members related to cultural practices tied to particular properties.

386 The existing Cultural Resource Program would be carried forward and funded under the No
387 Action Alternatives, MO1, MO2, and MO4 for continued archaeological monitoring through the
388 Columbia River study area. Mitigation for MO3 is discussed below. Activities implemented

389 under MO1, MO2, and MO4 could include the continued periodic use of drones and satellites to
390 document changes through time in sites. Activities include monitoring for erosion and other site
391 formation processes; providing opportunities for public education to increase awareness about
392 the importance, value, and need for protecting archaeological sites; increasing signage across
393 the study area to support public education and awareness where appropriate; data recovery,
394 and other various forms of mitigation activities to address effects to Traditional Cultural
395 Properties and historic properties of religious or cultural importance to tribes.

396 **5.2.1.7 Predation Management**

397 Existing avian and pinniped predator management programs are in place and would continue
398 with implementation of any of the MOs. The co-lead agencies would continue implementing
399 existing avian predator management actions in the lower Snake and Columbia Rivers and the
400 existing pinniped predator management program in the lower Columbia River. Predator
401 management actions are both in-place and out-of-place, and are intended to mitigate for
402 impacts to juvenile and adult fish that are adversely impacted by high TDG concentration during
403 migration, but the mitigation does not address elevated TDG itself. TDG concentrations would
404 remain unchanged under these mitigation measures. The number of fish impacted by spill
405 operations would decrease as a result of predator management actions.

406 **5.2.1.8 Invasive Species and Pest Management Programs**

407 The co-lead agencies currently plan and continue to implement invasive species management
408 on Federal lands within the study area to detect, manage, and control nuisance and invasive
409 species, including animals, plants, or other organisms. Invasive species can hinder or otherwise
410 adversely affect navigation, hydropower generation, flood risk management, water supply,
411 water quality, fish and wildlife habitat, and recreational activities (e.g., Corps 2017, 2019;
412 Reclamation 2019). Management activities include biological, chemical, and mechanical
413 methods as part of integrated management programs to control both terrestrial and aquatic
414 pests.

415 **5.2.1.9 Nutrient Supplementation Programs**

416 The co-lead agencies currently plan and continue to implement three existing programs to
417 improve water quality and enhance fisheries in the study area. One program is implemented in
418 Dworshak Reservoir, the second is implemented downstream of Libby in the Kootenai River,
419 and the third is in Kootenay Lake. These plans would continue with implementation of any MO.

420 The Dworshak Reservoir Nutrient Restoration Project is implemented by the Corps and Idaho
421 Department of Fish and Game in Dworshak Reservoir to restore ecological function, improve
422 water quality and enhance fisheries (Idaho Department of Fish and Game 2018). Construction
423 of the dam blocked upstream fish migration on the North Fork Clearwater River, depleting
424 nutrients upstream of the dam. Results from a pilot project implemented between 2007 and
425 2010 demonstrated that supplementing the reservoir with additional nitrogen balanced the
426 ratio of nutrients and improved overall ecological function. In 2017, the nutrient

427 supplementation project was incorporated into reservoir operations and maintenance, and
428 water quality is regularly monitored to ensure the program beneficially supports water quality,
429 plankton communities, and fish.

430 Funded by Bonneville and implemented by tribal and state partners, the Kootenai River
431 Nutrient Enhancement Program mitigates for a loss of nutrients in the river to benefit resident
432 fish, including Kootenai River White Sturgeon (*Acipenser transmontanus*) and bull trout
433 (*Salvelinus confluentus*), by supplementing the river with phosphorous and nitrogen. This action
434 is intended to support aquatic invertebrate production and contribute to the food web to
435 support fish and other aquatic organisms. (Kootenai River Ecosystem Final Environmental
436 Assessment, June 2005). Nutrients are trapped in the Libby Reservoir, depleting concentrations
437 in the Kootenai River and reducing overall productivity in the river. Nutrient concentrations
438 become increasingly diluted downstream of the dam. The program is planned to continue until
439 the summer of 2026. Continuation of the program would occur following evaluation of
440 conditions, research, and monitoring results.

441 Additionally, the Kootenay Lake Ecosystem Project provides an annual addition of nutrients to
442 the south arm of Kootenay Lake to increase biological productivity and restore native fish
443 populations. The nutrient additions promote zooplankton abundance, an important food
444 source for kokanee, and important food item for adult and juvenile Kootenai white sturgeon.
445 Under this program Bonneville funds the British Columbia Ministry of Forests, Lands, and
446 Natural Resource Operations to add nutrients and monitor from June through August using
447 boat-mounted applicator tanks. This project began in 2004, and complements another nutrient
448 supplementation program also implemented by British Columbia on the North Arm of the
449 Kootenay Lake. Details of this program may be found in Bonneville's Environmental Assessment
450 for the Kootenai River Ecosystem Project (2005, 2012).

451 **5.3 CONSIDERATIONS FOR ESA COMPLIANCE**

452 Compliance measures for the No Action Alternative were described in Chapter 2. The Preferred
453 Alternative is currently being coordinated for consultation with the USFWS and NMFS under the
454 Endangered Species Act. Results of consultation may change, supplement, or remove measures
455 previously carried forward in the No Action Alternative. Chapter 7 addresses those measures
456 added for the ESA compliance of the Preferred Alternative. Should MO1, MO2, MO3, or MO4
457 be selected as the Preferred Alternative, it would require additional analysis through
458 consultation with USFWS and NMFS, and may include, as appropriate, more or less ESA
459 measures to be compliant with the ESA.

460 **5.4 POTENTIAL MITIGATION FOR ALTERNATIVES**

461 This section describes the additional mitigation measures identified by the co-lead agencies for
462 impacts to resources from each of the MOs. Each MO includes a summary table of potential
463 mitigation the co-lead agencies would take if that MO were to be implemented. The sections
464 are organized according to region, resource, or subject area. Additional information about
465 mitigation measures that were considered but were screened or not selected for further

466 consideration can be found in Appendix R - Monitoring and Adaptive Management.
467 The list of mitigation measures for the Preferred Alternative will be updated after public review
468 of the draft EIS and included as a comprehensive list in the final EIS.

469 **5.4.1 Mitigation Measures for Multiple Objective Alternative 1**

470 The additional mitigation measures proposed for MO1 address impacts to water quality,
471 anadromous and resident fish, vegetation, wildlife, wetlands, and floodplains, and navigation
472 and transportation. Impacts to these resources are described fully in Chapter 3, Chapter 4, and
473 Chapter 6. Effects to cultural resources would be addressed by continuing to implement the
474 existing Cultural Resource Program discussed in Section 5.2.1.6. For MO1, there would be no
475 impacts requiring additional mitigation for flood risk management, aesthetics, noise, water
476 supply, recreation or cultural resources, as there are negligible impacts. Although power and
477 transmission have moderate adverse effects compared to the No Action Alternative, mitigation
478 actions are discussed within the Chapter 3 Power and Transmission section.

479 **5.4.1.1 Water Quality**

480 MO1 would have negligible effects to water quality in Region A, B, and D and therefore no
481 additional mitigation is warranted. In Region C, a measure is proposed to address public health
482 concerns as described below. In Region C and D, total dissolved gas (TDG) would increase.
483 Mitigation for effects of this TDG increase to fish is proposed in the Anadromous Fish Mitigation
484 section.

485 The co-lead agencies propose mitigation in Region C to limit impacts to water quality. Elevated
486 water temperatures in the lower Snake River during the summer months could increase algal
487 growth, which decreases water quality and poses health risks in recreational areas. To help
488 ameliorate impacts to water quality and public health to those recreating, the co-lead agencies
489 will either initiate monitoring or increase the existing monitoring at recreational areas in Region
490 C for algal growth. If monitoring indicates the presence of toxic algal blooms, then public
491 advisories would be posted in recreational areas to minimize risks to the public. This proposed
492 mitigation is not intended to reduce algal growth, but is intended to assist in protecting the
493 public.

494 **5.4.1.2 Anadromous Fish**

495 The co-lead agencies are not proposing any mitigation measures in Regions A or B (upstream of
496 Chief Joseph) for impacts to anadromous fish because there are no anadromous fish above
497 Chief Joseph Dam. One new measure is proposed for Region C and D for TDG impacts. No other
498 additional mitigation is proposed for anadromous fish. Ongoing programs for anadromous fish
499 in Regions B (below Chief Joseph), C, and D would continue, including habitat projects and fish
500 hatchery programs for salmon and steelhead discussed above in Section 5.2.1. Examples of
501 these projects are discussed below.

502 **NEW MITIGATION ACTIONS**

503 In Region C and D, concentrations of TDG would increase because of spill measures
504 implemented as part of MO1. If it is observed that conditions in the project tailrace are
505 impeding upstream passage of adult salmon and steelhead or actionable TDG impacts to fish
506 are observed, the co-lead agencies would implement performance standard spill operations
507 until the situation is remedied. These real-time decisions are made in the Regional Forum.
508 These operations are of short duration, and as-needed, to resolve the passage issues.

509 **EXAMPLES OF CONTINUING PROGRAMS WITH MO1**

510 Below Chief Joseph Dam, ongoing activities for anadromous fish would continue, including
511 habitat improvement actions in the tributaries and the Columbia River estuary for juvenile
512 salmon and steelhead species, and fish hatchery programs as discussed in the examples below.

513 In Region B, the Confederated Tribes of the Colville Reservation operate the Chief Joseph
514 Hatchery on the Colville Reservation below Chief Joseph Dam, releasing smolts to increase the
515 abundance of adult summer/fall and spring Chinook to the Okanogan River and Columbia River
516 mainstem above the Okanogan River confluence. This is for conservation and harvest purposes,
517 and assists in re-establishing a fourth population of UCR spring Chinook in the Okanogan River
518 Basin through reintroduction of an experimental population under the ESA.

519 In Region C, Bonneville F&W Program-funded hatchery programs include the captive
520 propagation for critically endangered Snake River sockeye, Snake River spring/summer Chinook
521 supplementation, Snake River fall Chinook supplementation and the reconditioning of Snake
522 River steelhead kelts. Further, the Springfield Hatchery, located near American Falls, Idaho, was
523 constructed to address recovery objectives for ESA-endangered Snake River Sockeye Salmon.

524 In Region D, Bonneville F&W Program-funded hatchery programs include coho reintroduction
525 and supplementation in the Mid-Columbia and reconditioning of Mid-Columbia steelhead kelts.

526 Throughout Regions C and D, the Bonneville F&W Program annually funds tributary habitat
527 improvement actions for ESA-listed anadromous stocks, such as Snake River steelhead distinct
528 population segment, Snake River spring/summer Chinook salmon evolutionary significant unit,
529 and the Middle Columbia steelhead distinct population segment. Further, in Region D, co-lead
530 agencies would continue to implement habitat restoration actions in the Columbia River
531 Estuary. These actions primarily focus on the restoration of disconnected tidally influenced
532 floodplain ecosystems for all juvenile salmonids and steelhead species in order to provide
533 greater opportunity, access, and capacity for juvenile salmonid and steelhead rearing
534 conditions. Additionally, in Region D, there are numerous actions to benefit Pacific lamprey,
535 including projects like the Pacific Lamprey Conservation Initiative and the Tribal Pacific Lamprey
536 Restoration Plan, which have been developed to improve understanding of Pacific Lamprey
537 status and limiting factors, and implement high-priority habitat restoration actions.

538 **5.4.1.3 Resident Fish**

539 Under MO1, the co-lead agencies propose mitigation measures for adverse effects to resident
540 fish in Region A near Bonners Ferry, Idaho and at Hungry Horse reservoir; and in Regions B for
541 at Lake Roosevelt. No additional mitigation is proposed in Regions C or D because implementing
542 MO1 results in minor adverse effects, occurs temporarily, or does not rise to the level of
543 severity warranting additional mitigation. Ongoing actions as described in Section 5.2.1 for
544 resident fish, such as bull trout and sturgeon in Regions A, B, C, and D, would continue. A few
545 examples of those actions are discussed below.

546 Collectively, the measures for MO1 affect seasonal water surface elevations and flows, and the
547 co-lead agencies do not expect a perceptible change to habitat conditions for resident fish. In
548 Region B, MO1 would adversely affect the abundance of non-native species, such as
549 smallmouth bass (*Micropterus dolomieu*) and walleye (*Sander vitreus*). Decreasing the
550 reproductive success of these populations would support increased survival of ESA-listed
551 species such as salmon and steelhead below Chief Joseph Dam. For these reasons, and the
552 adverse effects are to non-native species, the co-lead agencies are not proposing additional
553 mitigation.

554 **NEW MITIGATION ACTIONS**

555 To address impacts of MO1 in Region A, the co-lead agencies propose planting cottonwood
556 trees at Bonners Ferry, Idaho, to improve habitat and floodplain connectivity to benefit ESA-
557 listed Kootenai River White Sturgeon and bull trout. Similar to the proposed mitigation for
558 vegetation, wildlife, wetlands, and floodplains, expanding the quantity and distribution of
559 wetland habitats and increasing floodplain connectivity along the Kootenai River could help
560 address seasonal impacts at Bonners Ferry from the *December Libby Target Elevation* measure.
561 High winter levels could decrease the recruitment and long-term survival of cottonwood trees
562 adjacent to the river when seeds and saplings are swept downstream during winter flows.
563 While implementation of this MO negligibly effects these resources relative to the No Action,
564 the co-lead agencies propose to plant 1-2 gallon cottonwoods near Bonners Ferry to improve
565 habitat and floodplain connectivity, which would benefit ESA-Listed Kootenai River White
566 Sturgeon by providing a food source. This would complement ongoing habitat actions already
567 being taken in the region. This mitigation measure, when considered with the existing
568 Bonneville-funded Kootenai River Habitat Restoration Program, would further minimize any
569 negative effects.

570 Mitigation measures for the fish impacts of Libby dam are coordinated with adjacent tribal,
571 state, and provincial governments. Programs like the Libby Dam Fisheries Mitigation and
572 Implementation Plan (Montana Fish Wildlife and Parks et al. 1998) seek to enhance
573 hydropower-affected fish stocks in the Montana portion of the Kootenai Watershed consistent
574 with white sturgeon, bull trout, westslope cutthroat trout and redband trout conservation
575 needs and requirements. This program implements and evaluates habitat enhancement to
576 alleviate limiting factors to native species including projects to protect or enhance spawning,
577 rearing, and over-wintering habitats. Additionally, since 2010, BPA has funded the Kootenai

578 Tribe of Idaho (KTOI) to manage and implement habitat restoration measures within the
579 Kootenai River downstream of Libby Dam. These habitat restoration actions have increased
580 active floodplain, increased river pool depths, reduced erosion, and provided increased
581 complexity and velocities to aid in the survival and potential reproduction of Kootenai River
582 White Sturgeon and potentially benefit for the native salmonid populations as well. In addition
583 to their habitat work, KTOI operates the Kootenai Tribal sturgeon hatchery and the Tribal Twin
584 Rivers sturgeon and burbot hatchery facility, which was constructed in 2014. These facilities
585 have preserved sturgeon genetic and demographic diversity and have pioneered culture
586 techniques for burbot.

587 Under Bonneville's Fish and Wildlife Program, Bonneville funds the Confederated Salish and
588 Kootenai Tribes and the State of Montana to assess population level effects of CRS operations
589 on native fishes, implements habitat improvement, habitat conservation, and fish passage
590 actions, and quantifies and reduces the effects of non-native aquatic species on native fishes
591 for impacts from Hungry Horse Dam.

592 MO1 lowers water surface elevations and creates seasonal drawdowns in the Hungry Horse
593 reservoir, adversely affecting bull trout migration in late the summer and early fall. As reservoir
594 elevations decline, fish passage conditions at the mouth of spawning tributaries prohibit fish
595 migration into spawning tributaries. Under these conditions, bull trout are more susceptible to
596 angling and predation pressures due to a lack of sufficient cover while they hold until conditions
597 are passable. This also causes delays in migration which result in an overall decrease in
598 productivity. To offset these effects, the co-lead agencies propose installing structural
599 components like woody debris and vegetation at the mouth of tributaries, such as Wounded
600 Buck, Sullivan, Wheeler, and Bunker Creeks, to stabilize channels and increase cover for
601 migrating fish. These actions would improve habitat conditions for bull trout and minimize
602 impacts from fluctuating water levels on the reservoir. This mitigation action would also
603 increase the survival of outmigrating juveniles and increase production of terrestrial and
604 aquatic invertebrates. Considering the existing Bonneville-funded Confederated Salish and
605 Kootenai Tribes and State of Montana programs with this proposed mitigation component,
606 adverse effects are anticipated to be reduced to negligible.

607 In Region B, changes in elevation would leave current habitat in Lake Roosevelt dewatered and
608 expose new areas that could be appropriate for gravel spawning habitat. The co-lead agencies
609 would develop additional spawning habitat at Lake Roosevelt to minimize adverse effects to
610 resident fish. The co-lead agencies propose to place appropriate gravel for spawning habitat at
611 locations up to 100 acres along reservoir and tributaries. Prior to placement, the co-lead
612 agencies would conduct site surveys post operations of an alternative to determine where to
613 site spawning habitat at Lake Roosevelt for burbot, kokanee, and redband rainbow trout.

614 **EXAMPLES OF CONTINUING PROGRAMS WITH MO1**

615 There are numerous ongoing actions to benefit resident fish. Under Bonneville's Fish and
616 Wildlife Program, Bonneville funds the Confederated Salish and Kootenai Tribes and the State
617 of Montana to assess population level effects of CRS operations on native fishes, implements

618 habitat improvement, habitat conservation, and fish passage actions, and quantifies and
619 reduces the effects of non-native aquatic species on native fishes for impacts from Hungry
620 Horse Dam. Part of the mitigation work for Hungry Horse Dam involves fish production at two
621 small hatcheries in northern Montana. Bonneville funds Creston National Hatchery's production
622 of juvenile westslope cutthroat trout and juvenile rainbow trout for stocking in Montana
623 waters. Bonneville also funded the construction of Sekokini Springs Isolation Facility for
624 spawning, rearing, isolation, and release of genetically unique westslope cutthroat trout stocks
625 originating from wild parent stocks. Mitigation actions for the fish impacts of Libby dam are
626 coordinated with adjacent tribal, state, and provincial governments. Programs like the Libby
627 Dam Fisheries Mitigation and Implementation Plan (Montana Fish Wildlife and Parks et al.
628 1998) seek to enhance hydropower-affected fish stocks in the Montana portion of the Kootenai
629 Watershed consistent with white sturgeon, bull trout, westslope cutthroat trout, and redband
630 trout conservation needs and requirements. This program implements and evaluates habitat
631 enhancement to alleviate limiting factors to native species including projects to protect or
632 enhance spawning, rearing, and over-wintering habitats. Additionally, since 2010, BPA has
633 funded the Kootenai Tribe of Idaho (KTOI) to manage and implement habitat restoration
634 measures within the Kootenai River downstream of Libby Dam. These habitat restoration
635 actions have increased active floodplain, increased river pool depths, reduced erosion, and
636 provided increased complexity and velocities to aid in the survival and potential reproduction of
637 Kootenai River White Sturgeon and potentially benefit for the native salmonid populations as
638 well. In addition to their habitat work, KTOI operates the Kootenai Tribal sturgeon hatchery and
639 the Tribal Twin Rivers sturgeon and burbot hatchery facility, which was constructed in 2014.
640 These facilities have preserved sturgeon genetic and demographic diversity and have pioneered
641 culture techniques for burbot.

642 Bonneville's F&W Program provides funding to the Kalispel Tribe to develop and implement a
643 resident fish mitigation program for the impacts from Albeni Falls Dam. This work includes
644 improving bull trout habitat within the basin. Additional priorities are to restore habitats for
645 westslope cutthroat trout, and maintain the suppression effort on non-native predator and
646 competitive fish species within the Pend Oreille Basin. Finally, through the 2018 Albeni Falls
647 Dam Wildlife Mitigation Agreement, Bonneville and the State of Idaho to protect and enhance
648 1,378 acres to address operational impacts of Albeni Falls Dam on wildlife.¹² Much of this work
649 focuses on the Clark Fork Delta and restoration of riparian habitat and the reestablishment of
650 wetland plant communities, which will also benefit resident fish species.

651 In Region C, Bonneville F&W-funded projects with the Nez Perce Tribe in the Lochsa watershed
652 are working to improve habitat for resident fish. Idaho Department of Fish and Game are also
653 improving habitat for Yellowstone cutthroat trout. Riparian, wetland, and instream habitat
654 restoration in Regions C and D that targets anadromous fish or wildlife species also can improve
655 habitat conditions for resident fish species.

¹² Northern Idaho Memorandum of Agreement Between the State of Idaho and the Bonneville Power Administration for Wildlife Habitat Stewardship and Restoration section II.C.3, page 6 (2018) (on file with Bonneville).

656 **5.4.1.4 Vegetation, Wildlife, Wetlands, and Floodplains**

657 Under MO1, the co-lead agencies propose mitigation measures in Region A along the Kootenai
658 River. This mitigation measure would help address impacts to vegetation, wildlife, wetland, and
659 floodplain habitats. Collectively, the measures for MO1 affect seasonal water surface
660 elevations, but the co-lead agencies expect a minor to negligible perceptible change to habitat
661 conditions, wetlands, and floodplains.

662 While the *Predator Disruption Operations* and *Increased Forebay Range Flexibility* measures
663 may cause temporary effects to wetlands in Region D, specifically in Lake Umatilla or Lake
664 Celilo, no mitigation is proposed as the effects are not expected to result in perceptible changes
665 to wetland habitats. Similarly, while MO1 would result in a minor to negligible seasonal
666 decrease in water surface elevations in the Columbia River estuary downstream of Bonneville
667 Dam, the effects would not perceptibly change wetland or estuary habitat conditions.
668 Therefore, no additional mitigation is proposed for impacts from MO1 in the Columbia River
669 estuary.

670 As a result, no additional actions are proposed for Region B, C, or D. Ongoing actions for
671 impacts to vegetation and wildlife in Regions A, B, C, and D would continue, including
672 protection and enhancement of wildlife habitat as discussed in the examples below.

673 **NEW MITIGATION ACTIONS**

674 In Region A, the co-lead agencies propose two mitigation measures to help address impacts to
675 vegetation. First, the co-lead agencies propose updating and implementing an invasive species
676 management plan to offset the impacts from implementing the *Modified Draft at Libby*
677 measure. With this measure, lower summer reservoir elevations at Libby would increase the
678 exposure of mudflats during the growing season, which could increase spread and
679 establishment of invasive species along the shoreline. To address this concern, the co-lead
680 agencies would update existing management plans and implement them where warranted.
681 Existing Invasive Species management programs were described above in Section 5.2.1.8 for the
682 No Action Alternative.

683 Implementing the *December Libby Target Elevation* measure could decrease seasonal water
684 surface elevations during the growing season. Additionally, the *December Libby Target*
685 *Elevation measure* could result in higher winter flow and decrease the recruitment and long-
686 term survival of black cottonwood trees (*Populus balsamifera* ssp. *trichocarpa*) adjacent to the
687 river when seeds and saplings are swept downstream during winter flows. This measure could
688 adversely affect wetland quality, quantity, and distribution along the Libby reservoir and the
689 Kootenai River. To mitigate these effects, the co-lead agencies proposed planting approximately
690 100 acres of forested and scrub-shrub wetland habitat for the loss of these forests and support
691 vegetation succession. This mitigation measure, when considered with the existing Bonneville-
692 funded Kootenai River Habitat Restoration Program, would minimize any negative effects to
693 negligible. This expansion of wetland habitats along the Kootenai River would also help
694 ameliorate seasonal impacts at Bonners Ferry, Idaho.

695 **EXAMPLES OF CONTINUING PROGRAMS WITH MO1**

696 In Region A, Bonneville addressed the construction and inundation mitigation for Libby and
697 Hungry Horse dams wildlife using a comprehensive long-term agreement. To determine
698 acreage protected, Bonneville relied on reports from Montana Fish, Wildlife, and Parks. Under
699 the 1989 Montana Wildlife Mitigation Trust Agreement,¹³ Montana has protected or enhanced
700 272,104 acres¹⁴ (the Council's program called for a total of 55,837 acres for Libby and Hungry
701 Horse dams split between 29,171 acres of enhancement and 26,666 acres of protection).¹⁵ In
702 the 2018 Albeni Falls Dam Wildlife Mitigation Agreement, Bonneville and the State of Idaho
703 established that 14,087 acres had already been mitigated through the efforts of the state, the
704 Kalispel Tribe, Kootenai Tribe of Idaho, and the Coeur D'Alene Tribe (6,617 acres were impacted
705 as a result of the construction and inundation of Albeni Falls dam).¹⁶ In addition, Bonneville
706 agreed to fund the state to protect and enhance an additional 1,378 acres to fully address
707 operational impacts of Albeni Falls Dam on wildlife.¹⁷ Bonneville also agreed to fund the State of
708 Idaho to protect and enhance 1,279 acres of wetland habitat at the Clark Fork Delta and an
709 additional 99 acres at the Priest River Delta to address the upriver effects of Albeni Falls
710 operations. This is in addition to the 624 acres of wetland protected and enhanced on the Clark
711 Fork Delta by Idaho Department of Fish and Game (IDFG), which was funded by Bonneville
712 through a letter agreement in 2012.

713 In Region B, Bonneville funds the Colville Tribes' wildlife mitigation efforts, which are focused
714 on projects in the Hellsgate Game Reserve on the Colville Reservation. Under a 2008 agreement
715 between Bonneville and the Colville Tribes, the Colville Tribes have acquired almost 4,000
716 acres, completed over 54,000 acres of invasive/noxious weed control measures, engaged in
717 extensive boundary fence monitoring (over 270 miles), and modified fencing for reintroduced
718 pronghorn antelope.

719 In Region C, Bonneville funds acquisition and management of wildlife mitigation lands under
720 the 1992 Dworshak Wildlife Mitigation Agreement with the State of Idaho and the Nez Perce
721 Tribe. Bonneville has provided the State of Idaho \$3 million to manage the 60,000 acre Peter T.
722 Johnson Unit of the Craig Mountain Wildlife Management Area (formerly known as Craig

13 Montana Fish, Wildlife and Parks, Montana's Wildlife Mitigation Settlement (Power Point presented to Bonneville by MFWP wildlife managers on Nov. 19, 2013) (on file with Bonneville).

14 Montana Fish, Wildlife and Parks, Montana Wildlife Mitigation Program FY 2019, 1 (Oct. 2, 2019).

15 See, Council, 1987 Columbia River Basin Fish and Wildlife Program § 1000 138-39 tbl.4, <https://www.nwcouncil.org/media/6843101/1987Program.PDF>; see also, Montana Fish, Wildlife and Parks, Program for Mitigating Wildlife Impacts Caused by construction of Libby and Hungry Horse Dams: Five-Year Operating Plan 3 (July 1, 2009) (citing Yde and Olsen (1984)), <http://fwp.mt.gov/fwpDoc.html?id=53780> [hereinafter Program for Libby and Hungry Horse].

16 Northern Idaho Memorandum of Agreement Between the State of Idaho and the Bonneville Power Administration for Wildlife Habitat Stewardship and Restoration section II.C, page 5 (2018) (on file with Bonneville).

17 Northern Idaho Memorandum of Agreement Between the State of Idaho and the Bonneville Power Administration for Wildlife Habitat Stewardship and Restoration section II.C.3, page 6 (2018) (on file with Bonneville).

723 Mountain), which Bonneville purchased and transferred to Idaho. The Nez Perce Tribe has
724 purchased 7,576 acres of wildlife mitigation lands and has over \$9.5 million remaining in its
725 mitigation fund under the agreement.

726 In Region D, the Confederated Tribes of the Umatilla Indian Reservation secured and now
727 manage the 8,768 acre Rainwater project, the 5,937 acre Iskulpa project, and the 2,765 acre
728 Wanaket wildlife area located just above McNary Dam. Further, the 34,000 acre Pine Creek
729 Conservation Area in Wheeler County, Oregon is owned and managed as wildlife habitat by the
730 Confederated Tribes of the Warm Springs Reservation.

731 **5.4.1.5 Navigation and Transportation**

732 The co-lead agencies are not proposing any mitigation measures in Regions A, C, and D for
733 navigation and transportation because the measures implemented as part of MO1 would have
734 negligible effects on these resources as discussed in Chapter 3, and therefore no additional
735 mitigation was warranted.

736 In Region B, the Inchelium-Gifford Ferry would go out of service for longer durations, up 9 more
737 days in wet years than the No Action Alternative, when operational measures at Grand Coulee
738 cause the draft for flood risk management to begin sooner. The effect would isolate tribal
739 members in the community of Inchelium, and while the effect is temporary, it would affect the
740 potential days this community can use the ferry and their ability to reach emergency and
741 medical services and supplies. As a result, mitigation is proposed to extend the ramp at the
742 Inchelium-Gifford Ferry so that it is available at lower water elevations in Lake Roosevelt. This
743 would reduce the effects to negligible effects, and may be moderately beneficial comparative
744 when compared to the No Action Alternative.

745 **5.4.1.6 Cultural Resources**

746 In Region A and B, there could be moderate to major adverse effects to cultural resources from
747 an increase in number of acre-days that archaeological resources would be exposed. Region A
748 and B would use Cultural Resource Program funding for activities such as archaeological site
749 and traditional cultural property monitoring (pedestrian and drone use), reservoir and river
750 bank stabilization, data recovery, public education awareness, protective signage, and other
751 alternative mitigation to address impacts to TCPs. This mitigation measure, when considered
752 with the existing FCRPS Cultural Resource Program, would work to continue minimizing any
753 adverse effects to negligible (Table 5-1).

754 **Table 5-1. Mitigation Summary for MO1**

Resource	Impact	Proposed Mitigation Action	Effects After Mitigation
Water Quality	Region C: Moderate adverse effects from water temperatures can create increased algal growth due to high August water temperatures in the Lower Snake River Projects. This can be a public safety issue for water recreation.	On the Lower Snake River Increased harmful algal bloom monitoring at recreational areas; if algal blooms produce toxins, post public advisories at recreational areas with to protect the public.	Reduction of potential health impacts through public notification to reduce exposure would help to reduce effects to negligible.
Anadromous Fish	Regions C and D: Moderate adverse effect from increased spill levels, which create turbulence and eddies below the dams resulting in delays to adult passage.	Temporary extension of performance standard spill levels in coordination with the Regional Forum to assist fish migration.	Performance Standard Spill is effective in passing adult fish and delays in passage would be negated, resulting in negligible effects.
Resident Fish - ESA Kootenai River White Sturgeon	Region A: The current flow regime at Libby has made establishment of riparian vegetation difficult to sustain young stands of cottonwoods - major contributors to food web for Sturgeon. This results in moderate localized effects. While this MO would not exacerbate these effects above the No Action, it is an ongoing problem.	Plant 1-2 gallon cottonwoods near Bonners Ferry to improve habitat and floodplain connectivity, which would benefit ESA-Listed Kootenai River White Sturgeon by providing a food source. This would complement ongoing habitat actions already being taken in the region.	This mitigation measure, when considered with the existing Bonneville-funded Kootenai River Habitat Restoration Program, would minimize any negative effects to negligible.
Resident Fish – ESA Bull Trout	Region A: Drawdowns cause low water elevations at time of Bull Trout migration, which could make it difficult to enter spawning tributaries and make Bull Trout more susceptible to angling/predation. Negligible to Moderate adverse effect.	On the Hungry Horse Reservoir, install structural components like woody debris, and plant vegetation at the tributaries (Sullivan and Wheeler Creeks, possibly more) to stabilize channels, increase cover for migrating fish, and improve the varial zone.	Considering the existing Bonneville-funded Confederated Salish and Kootenai Tribes and State of Montana programs and the proposed mitigation component, this would minimize any negative effects to negligible.
Resident Fish - Burbot, Kokanee, and Redband Rainbow Trout	Region B: Changes in elevation would leave current habitat dewatered and expose new potential areas appropriate for developing additional gravel spawning habitat.	Develop additional spawning habitat at Lake Roosevelt to minimize impacts to resident fish. Determine post-operations where to site spawning habitat augmentation at Lake Roosevelt for burbot, kokanee, and redband rainbow trout to inform where mitigation is needed. Place appropriate gravel (spawning habitat) at locations up to 100 acres along reservoir and tributaries.	This action is in addition to the Bonneville program that addresses current habitat restoration in Lake Roosevelt and would compensate for additional effects of the new action. Exact sites and acreage would be determined post-alternative implementation.
Vegetation, Wildlife,	Region A and B: Exposure of mudflats and barren soils during the spring months could result in minor effects to native habitats by	In Region A, update and implement Invasive Plant Management Plan for the shoreline at	Recruitment of native plant communities in wetlands and

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Resource	Impact	Proposed Mitigation Action	Effects After Mitigation
Wetlands & Floodplains	establishment of non-native, invasive plant species.	Libby. Region B mitigation includes habitat for fish mitigation (see Resident Fish)	floodplains to preclude establishment of non-native plants.
Vegetation, Wildlife, Wetlands & Floodplains	Region A: Conversion of wetland to upland habitat in May through summer months (off-channel habitat) has adverse effects on wildlife phenology and fecundity (inverts, amphibian eggs, flycatchers, bats). Effects are minor and would occur seasonally.	On Kootenai River downstream of Libby: Plant native wetland and riparian vegetation up to ~100 acres along river.	This mitigation measure, when considered with the existing Bonneville-funded Kootenai River Habitat Restoration Program, would minimize any negative effects to negligible
Navigation & Transportation	Region B: Inchelium-Gifford Ferry (transportation for Tribal community of Inchelium) will go out of service for longer durations and isolate community members. This could be a moderate adverse effect that results in public safety concerns.	Extend the ramp at the Inchelium-Gifford Ferry on Lake Roosevelt so that it is available at lower water elevations.	Extending the ramp would eliminate additional effects to the community, potentially beneficial effect from the No Action condition. There would be no effects to public safety or environmental justice with this mitigation measure.
Cultural Resources	Region A and B: Major adverse effects from increase in number of acre-days that archaeological resources would be exposed.	Use the Cultural Resource Program funding for activities such as resource monitoring (pedestrian and drone use), reservoir and river bank stabilization, data recovery, public education awareness, protective signage, and other alternative mitigation to address impacts to TCPs.	This mitigation measure, when considered with the existing FCRPS Cultural Resource Program in addition to this measure, would work to continue minimizing any negative effects to negligible.

756 **5.4.2 Mitigation Measures Proposed for Multiple Objective Alternative 2**

757 The mitigation measures proposed for MO2 address impacts to water quality, resident fish,
758 vegetation, wildlife, wetlands, and floodplains, navigation and transportation, recreation, and
759 cultural resources. These impacts are described fully in Chapter 3, Chapter 4, and Chapter 6.
760 There would be no adverse impacts requiring additional mitigation for flood risk management,
761 visual aesthetics, noise, or water supply, as there are no to negligible effects as compared to
762 the No Action Alternative. Power and Transmission overall would experience major beneficial
763 effects from MO2, and would not require mitigation for this resource. Impacts to cultural
764 resources would be addressed by continuing to implement the existing Cultural Resource
765 Program discussed in Section 5.2.1.6.

766 **5.4.2.1 Water Quality**

767 The co-lead agencies are proposing mitigation in Region A for MO2 for impacts to water quality.
768 Effects to water quality in Regions B, C, and D are minor adverse effects that would not result in
769 measurable differences to water quality within the study area. As a result, no additional
770 mitigation is proposed in Region B, C, and D.

771 In Region A, the effects to water quality are negligible to minor adverse. The co-lead agencies
772 propose to continue supplementing nutrients, nitrogen, and phosphorous at Libby and to
773 initiate a similar nutrient supplementation program at Hungry Horse to aid in replacing primary
774 and secondary biological productivity that result from reservoir drawdowns and higher flushing
775 rates. A similar program is currently implemented at Dworshak with success, improving overall
776 reservoir productivity. In addition to impacts to water quality, the benefits from this mitigation
777 action would support resident fish populations, including ESA-listed bull trout. Monitoring and
778 adaptive management actions would be necessary to ensure nutrients do not become
779 imbalanced, which could lead to harmful algal blooms that dominate the system.

780 **5.4.2.2 Anadromous Fish**

781 The co-lead agencies are not proposing any mitigation measures in Regions A, B, C, or D to
782 mitigate for impacts to anadromous fish. There are no anadromous fish above Chief Joseph
783 Dam in Regions A and B. In Regions C and D, the measures implemented as part of MO2 could
784 have minor beneficial to moderate adverse effects, predicated on the differing modeling
785 results. Ongoing programs for anadromous fish in Regions B (below Chief Joseph dam), C, and D
786 would continue, including habitat projects and fish hatchery programs for salmon and
787 steelhead discussed above in Section 5.2.1.

788 **5.4.2.3 Resident Fish**

789 Under MO2, the co-lead agencies propose additional mitigation measures in Region A at
790 Bonners Ferry, Idaho, and at tributaries on Hungry Horse Reservoir. In Region B, C, and D, the
791 co-lead agencies do not expect a perceptible change to habitat conditions and measures would

792 have negligible effects. No additional mitigation is proposed in Region B, C, and D. Ongoing
793 programs for resident fish in Regions A, B, C, and D would continue, including projects and fish
794 hatchery programs for westlope cutthroat trout, kokanee salmon and rainbow trout discussed
795 above in Section 5.2.1.

796 In Region A, the co-lead agencies propose planting cottonwood trees at Bonner's Ferry, Idaho,
797 similar to the proposal under MO1, to improve habitat and floodplain connectivity to benefit
798 ESA-listed Kootenai River White Sturgeon and bull trout. Similar to the proposed mitigation for
799 vegetation, wildlife, wetlands, and floodplains, expanding the quantity and distribution of
800 wetland habitats and increasing floodplain connectivity along the Kootenai River could help
801 address seasonal impacts at Bonners Ferry from the *December Libby Target Elevation* measure.
802 High winter levels could decrease the recruitment and long-term survival of cottonwood trees
803 adjacent to the river when seeds and saplings are swept downstream during winter flows.
804 While implementation of this MO negligibly effects these resources relative to the No Action
805 Alternative, the co-lead agencies propose to plant 1-2 gallon cottonwoods near Bonners Ferry
806 to improve habitat and floodplain connectivity for the benefit ESA-Listed Kootenai River White
807 Sturgeon by providing a food source. This would complement ongoing habitat actions already
808 being taken in the region. This mitigation measure, when considered with the existing
809 Bonneville-funded Kootenai River Habitat Restoration Program, would further minimize any
810 negative effects.

811 Additional mitigation from the ongoing habitat programs carried out in the No Action
812 Alternative proposed by the co-lead agencies to benefit bull trout includes installing structural
813 components like woody debris and vegetation at the mouth of tributaries on the Hungry Horse
814 Reservoir, such as Wounded Buck, Sullivan, Wheeler, and Bunker Creeks, to stabilize channels
815 and increase cover for migrating fish. These actions would improve habitat conditions for bull
816 trout and minimize impacts from fluctuating water levels on the Hungry Horse Reservoir. This
817 mitigation action would also increase the survival of outmigrating juveniles and increase
818 production of terrestrial and aquatic invertebrates. In addition, the construction of bank-
819 channel habitat for juvenile bull trout on the Flathead River would help address impacts to fish
820 and aquatic invertebrates from high winter flows out of Hungry Horse. These measures, when
821 taken collectively across 15 tributaries in the Hungry Horse Reservoir, would help address
822 impacts to ESA-listed bull trout caused by implementing MO2 at Hungry Horse. Considering the
823 existing Bonneville-funded Confederated Salish and Kootenai Tribes and State of Montana
824 programs with this proposed mitigation component, adverse effects are anticipated to be
825 reduced to negligible.

826 In Region B, the co-lead agencies would develop additional spawning habitat at Lake Roosevelt
827 to minimize impacts to resident fish. The co-lead agencies propose to place appropriate gravel
828 for spawning habitat at locations up to 100 acres along reservoir and tributaries. Prior to
829 placement, the co-lead agencies would conduct site surveys post operations of alternative to
830 determine where to site spawning habitat augmentation at Lake Roosevelt for burbot, kokanee,
831 and redband rainbow trout is needed for construction of spawning habitat. This would build on

832 the 2019 program Bonneville funded, already in year one of a three year study to determine if
833 modifications in Lake Roosevelt refill would impact resident fish access to spawning habitat.

834 **5.4.2.4 Vegetation, Wildlife, Wetlands, and Floodplains**

835 Under MO2, the co-lead agencies propose to implement additional mitigation measures in
836 Region A to offset impacts to vegetation, wildlife, wetlands, and floodplains. No additional
837 mitigation measures are proposed for Regions B, C, and D as the measures in MO2 would not
838 result in measurable or perceptible changes to habitat conditions, and have negligible to minor
839 effects. These negligible effects to vegetation, wildlife, wetlands, and floodplains do not
840 warrant mitigation. However, ongoing actions for impacts to vegetation and wildlife in Regions
841 A, B, C, and D would continue as under No Action Alternative, including protection and
842 enhancement of wildlife habitat as described in Section 5.2.1.

843 In Region A, mitigation measures would help address impacts to vegetation and wildlife habitat
844 from implementing the *December Libby Target Elevation* measure. This measure potentially
845 decreases quality and quantity of wetland habitats in Libby and Hungry Horse Reservoirs by
846 decreasing water surface elevations and increasing the establishment of invasive species by
847 increasing the quantity and distribution of mudflats and duration of exposure. As a result of
848 these changes, invasive species could spread and become established in new or larger areas
849 throughout the reservoirs. To address this potential effect, the co-lead agencies would prepare
850 invasive species and pest management plans where they do not currently exist or update the
851 existing invasive species management plans and implement the plans where warranted.

852 Downstream of Libby Dam, lower water levels on the Kootenai River during the growing season
853 would affect the quality and quantity of forested and scrub-shrub wetlands adjacent to the
854 river. To help mitigate existing wetlands being converted to drier, upland habitat types, the co-
855 lead agencies propose planting approximately 100 acres of forested and scrub-shrub wetland
856 vegetation. This mitigation measure, when considered with the existing Bonneville-funded
857 Kootenai River Habitat Restoration Program, would minimize any negative effects to negligible.
858 This expansion of wetland habitats along the Kootenai River would also help ameliorate
859 seasonal impacts at Bonners Ferry, Idaho.

860 **5.4.2.5 Navigation and Transportation**

861 The co-lead agencies are not proposing any mitigation measures in Regions A, C, and D under
862 MO2 for navigation and transportation because the measures implemented as part of this
863 alternative would have negligible effects on these resources.

864 Similar to MO1, the Inchelium-Gifford Ferry in Region B would go out of service for longer than
865 the No Action Alternative durations when operational measures at Grand Coulee draft the
866 reservoir deeper. To help ameliorate effects to the tribal community at Inchelium, including
867 their ability to reach emergency and medical services and supplies, the co-lead agencies
868 propose extending the ramp at the Inchelium-Gifford Ferry so that it is available at lower water

869 elevations in Lake Roosevelt. This would reduce the effects to negligible effects, and may be
870 moderately beneficial comparative when compared to the No Action Alternative.

871 **5.4.2.6 Recreation**

872 The co-lead agencies are not proposing any mitigation measures in Regions A, B, and D under
873 MO2 for recreation as the measures implemented as part of this alternative would have
874 negligible effects on this resource.

875 In Region C, the co-lead agencies propose mitigation to offset impacts to recreation at
876 Dworshak State Park near Freeman Creek in Idaho. The *Slightly Deeper Draft for Hydropower*
877 measure implemented under MO2 to increase flexibility in power generation would lower
878 water levels in April when this park facility is used by hunters and sport fishers. The boat ramp
879 becomes inaccessible at lower water levels in April at the beginning of turkey hunting season
880 and bass fishing season. Terrain and road access make the Dworshak State Park one of the most
881 heavily used boat ramps in the middle reservoir area outside of the traditional (i.e., summer
882 and fall) recreation seasons. To offset these moderately adverse effects to recreational hunters
883 and fishers, the co-lead agencies propose extending the boat ramp approximately 26 feet to
884 maintain access to the reservoir during the early spring.

885 **5.4.2.7 Cultural Resources**

886 In Region A, B, and C, there could be moderate to major adverse effects to cultural resources
887 from an increase in number of acre-days that archaeological resources would be exposed.
888 Region A, B, and C the Cultural Resource Program funding would be increased for activities such
889 as archeological site and traditional cultural property monitoring (pedestrian and drone use),
890 reservoir and river bank stabilization, data recovery, public education awareness, protective
891 signage, and other alternative mitigation to address impacts to TCPs. This mitigation measure,
892 when considered with the existing FCRPS Cultural Resource Program, would work to continue
893 minimizing any negative effects to negligible (Table 5-2).

894 **Table 5-2. Mitigation Summary of MO2**

Resource	Impact	Proposed Mitigation Action	Effects After Mitigation
Water Quality	Region A: At Hungry Horse, the drawdown in summer impacts primary and secondary biological productivity that result from reservoir drawdowns and higher flushing rates.	Initiate a nutrient supplementation program at Hungry Horse.	This measure would improve the food source and reduce adverse effects to negligible.
Resident Fish – ESA Kootenai River White Sturgeon	Region A: The current flow regime at Libby has made establishment of riparian vegetation difficult to sustain young stands of cottonwoods - major contributors to the food web for Sturgeon. This results in moderate localized adverse effects. While this MO would not exacerbate these impacts in the No Action, it is an ongoing problem.	Plant 1-2 gallon cottonwoods near Bonners Ferry to improve habitat and floodplain connectivity, which would benefit ESA-Listed Kootenai River White Sturgeon by providing a food source. This would complement ongoing habitat actions already being taken in the region.	This mitigation measure, when considered with the existing Bonneville-funded Kootenai River Habitat Restoration Program, would minimize any negative effects to negligible.
Resident Fish – ESA Bull Trout	Region A: Drawdowns cause low water elevations at time of Bull Trout migration, which could make it difficult to enter spawning tributaries and make Bull Trout more susceptible to angling/predation. Negligible to Moderate adverse impact.	On the Hungry Horse Reservoir, install structural components like woody debris, and plant vegetation at the tributaries (Sullivan and Wheeler Creeks, possibly more) to stabilize the channels, increase cover for migrating fish, and improve the varial zone.	This mitigation measure, when considered with the existing Bonneville-funded Confederated Salish and Kootenai Tribes and State of Montana programs, minimizes any negative effects to negligible.
Resident Fish - Burbot, Kokanee, and Redband Rainbow Trout	Region B: Changes in elevation would leave current habitat dewatered and expose new potential areas appropriate for developing additional gravel spawning habitat.	Develop additional spawning habitat at Lake Roosevelt to minimize impacts to resident fish. Determine post-operations where to site spawning habitat augmentation at Lake Roosevelt for burbot, kokanee, and redband rainbow trout to inform where mitigation is needed. Place appropriate gravel (spawning habitat) at locations up to 100 acres along reservoir and tributaries.	This action is in addition to the Bonneville program that addresses current habitat restoration in Lake Roosevelt and would compensate for additional effects of the new action. Exact acreage would be determined post-implementation.

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Resource	Impact	Proposed Mitigation Action	Effects After Mitigation
Vegetation, Wildlife, Wetlands & Floodplains	Region A: Conversion of wetland to upland habitat in May through summer months (off-channel habitat) has adverse effects on wildlife phenology and fecundity (inverts, amphibian eggs, flycatchers, bats). Effects are minor and would occur seasonally.	On Kootenai River downstream of Libby: Plant native wetland and riparian vegetation up to ~100 acres along river.	This mitigation measure, when considered with the existing Bonneville-funded Kootenai River Habitat Restoration Program would minimize any negative effects to negligible.
Vegetation, Wildlife, Wetlands & Floodplains	Region A and B: Exposure of mudflats and barren soils during the spring months could result in minor effects to native habitats by establishment of non-native, invasive plant species.	In Region A, update and implement Invasive Plant Management Plan for the shoreline at Libby. Region B mitigation includes habitat for fish mitigation (see Resident Fish).	Recruitment of native plant communities in wetlands and floodplains to preclude establishment of non-native plants.
Navigation & Transportation	Region B: Inchelium-Gifford Ferry (transportation for Tribal community of Inchelium) will go out of service for longer durations and isolate community members. This would be a moderate adverse effect that results in public safety concerns.	Extend the ramp at the Inchelium-Gifford Ferry on Lake Roosevelt so that it is available at lower water elevations.	Extending the ramp would eliminate additional effects to the community, potentially beneficial effect from the No Action condition. There would be no effects to public safety or environmental justice with this mitigation measure.
Recreation	Region C: Changes in water levels would make the Dworshak State Park (Freeman Creek) boat ramp inaccessible for 30 days in the month of April, the start of turkey hunting season and early bass fishing season. Because of the steep terrain and limited road access at Dworshak, this boat ramp is heavily used by recreators, especially hunters and fishermen, outside of the traditional recreation season. The alternative results in minor impacts to recreation.	Extend the boat ramp at Dworshak State Park (Freeman Creek) to make it accessible in April, when it is used by hunters and fishermen.	The extension of the Dworshak State Park boat ramp would eliminate the impact to boat ramp users.
Cultural Resources	Region A and B: Major adverse effects from increase in number of acre-days that archaeological resources would be exposed.	Region A, B, and C increase Cultural Resource Program funding for activities such as resource monitoring (pedestrian and drone use), reservoir and river bank stabilization, data recovery, public education awareness, protective signage, and other mitigation to address impacts to TCPs.	This mitigation measure, when considered with the existing FCRPS Cultural Resource Program, in addition to this measure would work to continue minimizing any negative effects to negligible.

896 **5.4.3 Mitigation Measures Proposed for Multiple Objective Alternative 3**

897 The mitigation measures proposed for MO3 address impacts to water quality, anadromous and
898 resident fish, vegetation, wildlife, wetlands, and floodplains, navigation and transportation,
899 cultural resources and public safety. These effects are described fully in Chapter 3, Chapter 4,
900 and Chapter 6. No mitigation is proposed for flood risk management or noise, as effects are
901 negligible. While effects to power and transmission, water supply and navigation are major
902 adverse effects, no feasible mitigation has been identified. In some cases, mitigation can be
903 completed by public and private entities. Recreation would major adverse effects; however
904 change in types of usage would alleviate some of these effects. Cultural resources in Region C
905 would experience a major adverse effect. In Region D, mitigation is proposed using the existing
906 PA; however, a new programmatic agreement with Tribes would be required to carry out 106
907 responsibilities on the lower Snake River properties in the interim, until such a time that the
908 deauthorized project lands are transferred to new ownership. These real-estate transactions
909 would require their own review and are outside the scope of this EIS. They would be initiated
910 concurrent with the engineering and design work for implementing the breaching actions.

911 **5.4.3.1 Water Quality**

912 The co-lead agencies are not proposing any mitigation measures in Regions A, B, or D to
913 mitigate for impacts under MO3 for impacts to water quality because the measures
914 implemented as part of this alternative would have negligible effects, the severity of impact is
915 low, and the effect would occur infrequently. Several mitigation actions would be taken by the
916 co-lead agencies to further define sediment and dissolved oxygen effects in Region C for the
917 time of dam removal and up to 7 years while the system flushes sediments and stabilizes. A few
918 additional mitigation actions are recommended to be taken by other entities prior to breaching
919 actions, as described below.

920 Because of limited data to determine the exact magnitude of water quality impacts from
921 breaching the dams on the lower Snake River, effects in Chapter 3 are described as a range
922 from low to most severe anticipated scenarios. If MO3 is selected for implementation,
923 additional data collection and monitoring would be required during engineering and detailed
924 project design, including sediment sampling and analysis to determine sediment oxygen
925 demand, monitoring of the bio-accumulation of contaminants in sediment and fish tissues, and
926 any potential hazard for human health. The co-leads would conduct these studies to investigate
927 more accurately the impacts of water quality and specifically, dissolved oxygen to aquatic
928 organisms and fish. The co-lead agencies would coordinate with state and Federal resource
929 agencies to determine the best way to minimize any impacts to water quality. Some potential
930 options could include aeration, dilution from upstream sources (e.g., the North Fork Clearwater
931 River), or chemical treatment (e.g., peroxide dosing). During the design phase, timing of the
932 dam breaching would be coordinated with the U.S. Fish and Wildlife Service and NMFS, and
933 other regulatory agencies, to determine the appropriate work window to minimize
934 construction-related effects for water quality and fish. If necessary, a tiered NEPA document

935 would be prepared to disclose any impacts not contained within this EIS and site-specific
936 impacts associated with the construction (removal) of the dam infrastructure.

937 Additionally, several mitigation actions are recommended to be carried out by others with
938 responsibilities and authorities to remediate contaminated sediments and ground water. These
939 contaminants are not caused by the actions taken by the co-lead agencies, but could be
940 mobilized by implementing MO3. The co-lead agencies identified the potential re-suspension of
941 contaminated sediments in Region C that contain bioaccumulative compounds such as dioxins,
942 pesticides, mercury, and others. The suspension and downstream deposition of contaminated
943 sediments could expose fish and invertebrate populations to new, higher levels of
944 contaminants for several years following implementation. The co-lead agencies do not have
945 authorities for removing in-stream contaminated sediments, and have not identified a feasible
946 way to avoid mobilization. To offset this impact and any associated impacts to bioaccumulation
947 in fish and other aquatic species, other entities could remove or cap contaminated sediment
948 “hot spots” in lower Snake River prior to implementing the *Breach Snake Embankments*
949 measure.

950 In addition to contaminated sediments, the co-lead agencies identified there would be effects
951 to groundwater flows from changes in river flow and substantial decreases in reservoir
952 elevations in Region C. Combined, this could cause movement from polluted sources of
953 groundwater near Lewiston, Idaho. The movement of groundwater could pollute neighboring
954 systems and potentially enter the lower Snake River. If this is selected as the Preferred
955 Alternative, prior to implementing the *Breach Snake Embankments* measure, the co-lead
956 agencies would recommend responsible entities of contaminated groundwater sources provide
957 the following one or more mitigation measures: installing groundwater cutoff walls or
958 treatment curtains along areas of known groundwater contamination, pumping and treating
959 groundwater to prevent flows from entering the river, and/or remediating known
960 contamination areas. Additional actions include redefining National Pollutant Discharge
961 Elimination System permits. Containing or remediating contaminated groundwater areas would
962 reduce polluted inputs into lower Snake River following implementation of MO3, and any
963 associated impacts to fish and other aquatics, wildlife, and public safety.

964 **5.4.3.2 Anadromous Fish**

965 The co-lead agencies are not proposing any mitigation measures in Regions A or B for impacts
966 to anadromous fish because there are no anadromous fish in Regions A or B. As described
967 below, mitigation measures are proposed for Regions C for MO3 for short-term impacts.
968 Monitoring for real time operations adjustments is proposed in Region D because for minor
969 effects to anadromous fish in this region. Ongoing actions for impacts to anadromous fish in
970 Regions B (below Chief Joseph Dam), C and D would continue as under No Action Alternative,
971 including habitat and hatchery projects as described in Section 5.2.1.

972 In Region C, the co-lead agencies propose constructing a new trap and haul facility at McNary
973 and conduct at least two years of trap-and-haul operations for Snake River fish (Chinook
974 salmon, Sockeye, Steelhead) to allow removal and transport of these fish from the lower Snake

975 River prior to implementing the *Breach Snake Embankments* measure. Removing the dam
976 embankments would result in temporary however major adverse effects to water quality,
977 including high levels of turbidity and suspended sediments between Lower Granite and Ice
978 Harbor. Fish collected at trap and haul facilities would be transported by truck to a release
979 point upstream of the affected area. While the effect of this mitigation measures does not
980 offset the impact of degraded water quality conditions that directly impact in-river survival of
981 fish during the initial phase of implementation, or aid other non-listed fish or aquatic organisms
982 adversely affected by MO3, the mitigation measure reduces the number of targeted fish
983 impacted by the alternative.

984 Additionally, the co-lead agencies propose raising additional hatchery fish to offset two lost
985 year classes prior to start of breach on the Lower Snake River. The timing of dam breaching
986 would occur during migration for Snake River Chinook, upper Columbia River fall Chinook, and
987 upper Snake River sockeye, which could result in the mortality of 20 to 40 percent of these
988 populations. Low concentrations of dissolved oxygen would impact survival of fish at Little
989 Goose and Lower Monumental during the first phase of demolition, potentially removing an
990 entire generation or year class of migrating Snake River fall Chinook and upper Snake River
991 sockeye from the system. These additional hatchery fish should provide a safety replacement of
992 those populations potentially adversely affected during the short-term construction.

993 In Region D, concentrations of TDG could increase as a result of spill measures implemented as
994 part of MO3. If it is observed that conditions in the tailrace are impeding upstream passage of
995 adult salmon and steelhead or actionable TDG impacts to fish are observed, the co-lead
996 agencies would implement performance standard spill operations until the situation is
997 remedied. These real-time decisions are made in the Regional Forum. These operations are of
998 short duration, as needed, to resolve the passage issues.

999 **5.4.3.3 Resident Fish**

1000 Under MO3, the co-lead agencies propose mitigation measures in Region A at Bonners Ferry,
1001 Idaho along the Kootenai River and at Hungry Horse. In Region B, mitigation is proposed in Lake
1002 Roosevelt. In Region C, mitigation for impacts to fish access to mouths of Tucannon Tributary
1003 due to short-term impacts to both resident and anadromous species is proposed. No mitigation
1004 is proposed in Region D because implementing MO3 results in minor effects to resources, and
1005 the effect does not rise to the level of severity warranting mitigation. Ongoing actions as
1006 described in Section 5.2.1 for resident fish, such as bull trout and sturgeon in Regions A, B, C,
1007 and D, would continue.

1008 In Region A, the co-lead agencies propose actions similar to the proposed mitigation measures
1009 for MO1 and MO2. Specifically, planting cottonwoods along the Kootenai River at Bonners Ferry
1010 would mitigate adverse effects to ESA-listed Kootenai River white sturgeon from the loss of
1011 wetland habitat and floodplain connectivity. In addition, installing structural components like
1012 woody debris and planting vegetation around the upper 10 feet of the reservoir and at the
1013 mouths of spawning tributaries would stabilize the channels, increase cover for migrating fish,
1014 and improve habitat conditions to offset impacts to resident fish, including ESA-listed bull trout,

1015 from reservoir fluctuations, seasonal drawdowns, and fewer days at full pool, which collectively
1016 result in a reduction in habitat quality and benthic productivity supporting the food web at
1017 Hungry Horse. This mitigation measure, when added with the existing Bonneville-funded
1018 Kootenai River Habitat Restoration Program, would minimize any adverse effects to negligible.

1019 To offset effects to bull trout in the Hungry Horse Reservoir, the co-lead agencies propose a
1020 mitigation measure to improve habitat conditions for bull trout. MO3 lowers water surface
1021 elevations in the reservoir and increases summer outflows. As reservoir elevations decline, fish
1022 passage conditions at the mouth of spawning tributaries prohibit fish migration into spawning
1023 tributaries. Under these conditions, bull trout are more susceptible to angling and predation
1024 pressures due to a lack of sufficient cover while they hold until conditions are passable. This
1025 also causes delays in migration which result in an overall decrease in productivity. To mitigate
1026 these effects, the co-lead agencies propose installing structural components like woody debris
1027 and vegetation at the mouth of tributaries, such as Wounded Buck, Sullivan, Wheeler, and
1028 Bunker Creeks, to stabilize channels and increase cover for migrating fish. These actions would
1029 improve habitat conditions for bull trout and minimize impacts from fluctuating water levels on
1030 the reservoir. This mitigation action could also increase the survival of outmigrating juveniles
1031 and increase production of terrestrial and aquatic invertebrates. Considering the existing
1032 Bonneville-funded Confederated Salish and Kootenai Tribes and State of Montana programs
1033 with this proposed mitigation component, adverse effects are anticipated to be reduced to
1034 negligible.

1035 In Region B, the co-lead agencies would develop additional spawning habitat at Lake Roosevelt
1036 to minimize impacts to resident fish. The co-lead agencies propose to place appropriate gravel
1037 for spawning habitat at locations up to 100 acres along reservoir and tributaries. Prior to
1038 placement, the co-lead agencies would conduct site surveys post operations of the alternative
1039 implementation to determine where to site spawning habitat augmentation at Lake Roosevelt
1040 for burbot, kokanee, and redband rainbow trout is needed for construction of spawning
1041 habitat. This would build on the 2019 program Bonneville funded, already in year one of a three
1042 year study to determine if modifications in Lake Roosevelt refill would affect resident fish
1043 access to spawning habitat.

1044 In Region C, the co-lead agencies propose modifying the channel at the mouth of the Tucannon
1045 River, a tributary of the Snake River, to offset adverse impacts to upstream fish passage
1046 following implementation of the *Breach Snake Embankments* measure. Implementing this
1047 measure, in associated with other measures in MO3, would disconnect the Tucannon River
1048 from the Snake River until high flows create a stable, fish passable channel for bull trout. To
1049 mitigate for this temporary loss of connectivity, the co-lead agencies propose constructing a
1050 channel to support year-round connectivity at the confluence of the two rivers during bull trout
1051 migration.

1052 Prior to implementing the *Breach Snake Embankments* measure, the co-lead agencies propose
1053 mitigating effects to bull trout and white sturgeon on the Snake River from a temporary
1054 adverse effect, but with long-lasting consequences. MO3 would reduce forage fish and

1055 invertebrates resulting from poor water quality during and immediately after dam breaching.
1056 Dam breaching would create lethal concentrations of suspended sediments, turbidity, and low
1057 dissolved oxygen between Lower Granite and Ice Harbor, resulting in widespread loss of white
1058 sturgeon, the forage fish they feed on, and other aquatic organisms. To mitigate for these
1059 effects to white sturgeon, the sturgeon would be trapped in the lower Snake River and
1060 relocated upriver to Hells Canyon or locations below McNary on the Columbia River. For
1061 avoiding adverse effects to bull trout, their abundance in the lower Snake River is low after fall
1062 migration. Implementation of the *Breach Snake Embankments* measure would be coordinated
1063 to occur during low water conditions in the fall and winter to minimize adverse effects to this
1064 species.

1065 **5.4.3.4 Vegetation, Wildlife, Wetlands, and Floodplains**

1066 Under MO3, the co-lead agencies propose to implement mitigation measures in Regions A, C,
1067 and D to offset adverse effects to vegetation, wildlife, wetlands, and floodplains. No mitigation
1068 measures are proposed for Region B because implementing measures associated with MO3
1069 would result in negligible impacts to these resources. In Region A, the *December Libby Target*
1070 *Elevation, Modified Draft at Libby*, and *Sliding Scale at Libby and Hungry Horse* measures affect
1071 seasonal water surface elevations. In Regions C and D, the *Breach Snake Embankments* and
1072 *Increased Forebay Range Flexibility* measures influence water surface elevations and result in
1073 changes to vegetation and habitat conditions. Many of the major adverse effects are short-
1074 term, with long-term negligible effects to both major beneficial and major adverse effects in
1075 Region C. Ongoing actions for impacts to vegetation and wildlife in Regions A, B, C, and D would
1076 continue as under No Action Alternative, including protection and enhancement of wildlife
1077 habitat as described in Section 5.2.1.

1078 In Region A, mitigation measures would mitigate effects to vegetation and wildlife habitat from
1079 implementing the *December Libby Target Elevation* measure. This measure potentially
1080 decreases quality and quantity of wetland habitats in Libby by decreasing water surface
1081 elevations and increasing the establishment of invasive species by increasing the quantity and
1082 distribution of mudflats and duration of exposure. As a result of these changes, invasive species
1083 could spread and become established in new or larger areas throughout the reservoir. To
1084 address this potential effect, the co-lead agencies would prepare invasive species and pest
1085 management plans where they do not currently exist or update the existing invasive species
1086 management plans and implement the plans where warranted.

1087 The *Modified Draft at Libby* and *Sliding Scale at Libby and Hungry Horse* measures would result
1088 in a conversion of wetland habitats to upland habitats along the Kootenai River from a seasonal
1089 decrease in water surface elevations. To offset this impact, the co-lead agencies propose
1090 planting approximately 100 acres of native wetland vegetation along the Kootenai River to
1091 restore wetland habitats similar to the proposals described under MO1.

1092 Breaching the four lower Snake River dams would significantly decrease water surface
1093 elevations on the lower Snake River, as well as mobilize sediments to deposit in downstream
1094 portions of the river channel and along the shoreline. These actions would have a major

1095 adverse effect to existing upland, wetland, and aquatic vegetation, reducing the quality,
1096 quantity, and distribution of habitats in Region C. To offset these effects, mitigation proposed
1097 would be to replant approximately 13,000 acres of arid, upland native vegetation on newly
1098 exposed soils and approximately 1,500 acres of emergent and forested, scrub-shrub wetland
1099 habitat adjacent to the new surface elevations of the lower Snake River.

1100 Additionally, in Region D the co-lead agencies propose approximately 155 acres of emergent
1101 and forested scrub-shrub wetland habitats on the Columbia River downstream of the
1102 confluence with the Snake River would be planted to comply with CWA regulations. On the 155
1103 acres, newly deposited sediments would be excavated to maintain the hydrologic conditions
1104 necessary to support wetland habitats. Twenty-three of the 155 acres would be planted with
1105 wetland vegetation. For consideration of mitigation to cultural resources, the planting plans
1106 would be developed to incorporate proposed tule (*Schoenoplectus acutus*) restoration and
1107 other culturally significant vegetation. The plant list used for restoration activities would be the
1108 existing list developed through coordination with regional tribes under the existing Cultural
1109 Resource Program.

1110 **5.4.3.5 Navigation and Transportation**

1111 MO3 would result in moderate to major effects to navigation and transportation in Regions B
1112 and C.

1113 In Region B, the Inchelium-Gifford Ferry would be out of service two additional days in the wet
1114 years than the No Action Alternative. While this is a minor change, limiting access to medical
1115 and emergency service is a significant risk. The co-lead agencies propose extending the ramp at
1116 the Inchelium-Gifford Ferry to provide service at lower water elevations on Lake Roosevelt,
1117 similar to what is proposed for MO1 and MO2.

1118 In Region C, MO3 would result in a complete loss of commercial navigation on the lower Snake
1119 River. Conditions on the lower Snake River after implementing the *Breach Snake Embankments*
1120 measure would not support commercial navigation, and could not be feasibly mitigated. Other
1121 entities could take actions and/or build infrastructure to change their transportation modes or
1122 connect to the navigation system at a different point on the river.

1123 In Region D, at the confluence of the lower Snake River as described in the River Mechanics
1124 Section 3.3.3.5, there would be increased sediment passing from the lower Snake River into
1125 the Columbia River. During the two year construction period, beginning with breaching and
1126 drawdown of the upper two projects, modeling indicates that sediment volumes and
1127 concentrations passing out of the lower Snake River would be elevated immediately following
1128 draw-down, and for the two years that follow as the system transitions from reservoirs to run
1129 of river. After the near-term period, there would be an estimated period of two to seven years
1130 where lower Snake River would continue moving higher volumes of sediment. Over the long-
1131 term the lower Snake River is expected to eventually reach a new quasi-equilibrium condition
1132 and largely pass incoming sediment loads. This sediment load will cause a short term major
1133 adverse effect to the navigation channel.

1134 Based upon these changing sediment patterns and timing, dredging operations within the
1135 McNary pool (Wallulla Reservoir) and at the confluence of the lower Snake River would need to
1136 increase substantially to keep the channel operational. . Sediment relocation and deposition is
1137 expected to occur within the federal navigation channel and on the left bank of Lake Wallulla.
1138 The mitigation proposal is to dredge to maintain this reach of the federal navigation channel.
1139 Likewise, public and private port facilities both near the confluence of the lower Snake River
1140 and on the left bank of Lake Wallulla would need to conduct sequential dredging in order to
1141 avoid interruptions in service and maintain access to the navigation channel. Dredging
1142 mitigation for maintaining the federal navigation channel would be a Corps expense, while
1143 dredging to maintain port facilities and access to the federal navigation channel would not.

1144 Dredging operations are expected to remain similar to No Action in the remaining reach of the
1145 Columbia navigation channel.

1146 **NON-FEDERAL TRANSPORTATION INFRASTRUCTURE**

1147 In evaluating the feasibility of implementing MO3 and breaching the four dams on the lower
1148 Snake River, the co-lead agencies also evaluated impacts to transportation infrastructure not
1149 associated with the Federal projects, but crucial infrastructure for the region. The following is a
1150 brief description of additional actions that would be needed to mitigate effects on regional
1151 transportation infrastructure.

1152 Bridge piers on the lower Snake River would experience a permanent change in water velocity,
1153 and higher seasonal flows would increase scour and cause erosion around bridge piers. The co-
1154 lead agencies propose armoring piers of up to 25 bridges to protect them from increased
1155 erosion due to the *Breach Snake Embankments* measure.

1156 In addition to bridge piers, approximately 80 miles of railroad and highway embankments
1157 would need to be armored to protect them from erosion resulting from higher water velocities
1158 and higher flows through existing drainage structures and culverts. Of the 80 miles identified,
1159 approximately 45 miles are constructed of engineered fill which would be exposed to river
1160 flows at lower river elevations. These locations are the highest risk for failure, posing a risk to
1161 public safety, and would require additional evaluation to identify the appropriate modification
1162 to maintain stability.

1163 **5.4.3.6 Recreation**

1164 Although moderate effects are anticipated to recreation resources in Region C, the co-lead
1165 agencies are not proposing any mitigation for recreation with implementation of MO3. In
1166 Regions A, B, and most of D, measures implemented as part of this alternative would have
1167 negligible effects on this recreational resource and no mitigation is warranted.

1168 In Region C and upper reach of Region D, major adverse effects to water based recreation and
1169 water accessibility would occur. Existing recreational activities in the lower Snake River would
1170 transition from lake to river recreation following implementation of the *Breach Snake*
1171 *Embankments* measure under MO3. As a result of this measure, water surface elevations on the

1172 lower Snake River and extending into the Columbia River confluence would drop significantly,
1173 disconnecting boat ramps from the river at Lower Granite, Little Goose, Lower Monumental,
1174 and Ice Harbor. Sediment deposition in the lower portion McNary Reservoir would decrease
1175 accessibility to existing marinas, parks, and access channels in Lake Wallula. While overall
1176 beneficial effects would occur for those activities related to river and faster flowing water-
1177 activities, reservoir-type activities would cease. The major adverse effects to recreation are
1178 from lack of boat ramps accessibility from federal lands. The co-lead agencies would no longer
1179 operate project lands for recreation after the projects are de-authorized. Recreational sites
1180 could be modified in the future as project land is transferred through real estate actions. In
1181 other areas below Ice Harbor bordering the Region C and D, local entities could extend public
1182 boat ramps to maintain water accessibility.

1183 **5.4.3.7 Water Supply**

1184 In Region C, and potentially Region D around the confluence of the lower Snake River, MO3
1185 would have adverse effects to incidental irrigation. Currently and in the No Action Alternative,
1186 water is available from the pools of these facilities and from groundwater that results from the
1187 pools. The pumps that supply this water would no longer be operational once the dams were
1188 breached. The effect is nearby groundwater elevations could be substantially impacted.
1189 Additionally, M&I pumps in the Lewiston area would also likely be adversely effected, along
1190 with other small M&I uses along the river, as groundwater would have the potential to drop by
1191 the entire height of the dams, i.e., up to 100 feet. This would affect all well users in the region.
1192 Chapter 3 analyzes the social and economic effects of implementing this measure. The co-lead
1193 agencies would not mitigate for these impacts to water users. However, private and public
1194 entities could extend intake pumps, ground water wells, or other infrastructure. .

1195 **5.4.3.8 Cultural Resources**

1196 In Region A, there is a moderate to major adverse effects to cultural resources from an increase
1197 in number of acre-days that archaeological resources would be exposed. In Region A, an
1198 increase Cultural Resources Program funding for activities such as archeological site and
1199 traditional cultural property monitoring (pedestrian and drone use), reservoir and river bank
1200 stabilization, data recovery, public education awareness, protective signage, and other
1201 mitigation is proposed to address impacts to TCPs. This mitigation measure, when considered
1202 with the existing FCRPS Cultural Resource Program, would work to continue minimizing any
1203 negative effects to negligible.

1204 In Regions B, no additional mitigation, as compared to the No Action Alternative, is proposed
1205 and the existing Cultural Resource Program and System-wide PA would continue to be
1206 implemented.

1207 In Region C, there would be major adverse effects to cultural resources due to an extensive
1208 increase in the archeological resources that would be exposed as part of dam breaching.
1209 Following implementation of the *Breach Snake Embankments* measure, over 350 known
1210 cultural resources would be exposed or accessible after the reservoirs on the lower Snake River
1211 are drawn down. The scale of protecting and monitoring these sites, as well as recovering data,
1212 would exceed the existing Cultural Resource Program. Given this, the co-lead agencies would

1213 prepare and implement a new programmatic agreement to avoid, minimize, and mitigate
1214 impacts to these locations, sites, and resources.

1215 Mitigation specific to dam breaching would include law enforcement patrols of exposed areas
1216 along 150 river miles to deter looting until vegetation is re-established, reseeding 14,000 acres
1217 with native species, irrigation to stimulate plant growth in 10 locations, archaeological
1218 monitoring of exposed sites to identify issues that need quick remediation, and conducting
1219 Section 106 of the NHPA compliance activities. The new PA would cover activities for an interim
1220 period, up to ten years for cultural resource management, until federal properties are disposed.

1221 Additional mitigation measures proposed in Region C include implementing the Historic
1222 American Building Survey and Historic American Engineering Record programs to document
1223 historic places, infrastructure, and landscape features prior to implementation of MO3
1224 measures associated with dam breaching. During dam breach, security fencing and signs would
1225 be installed to prevent access, a public outreach campaign would be developed and
1226 implemented to document and excavate exposed sites that are in danger of loss, and collect
1227 artifacts for museum curation or repatriation to Tribes under NAGPRA.

1228 In Region D, sediment deposition along the shorelines of the Columbia River in the McNary
1229 Reservoir would affect the distribution of wetland plant communities critical to traditional
1230 cultural practices. For example, tule plant communities in Lake Wallula would be buried due to
1231 sediment deposition following breach of Ice Harbor Dam. This cultural resource would be
1232 unavailable in Lake Wallula for several years until vegetation is reestablished following
1233 implementation of MO3. The co-lead agencies propose implementing mitigation measures
1234 consistent with the existing Cultural Resource Program to restore tule habitat at alternate sites
1235 in Region D as described in the vegetation, wildlife, wetlands, and floodplains section above.

1236 **5.4.3.9 Public Safety**

1237 In evaluating the feasibility of implementing MO3 and breaching the four dams on the lower
1238 Snake River, the co-lead agencies identified additional actions to maintain safety that would be
1239 needed to mitigate effects from changes in river conditions with implementing the *Breach
1240 Snake Embankments* measure. In Region C, gas lines that cross the Snake River near Lyons Ferry
1241 would need to be modified to withstand the higher velocities and scour due to breach. The co-
1242 lead agencies would coordinate these modifications prior to implementing the MO3 breach
1243 (Table 5-3).

1244 **Table 5-3. Mitigation Summary of MO3**

Resource	Impact	Proposed Mitigation Action	Effects After Mitigation
Anadromous Fish	Regions D: Moderate adverse effect from increased spill levels, which create turbulence and eddies below the dams resulting in delays to adult passage.	Temporary extension of performance standard spill levels in coordination with the Regional Forum	Performance Standard Spill is effective in passing adult fish and delays in passage would be negated, resulting in negligible effects.
Anadromous Fish	Region C: Breaching the lower Snake River dams would have major short-term adverse effects. Breaching would create lethal river conditions (turbidity and suspended sediment, low dissolved oxygen) which would cause major effects to Snake River anadromous fish populations in the short-term.	Construct a trap-and-haul facility at McNary and conduct at least two years of trap-and-haul operations for Snake River fish (Chinook salmon, Sockeye, Steelhead) to allow removal and transport of these fish from the lower Snake River prior to breaching.	Trapping and transport of affected fish populations would lower effects to the Snake River anadromous fish populations. When implemented with other anadromous fish mitigation measures for MO3, this action would contribute to lowering impacts from major to minor.
Anadromous Fish	Region C: Breaching the lower Snake River dams would create major adverse short-term effects from high levels of turbidity/suspended sediment from Lower Granite Dam to Ice Harbor Dam during fall fish migration. This could result in mortality of 20-40% of the populations. Very low dissolved oxygen levels caused by dam breaching would result in fish mortality in the lower Snake River, with considerable impacts to year class of fall migrating fish.	Raise additional hatchery fish to help to address two lost year classes of anadromous fish, prior to the initiation of each phase of breaching (2 phases) of the lower Snake River dams.	Raising additional hatchery fish would help to lower the negative impacts of dam breaching to lower Snake River anadromous fish populations. When implemented with other anadromous fish mitigation measures for MO3, this action would contribute to lowering impacts from major adverse effect to minor adverse effect.
Resident Fish – ESA Kootenai River White Sturgeon	Region A: The current flow regime at Libby has made establishment of riparian vegetation difficult to sustain young stands of cottonwoods - major contributors to food web for Sturgeon. This results in moderate localized adverse effects. While this MO would not exacerbate these effects in the No Action, it is an ongoing problem.	Plant 1-2 gallon cottonwoods near Bonners Ferry to improve habitat and floodplain connectivity, which would benefit ESA-Listed Kootenai River White Sturgeon by providing a food source. This would complement ongoing habitat actions already being taken in the region.	This mitigation measure, when considered with the existing Bonneville-funded Kootenai River Habitat Restoration Program, would minimize any negative effects to negligible.
Resident Fish – ESA Bull Trout	Region A: Drawdowns cause low water elevations at time of Bull Trout migration, which could make it difficult to enter spawning tributaries and make	On the Hungry Horse Reservoir install structural components like woody debris, and plant vegetation at the tributaries (Sullivan and Wheeler Creeks, possibly	This mitigation measure, when considered with the existing Bonneville-funded Confederated Salish and Kootenai Tribes and State

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Resource	Impact	Proposed Mitigation Action	Effects After Mitigation
	Bull Trout more susceptible to angling/predation. Negligible to Moderate adverse impact.	more) to stabilize the channels, increase cover for migrating fish, and improve the varial zone.	of Montana programs, minimizes any negative effects to negligible.
Resident Fish - Burbot, Kokanee, and Redband Rainbow Trout	Region B: Changes in elevation would leave current habitat dewatered and expose new potential areas appropriate for developing additional gravel spawning habitat.	Develop additional spawning habitat at Lake Roosevelt to minimize impacts to resident fish. Determine post-operations where to site spawning habitat augmentation at Lake Roosevelt for burbot, kokanee, and redband rainbow trout to inform where mitigation is needed. Place appropriate gravel (spawning habitat) at locations up to 100 acres along reservoir and tributaries.	This action is in addition to the Bonneville program that addresses current habitat restoration in Lake Roosevelt and would compensate for additional effects of the new action. Exact acreage would be determined post-implementation.
Resident & Anadromous Fish	Region C: Breaching the lower Snake River Dams would result in major short-term adverse effects from reservoir drawdown. These conditions could make the Tucannon River (a tributary of the Snake River) delta inaccessible to Bull Trout, salmon and steelhead, inhibiting their access to spawning habitat.	Modify the Tucannon River channel at the delta to allow bull trout, salmon, and steelhead passage after Snake River water elevations decrease from breaching.	This mitigation measure would provide access to the Tucannon River and could reduce and minimize anticipated adverse short-term effects from major to minor for Tucannon River populations.
Resident Fish – White Sturgeon	Region C: Breaching the lower Snake River dams would create major adverse short-term effects from high levels of turbidity/suspended and very low dissolved oxygen levels in the river. This could result in mortality for sturgeon and the forage fish they feed on. Although sturgeon are not ESA-listed, they are important to regional tribes and sport fishers.	On the Snake River, trap –and-haul White Sturgeon from impacted areas prior to dam breaching. Relocate trapped sturgeon to locations in Hells Canyon on the Snake River, and downstream of McNary project on the Columbia River.	Relocation of White Sturgeon from the lower Snake River prior to breaching could lower impacts of breaching to the overall population, and moving effects from major to minor.
Vegetation, Wildlife, Wetlands & Floodplains	Region A: Operations at Libby Dam will affect wetland vegetation along the Kootenai River and could cause conversion of wetland habitat to upland habitat. This could cause impact to wildlife. Moderate adverse effects would occur seasonally.	On Kootenai River downstream of Libby: Plant native wetland and riparian vegetation up to ~100 acres along river.	Considering the existing Bonneville-funded Kootenai River Habitat Restoration Program, would minimize any negative effects to negligible.

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Vegetation, Wildlife, Wetlands & Floodplains	Region A: Exposure of mudflats and barren soils could result in establishment of non-native, invasive plant species, a moderate, adverse effect.	Update and implement the existing Invasive Plant Management Plan at Libby to prevent establishment of invasive plant species.	Implementation of this mitigation measure would minimize adverse effects from moderate to negligible.
Vegetation, Wildlife, Wetlands & Floodplains	Region C: Lowering of the water table associated with breaching could have a major adverse effect by conversion of plant communities to non-native, invasive plant communities.	Develop and implement a planting plan to restore arid, native plant communities on approximately 13,000 acres of lands along the lower Snake River.	Implementation of this measure to restore native plant communities would reduce major adverse effects to minor to negligible.
Vegetation, Wildlife, Wetlands & Floodplains	Region C: Breaching the lower Snake River dams would expose approximately 13,800 acres of shoreline, creating major negative effects to wetland and riparian plant communities.	Develop and implement a planting plan for approximately 1500 acres of wetland and riparian species along the exposed shorelines.	Implementation of this measure to restore native plant communities would reduce major adverse effects to minor to negligible.
Vegetation, Wildlife, Wetlands & Floodplains	Region C: Breaching the lower Snake River dams would result in sediment deposition, causing major adverse impacts for wetlands downstream of Ice Harbor dam.	Develop and implement a restoration plan for approximately 155 acres of wetlands downstream of Ice Harbor. The plan may include excavation of sediments deposited after breaching.	Implementation of this measure to restore native plant communities would reduce major adverse effects to minor to negligible.
Navigation & Transportation	Region B: Inchelium-Gifford Ferry (transportation for Tribal community of Inchelium) will go out of service for longer durations and isolate community members. This would be a moderate adverse effect that results in public safety concerns.	Extend the ramp at the Inchelium-Gifford Ferry on Lake Roosevelt so that it is available at lower water elevations.	Extending the ramp would eliminate additional effects to the community, potentially beneficial effect from the No Action condition. There would be no effects to public safety or environmental justice with this mitigation measure.

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Resource	Impact	Proposed Mitigation Action	Effects After Mitigation
Navigation & Transportation	Region C: Breaching the lower Snake River Dams would result in higher water velocities, increasing scour around bridge piers and creating a major adverse effect to transportation and public safety.	Armor piers of up to 25 bridges to protect them from erosion caused by higher velocity flows in the river after breaching.	Armoring bridge piers would reduce the effects from higher water velocities from major adverse effect to negligible.
Navigation & Transportation	Region C: Breaching the lower Snake River dams will result in higher water velocities in the river, increasing erosion of road and railroad embankments and higher flows through drainage structures and culverts, creating a major adverse effect to transportation and public safety.	Armor approximately 80 miles of railroad and highway embankments previously designed or constructed by the Corps to protect them from erosion caused by the breaching measure.	Armoring road and railroad embankments would reduce the effects to public safety and transportation infrastructure from higher water velocities from major adverse effect to negligible.
Navigation & Transportation	Region D: At the breaching of the lower Snake River dams would cause sediment to deposit in the federal navigation channel in the lower Snake River near the confluence with the Columbia River in the upper part of McNary Reservoir.	At the confluence of the lower Snake River in Region D the Corps would dredge the Federal navigation channel post breaching and until the river equilibrium is achieved, as needed, to maintain the federal channel.	With a series of dredging actions, the effects to the federal channel in Region D should be minimized to negligible.
Cultural Resources	Region A and B: Major adverse effects from increase in number of acre-days that archaeological resources would be exposed.	In Region A and B, an increase to the Cultural Resource Program funding for activities such as resource monitoring (pedestrian and drone use), reservoir and river bank stabilization, data recovery, public education awareness, protective signage, and other mitigation to address impacts to TCPs.	This mitigation measure, when considered with the existing FCRPS Cultural Resource Program, in addition to this measure would work to continue minimizing any negative effects to negligible.

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Resource	Impact	Proposed Mitigation Action	Effects After Mitigation
Cultural Resources	Region C: Drawdown of the reservoirs on the lower Snake River caused by dam breaching would result in the exposure of over 350 known cultural resources.	Develop a new Programmatic Agreement under the existing FCRPS Cultural Resource Program for cultural resources exposed in the four reservoir areas.	Implementation of this measure would help to reduce major adverse effects to minor effects.
Public Safety	Region C: Breaching the lower Snake River dams would create high water velocities that could increase scour conditions that would damage existing gas pipelines that cross the lower Snake River near Lyons Ferry. This could cause a major adverse effect to utilities, contribute to an interruption in service, and pose public safety effects.	After breaching the lower Snake River dams, the gas lines would need to be modified to withstand the velocities due to breach.	Implementation of this measure would reduce the effects from higher water velocities from major adverse effect to negligible and maintain utility and public safety.

1246 **5.4.4 Mitigation Measures for Multiple Objective Alternative 4**

1247 The mitigation measures proposed for MO4 address impacts to water quality, anadromous and
1248 resident fish, vegetation, wildlife, wetlands, and floodplains, and navigation and transportation.
1249 There would be no mitigation proposed for flood risk management, water supply, noise, or
1250 visual, as these effects are minor adverse to negligible. While power and transmission would
1251 experience a major adverse effect, no feasible mitigation has been identified. Mitigation
1252 considerations for power and transmission are discussed within Chapter 3 - Power and
1253 Transmission section. Effects are fully described in Chapter 3, Chapter 4, and Chapter 6. For
1254 MO4, effects to cultural resources would be addressed by continuing to implement the existing
1255 Cultural Resource Program discussed in Section 5.2.1.6.

1256 **5.4.4.1 Water Quality**

1257 In MO4, the co-lead agencies are only proposing additional mitigation for water quality in
1258 Region A. In Region B, the measures cause negligible effects. In Regions C and D
1259 implementation of measures would have negligible to major adverse effect to elevation in TDG,
1260 which would have mitigation under anadromous fish. The co-lead agencies would need to
1261 comply with updated water quality standards under the CWA.

1262 In Region A, the effects to water quality are negligible to minor. However, the co-lead agencies
1263 propose to continue supplementing nutrients, nitrogen, and phosphorous at Libby and initiate a
1264 similar nutrient supplementation program at Hungry Horse to offset impacts to primary and
1265 secondary biological productivity that result from reservoir drawdowns and higher flushing
1266 rates similar to MO2.

1267 Mitigation is also proposed at Albeni Falls to offset impacts from the *McNary Flow Target*
1268 measure, which results in warmer water temperatures that support increased growth of
1269 macrophytes or other aquatic plants (e.g., Eurasian water milfoil [*Myriophyllum spicatum*]).
1270 Increased macrophyte density decreases overall water quality, habitat quality, and inhibits
1271 accessibility for recreation. The co-lead agencies propose implementing and expanding an
1272 existing invasive aquatic plant removal program to offset impacts to water quality, wildlife
1273 habitat, and recreation.

1274 **5.4.4.2 Anadromous Fish**

1275 The co-lead agencies are not proposing any mitigation measures in Regions A or B for impacts
1276 to anadromous fish because there are no anadromous fish in these regions. Effects to fish in
1277 Region C and D varies from minor adverse effects to major beneficial effect, depending on the
1278 species and the predictions of separate models. Additional mitigation measures are proposed
1279 for Regions C and D for MO4. Ongoing actions for impacts to anadromous fish in Regions B
1280 (below Chief Joseph Dam), C and D would continue as under No Action Alternative, including
1281 habitat and hatchery projects as described in Section 5.2.1.

1282 Similar to MO1, in Region C and D, concentrations of TDG increase as a result of the juvenile
1283 spill passage measures implemented as part of MO1. To limit increased TDG concentrations and
1284 adverse effects to anadromous fish during upstream passage, the co-lead agencies propose
1285 implementing performance spill operations consistent with the No Action Alternative to
1286 increase upstream passage opportunities for adult salmon and steelhead. If it is observed that
1287 conditions in the tailrace are impeding upstream passage of adult salmon and steelhead or
1288 actionable TDG impacts to fish are observed, the co-lead agencies would implement
1289 performance standard spill operations until the situation is remedied. These real-time decisions
1290 are made in the Regional Forum. These operations are of short duration, as needed, to resolve
1291 the passage issues.

1292 An additional mitigation action in Region C is a proposed to modify the raceway at Little Goose
1293 dam to reduce TDG concentrations. Incorporate infrastructure that promotes water de-gassing
1294 decreases TDG exposure during fish collection for juvenile salmon and steelhead. As a result of
1295 this action, fish would be transported in water with lower TDG compared to river conditions,
1296 mitigating adverse effects associated with spill operations, and increasing overall survival for
1297 fish throughout the lower Columbia and Snake Rivers.

1298 **5.4.4.3 Resident Fish**

1299 Under MO4, the co-lead agencies propose mitigation measures in Regions A, B, and C. No
1300 additional mitigation is proposed in Region D as implementing MO4 results in minor effects that
1301 do not rise to the level of severity warranting mitigation. Ongoing actions as described in
1302 Section 5.2.1 for resident fish, such as bull trout and sturgeon in Regions A, B, C, and D, would
1303 continue. Implementing MO4 would results in increased outflows from the Hungry Horse
1304 Reservoir which reduces the availability of zooplankton, phytoplankton, and other aquatic
1305 invertebrates for bull trout in late summer. Additionally, in MO4, the impact from the McNary
1306 Flow Target measure on food resources for bull trout is severe in wet and average water years,
1307 but extremely severe in dry years. The co-lead agencies propose installing structural
1308 components like woody debris and planting vegetation at Hungry Horse reservoir to stabilize
1309 channels, increase cover for migrating fish, and improve habitat conditions. These actions
1310 would offset impacts to bull trout from reservoir fluctuations and seasonal drawdowns during
1311 spring and fall migration, and improve availability of food production and fish passage into
1312 spawning streams similar to the proposals in MO1, MO2, and MO3. Considering the existing
1313 Bonneville-funded Confederated Salish and Kootenai Tribes and State of Montana programs
1314 with this proposed mitigation component, adverse effects are anticipated to be reduced to
1315 negligible.

1316 In Region B, the co-lead agencies would develop additional spawning habitat at Lake Roosevelt
1317 to minimize impacts to resident fish. The co-lead agencies propose to place appropriate gravel
1318 for spawning habitat at locations up to 100 acres along reservoir and tributaries. Prior to
1319 placement, the co-lead agencies would conduct site surveys post operations of the alternative
1320 implementation to determine where to site spawning habitat augmentation at Lake Roosevelt
1321 for burbot, kokanee, and redband rainbow trout is needed for construction of spawning

1322 habitat. This would build on the 2019 program Bonneville funded, already in year one of a three
1323 year study to determine if modifications in Lake Roosevelt refill would impact resident fish
1324 access to spawning habitat.

1325 **5.4.4.4 Vegetation, Wildlife, Wetlands, and Floodplains**

1326 The co-lead agencies propose no mitigation measures for Region A, B, C, or D as implementing
1327 MO4 would result in minimal to negligible effects when considering ongoing programs in the
1328 No Action. The ongoing actions for impacts to vegetation, wildlife, wetlands, and floodplains for
1329 Regions A, B, C, and D would continue, including protection and enhancement of wildlife
1330 habitat as described in Section 5.2.1.

1331 In Region A, the McNary Flow Target measure decreases water surface elevations in Lake Pend
1332 Oreille. As a result of decreased water surface elevations, wetland habitats could become drier
1333 and the opportunity for non-native, invasive species to become established on exposed
1334 mudflats would increase. To help address these potential impacts offset impacts to wetlands,
1335 the co-lead agencies would use the existing programs at Albeni Falls and Lake Pend Oreille to
1336 address potential effects in this region.

1337 **5.4.4.5 Navigation and Transportation**

1338 The co-lead agencies are not proposing any mitigation measures in Regions A under MO4 for
1339 navigation and transportation because the measures implemented as part of this alternative
1340 would have negligible effects on these resources.

1341 In Region B, the co-lead agencies propose extending the boat ramp at the Inchelium-Gifford
1342 Ferry to provide service at lower water elevation on Lake Roosevelt similar to MO1 and MO2.

1343 In Regions C and D, the *Spill to 125 Percent TDG* operational measure and lower tail waters
1344 would increase shoaling in the navigation channel of the lower Snake and Columbia Rivers and
1345 would adversely affect navigation. In order to maintain the navigation channel and reduce
1346 adverse effects to negligible, proposed mitigation includes increasing the frequency and total
1347 volume of dredging at John Day, McNary, Ice Harbor, Lower Monument, and Lower Granite at a
1348 4 -7-year interval. Higher spill volumes combined with tailrace conditions could also result in
1349 infrastructure damage and shoaling. Regular monitoring of the tailrace would take place to
1350 determine if additional mitigation to install coffer cells at Lower Monumental, Little Goose,
1351 McNary, and John Day would be needed. Coffers would dissipate energy during high spill
1352 operations, which would support movement of sediment in the navigation channel, thereby
1353 maintaining navigational capacity and river transportation. These measures would increase
1354 overall maintenance costs for the projects, but would reduce the adverse effects to negligible.

1355 **5.4.4.6 Recreation**

1356 The co-lead agencies are not proposing any mitigation measures in Regions A, B, C, or D under
1357 MO4 for recreation as the measures implemented as part of this alternative are minor adverse
1358 to negligible effects, and temporary.

1359 In Region A, deep drafts to Lake Pend Oreille to meet the *McNary Flow Target* would lower lake
1360 elevations, creating inability to use these boat ramps during periods of time in low water years.
1361 To mitigate for these occasional, short-term effects, local entities could extend public and
1362 private boat ramps to reach new surface elevations similar to usage in the No Action
1363 Alternative.

1364 In Region B, the co-lead agencies considered extending boat ramps at several recreational
1365 access locations in Lake Roosevelt to maintain accessibility. The *McNary Flow Target* measure
1366 decreases water surface elevations above Grand Coulee, which would reduce accessibility at
1367 numerous existing boat ramps when they become disconnected from the lake, including Evans,
1368 Hawk Creek, Marcus Island, Napoleon Bridge, and North Gorge. However, because recreation
1369 would be impacted fewer than 10 days per calendar year, the co-lead agencies determined that
1370 the severity of impact is minor and temporary, and the effect does not warrant mitigation.

1371 **5.4.4.7 Cultural Resources**

1372 In Region A, B, and C, there is a moderate to major adverse effects to cultural resources from an
1373 increase in number of acre-days that archaeological resources would be exposed. In Region D,
1374 there is a major adverse effect to cultural resources from an increase in number of acre-days
1375 that archaeological resources would be exposed. Effects in Regions A, B, C, and D could be
1376 mitigated by increasing Cultural Resource Program funding for activities such as archeological
1377 site and traditional cultural property monitoring (pedestrian and drone use), reservoir and river
1378 bank stabilization, data recovery, public education awareness, protective signage, and other
1379 mitigation to address impacts to TCPs. These mitigation measures, when considered with the
1380 existing FCRPS Cultural Resource Program, would work to continue minimizing any adverse
1381 effects to negligible (Table 5-4).

1382 **Table 5-4. Mitigation Summary of MO4**

Resource	Impact	Proposed Mitigation Action	Effects After Mitigation
Water Quality	Region A: Lower lake levels at Albeni Falls could make near shore areas more difficult to access due to greater macrophyte and periphyton growth (e.g. Eurasian water milfoil). This is estimated to be a negligible to minor effect.	Implement and expend the existing Invasive Aquatic Plant Removal program at Albeni Falls.	Implementation of this mitigation measure, combined with ongoing programs, would reduce effects to negligible.
Water Quality	Region A: At Hungry Horse, the drawdown in summer affects primary and secondary biological productivity that result from reservoir drawdowns and higher flushing rates.	In Region A, initiate a nutrient supplementation program at Hungry Horse Reservoir.	This measure would improve the food source and reduce adverse effects to negligible.
Anadromous Fish	Regions C and D: Moderate adverse effect from increased spill levels, which create turbulence and eddies below the dams resulting in delays to adult passage.	Temporary extension of performance standard spill levels in coordination with the Regional Forum	Performance Standard Spill is effective in passing adult fish and delays in passage would be negated, resulting in negligible adverse effects.
Anadromous Fish	Region C: Water in the Little Goose raceway is expected to have high TDG due to higher spill levels. This could have major adverse effects to transported fish.	Modify the Little Goose Raceway infrastructure to de-gas the water in the raceway during collection for transport. This would allow the fish to be transported in water with lower TDG than that in the river.	Implementation of this measure would reduce major adverse effects from TDG to transported fish negligible.
Resident Fish – ESA Bull Trout	Region A: Drawdowns cause low water elevations at time of Bull Trout migration, which could make it difficult to enter spawning tributaries and make Bull Trout more susceptible to angling/predation. Negligible to Moderate adverse impact.	On the Hungry Horse Reservoir install structural components like woody debris, and plant vegetation at the tributaries (Sullivan and Wheeler Creeks, possibly more) to stabilize the channels, increase cover for migrating fish, and improve the varial zone.	This mitigation measure, when considered with the existing Bonneville-funded Confederated Salish and Kootenai Tribes and State of Montana programs, minimizes any negative effects to negligible.
Resident Fish - Burbot, Kokanee, & Redband Rainbow Trout	Region B: Changes in elevation would leave current habitat dewatered and expose new potential areas appropriate for developing additional gravel spawning habitat.	Develop additional spawning habitat at Lake Roosevelt to minimize impacts to resident fish. Determine post-operations where to site spawning habitat augmentation at Lake Roosevelt for burbot, kokanee, and redband	This action is in addition to the Bonneville program that addresses current habitat restoration in Lake Roosevelt and would compensate for additional effects of the new action.

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Resource	Impact	Proposed Mitigation Action	Effects After Mitigation
		rainbow trout to inform where mitigation is needed. Place appropriate gravel (spawning habitat) at locations up to 100 acres along reservoir and tributaries.	Exact acreage would be determined post-implementation.
Navigation & Transportation	Region B: Inchelium-Gifford Ferry (transportation for Tribal community of Inchelium) will go out of service for longer durations and isolate community members. This would be a moderate adverse effect that results in public safety concerns.	Extend the ramp at the Inchelium-Gifford Ferry on Lake Roosevelt so that it is available at lower water elevations.	Extending the ramp would eliminate additional effects to the community, potentially beneficial effect from the No Action condition. There would be no effects to public safety or environmental justice with this mitigation measure.
Navigation & Transportation	Regions C and D: High spill, combined with tailrace conditions could result in infrastructure damage and more frequent O&M of navigation channel at projects.	Regular monitoring of tailrace conditions will be conducted. If any discovery of adverse or damaging effects, install coffer cells at Lower Monumental, Lower Granite, McNary, and John Day to dissipate energy from higher spill levels.	Installation of coffer cells could reduce adverse effects to the tailrace and navigation channel from constant high spill to negligible.
Navigation & Transportation	In Region C & D, high spill volumes and lower tail water increase scour, creating sediments and filling of the navigation channel. This is a moderate adverse impact to navigation.	Monitoring of scour and infill at John Day, McNary, Ice Harbor, Lower Monumental, and Lower Granite projects and increase dredging maintenance, as needed to maintain navigation channel. This is predicted to be needed every 4-7 years.	Increasing the routine maintenance frequency and for total volume of dredging would reduce these navigation impacts to negligible.
Cultural Resources	Region A and B: Major adverse effects from increase in number of acre-days that archaeological resources would be exposed.	Region A, B and C increase Cultural Resource Program funding for activities such as resource monitoring (pedestrian and drone use), reservoir and river bank stabilization, data recovery, public education awareness, protective signage, and other alternative mitigation to address impacts to TCPs.	This mitigation measure, when considered with the existing FCRPS Cultural Resource Program in addition to this measure, would work to continue minimizing any negative effects to negligible.

1384 **5.5 MONITORING AND ADAPTIVE MANAGEMENT**

1385 Monitoring and adaptive management address sources of uncertainty, steer project
1386 implementation and maintenance to ensure that the intended project benefits are attained,
1387 and documents project effects for communication to participants and stakeholders. When
1388 effectiveness monitoring indicates that projects or mitigation measures do not effectively
1389 address an impacted resource, mitigation measures can be adaptively managed to improve
1390 effectiveness. For the purposes of this EIS, adaptive management is defined as a structured and
1391 iterative process to reduce uncertainty over time. Monitoring mitigation measures can
1392 incorporate elements of adaptive management if monitoring results indicate a change is
1393 needed to more fully offset impacts to an impacted resource.

1394 **5.5.1 Monitoring Strategy**

1395 A monitoring plan would be developed to address an individual measure of the preferred
1396 alternative, or a group of similar measures throughout the study area. The co-lead agencies
1397 would prepare a monitoring plan which specifies the following:

- 1398 • The intended goal or goals of the project or measure
- 1399 • Objectives for measuring the progress toward the goal(s)
- 1400 • Any uncertainties involved with the implementation or the body of knowledge supporting
1401 the implementation of the proposed action
- 1402 • The strategy for implementing the project or program
- 1403 • The process of evaluating project success and the metrics used to evaluate success

1404 The co-lead agencies would prepare an appropriate monitoring and adaptive management plan
1405 prior to implementation of the preferred alternative. The plan would identify what data are
1406 needed to assess project effectiveness, as well as the method and frequencies of monitoring
1407 the project after implementation or construction. If mitigation does not adequately address
1408 impacts to an affected resource, or is ineffective at meeting the goal, then adaptive
1409 management would be used to assess and implement changes to achieve the intended goal of
1410 the mitigation action. If significant changes to the project or program cannot be adequately
1411 addressed through operational changes described in this EIS, a supplemental NEPA evaluation
1412 may be needed.

1413 Monitoring requirements included as part of project-specific permits would be developed in
1414 consultation with the appropriate Federal or state agencies as the preferred alternative
1415 advances through any applicable permitting process. For example, projects requiring
1416 coordination with state agencies to prepare erosion and stormwater control plans would
1417 include monitoring to ensure projects maintain water quality. The specific monitoring
1418 requirements would be identified in the permit or authorization from the state agency and the
1419 co-lead agencies' monitoring plan would incorporate these requirements as part of project

1420 implementation. Monitoring plans typically include biological monitoring to evaluate fish and
1421 invertebrate presence and abundance, as well as harmful aquatic organisms and toxic algal
1422 blooms. Monitoring could also include water and sediment chemistry to assess changes in
1423 water and sediment quality and toxicity. Monitoring plans can also be developed to assess
1424 sediment erosion and deposition to evaluate changes to channel structure and flow
1425 characteristics, which can be used to assess fish and wildlife habitat.

1426 **5.5.2 Adaptive Management**

1427 Adaptive management is often defined as a structured and iterative process to improve the
1428 decision-making process while allowing for uncertainty during implementation. Adaptive
1429 management is intended to reduce uncertainties through monitoring the effectiveness of a
1430 project in mitigating adverse impacts and using monitoring results to determine if changes are
1431 needed to improve project implementation. In general, adaptive management is used to
1432 improve the process that leads to more effective, strategic, and beneficial projects.

1433 Integrating adaptive management into the decision-making process enables managers to
1434 address uncertainties associated with implementation of an individual project or a
1435 comprehensive program. The co-lead agencies have incorporated lessons learned from
1436 monitoring previous projects implemented in the study area and conducting research to
1437 improve the proposed measures and MOs. The co-lead agencies would integrate adaptive
1438 management into future planning, implementation, and monitoring for projects implemented
1439 under the preferred alternative to ensure relevant, high-quality information is available and
1440 used during the decision-making process.

1441 Furthermore, by integrating an adaptive management strategy into the monitoring plan, the co-
1442 lead agencies would accomplish the following goals:

- 1443 • Ensure collaborative decision-making processes are maintained through cooperation with
1444 regional stakeholders, tribes, and other Federal and state government agencies
- 1445 • Ensure monitoring and research results are implemented as intended
- 1446 • Ensure data are collected, analyzed, and documented in a manner that promotes review
1447 and integration of any lessons learned to influence future management decisions
- 1448 • Ensure there is flexibility in implementation of projects or programs that allows for
1449 adjusting methods to achieve success in meeting project or program objectives

1450 A component of the monitoring and adaptive management plan would specify the performance
1451 standard or success criteria used to determine overall project performance. In addition, the
1452 trigger for adaptively managing project implementation would be identified in the monitoring
1453 and adaptive management plan. The monitoring and adaptive management plan would also
1454 identify the minimum timeframe necessary to evaluate project success, as well as when
1455 monitoring tasks are complete and would cease. If monitoring results are not returning useful
1456 information to determine project success, the monitoring and adaptive management plan
1457 would specify timeframes for reviewing monitoring results and the process by which the co-
1458 lead agencies would modify monitoring efforts or project implementation.

CHAPTER 6 - CUMULATIVE EFFECTS

6.1 INTRODUCTION

Council on Environmental Quality (CEQ) regulations for implementing the National Environmental Policy Act (NEPA) requires an assessment of cumulative effects. CEQ defines a cumulative effect as “the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions” (40 Code of Federal Regulations § 1508.7). This section describes the methods for identification of cumulative actions and presents the results of the cumulative effects analysis.

6.1.1 Analysis Approach

The cumulative action analysis methods are based on the policy guidance and methodology originally developed by CEQ (1997a). This method includes identifying affected resources and direct/indirect effects, establishing the geographic and temporal boundaries of the analysis, identifying applicable cumulative actions, and analyzing the cumulative effects.

The *Environmental Consequences* sections of Chapter 3 present the direct and indirect effects of the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS) Multiple Objective Alternatives (MOs) on each resource’s affected environment as presented in the *Affected Environment* sections of Chapter 3. The resource conditions described in those sections account for the effects to resources related to past and present actions. Chapter 6, *Cumulative Effects*, further considers the cumulative effects of each alternative combined with reasonably foreseeable future actions and conditions. Climate change, for example, can be considered an effect of past, present, and future actions that may have a cumulative effect on certain resources in the analysis area. The effects of climate change on all affected resources (indirect, direct, and cumulative) are analyzed and discussed in detail in Chapter 4.

6.1.2 Geographic and Temporal Scope

The geographic boundary for each resource considered in this cumulative effects analysis is referred to as the cumulative impact analysis area (CIAA). The CIAA follows the geographic boundaries of direct and indirect effects for each resource identified in Chapter 3 unless noted otherwise under specific resources.

The temporal boundaries for cumulative effects in this analysis have three components—past, present, and future. In this analysis, past cumulative effects have been discussed in the *Affected Environment* sections of Chapter 3, insofar as they are relevant to effectively describing the existing condition for each resource. Conversely, present and reasonably foreseeable future actions are included in this chapter if they are expected to overlap in space and time with the scope of this EIS, which unless otherwise noted is, for temporal purposes, approximately 25 years into the future.

37 **6.1.3 Identification of Past, Present, and Reasonably Foreseeable Future Actions**

38 **6.1.3.1 Past Actions**

39 The effects of past actions are reflected in the resource descriptions under each resource in the
40 *Affected Environment* sections of Chapter 3, which describes the existing condition for each
41 resource. According to CEQ, a cumulative effects analysis may assess past actions in the project
42 area by focusing on the “current aggregate effects of past actions without delving into the
43 historical details of individual past actions” (CEQ 2005). The effects of all past actions do not
44 need to be identified for the cumulative impact analysis. That said, a summary of past actions in
45 the CIAA is described in the following section with regard to Columbia River Basin aquatic
46 species (including fish), aquatic invertebrates, and their habitats, which have been particularly
47 vulnerable to past anthropogenic (human-caused) pressures.

48 Human uses and development have had substantial influences on the CIAA for nearly all of the
49 resources analyzed. Human presence in the Columbia and Snake River Basins dates back more
50 than 16,000 years, to a time when the Columbia River was the dominant contributor of food,
51 water, and transportation for humans. Within the analysis area, aquatic, riparian, and
52 floodplain habitat have been changed throughout history, including habitat loss, modification,
53 degradation, and restoration. This includes modification of the hydrograph since pre-dam
54 conditions. Before dams existed in the basin, the hydrograph was that of a natural riverine
55 system. Hundreds of miles of riverine habitat have been converted to slack water reservoirs
56 along the mainstem Columbia and Snake Rivers (Ebel et al. 1989).

57 In general, relevant past cumulative actions that have affected aquatic species and other
58 wildlife include construction and operation of dams, levees, and other river infrastructure;
59 dredging and sediment management; commercial and recreational fishing harvest; invasive
60 species; floodplain development; water pollution; logging and mining; water withdrawals to
61 support human development; and agricultural, urban, and transportation corridor
62 development. These actions have had adverse effects throughout their implementation,
63 including direct mortality to species and habitat loss and degradation. Examples of the various
64 ways that habitat can be lost and/or degraded include the creation of fish passage barriers,
65 overharvest and overconsumption of aquatic species, introduction of invasive and predatory
66 species, flow modifications, water temperature variability, and water pollution.

67 Relevant past cumulative actions also include the voluntary actions and Federal- and state-
68 mandated actions of private and public parties to create positive and offsetting effects for
69 affected aquatic species and other wildlife. These include but are not limited to hatcheries and
70 fisheries management; predation management; hydro operations and asset management;
71 water quality management; and habitat, conservation, and land management.

72 Appendix E provides a glimpse into the host of actors and actions engaged in these and other
73 activities affecting salmon and steelhead in and around the Columbia, Snake, and Willamette
74 Rivers from 2010 to 2019. During this time, over 400 formal and formal programmatic biological
75 opinions (BiOps) were issued by NMFS to govern salmon and steelhead protection. The BiOps

76 vary widely in the scope of effects, required analyses, responsible parties, and required actions.
77 They also provide concrete examples of how the co-lead agencies' ability to successfully carry
78 out mitigation responsibilities depends on a myriad of other actors and actions upstream,
79 downstream, and inland from mitigation activities.

80 **6.1.3.2 Ongoing and Present Actions**

81 Present actions are typically ongoing activities that have already been incorporated into the
82 affected environment for each resource. Presently, influencing factors on the Columbia and
83 Snake Rivers are the dams that provide hydroelectric power, flood risk management (FRM),
84 navigation (including commercial and cruise lines), recreation, timber and logging industry, non-
85 point source pollution, and municipal and industrial (M&I) water supply. Ongoing and present
86 actions also include the exercise of existing Federal and state environmental regulatory
87 authorities and mechanisms. The EIS alternatives analysis broadly assumes existing laws,
88 policies, agency jurisdictions, rulings, BiOps, etc., will remain in place for their stated duration
89 (see Appendix E for the last 10 years of formal and formal programmatic NMFS BiOps for
90 salmon and steelhead on the Columbia, Snake, and Willamette Rivers).

91 Likewise, the adequacy and health of existing regional coordination, alignment, and planning
92 actions will not be assessed for the purposed of this EIS, but nonetheless merits mention for
93 context. The United States and Canada began negotiations in 2018 to modernize the Columbia
94 River Treaty regime. The negotiations are currently ongoing, therefore any potential effects on
95 the environment that may result from that effort are not reasonably foreseeable. Notable
96 efforts are also underway to create more integrated and regional approaches to salmon and
97 steelhead challenges that require collaboration across Federal, state and Tribal Government
98 jurisdictions (e.g., Columbia Basin Partnership Taskforce). Anticipated future effects of these
99 activities are included where applicable herein, and cumulative effects are analyzed where
100 reasonably foreseeable future actions exist.

101 **6.1.3.3 Reasonably Foreseeable Future Actions**

102 RFFAs are considered in the cumulative effects analysis for each resource in this chapter. RFFAs
103 are proposed activities that could cause similar effects in the same space and time as the MOs,
104 but that are proposed by an outside entity. RFFAs are not yet implemented. In order to be
105 deemed reasonably foreseeable, RFFAs must typically be budgeted for and included under
106 formal proposals or decisions (such as an official agency decision document or a county land
107 use plan). RFFAs include proposed and planned developments, actions, and trends related to
108 population growth; agriculture (including timber and logging industry); urban development;
109 climate change; power generation (including operations and maintenance activities); new
110 transmission lines; existing transmission maintenance activities; environmental management,
111 laws, and policies; fisheries management; and the maintenance and operation of the Columbia
112 River System (CRS), as well as other Federal and private dams and river infrastructure.

113 **6.2 CUMULATIVE ACTIONS SCENARIO**

114 This section lists resources analyzed in the direct and indirect analysis in Chapter 3, *Affected*
115 *Environment and Environmental Consequences*, where only minor direct and indirect effects
116 were identified in Chapter 3 and little to no cumulative actions were identified. A summary of
117 actionable RFFAs and potentially affected resources are provided in Table 6-1 and Table 6-2,
118 and discussed throughout the remainder of the chapter.

119 In addition, there are numerous reasonably foreseeable future trends, planning efforts,
120 programs, proposals, projects, and new legislation within the Columbia River Basin that overlap
121 in space and time and are therefore additive in impact when combined with those effects from
122 the MOs. Primarily, these cumulative actions and trends are focused on the management of fish
123 and wildlife (primarily fish), environmental management, water quality management, industrial
124 and agricultural developments, population growth in the region, energy development, and
125 operations and maintenance of existing Federal and non-Federal dams and other river
126 infrastructure. These are listed in Table 6-1 below with a key used for identification in certain
127 portions of the chapter.

128 **Table 6-1. Reasonably Foreseeable Future Actions and Trends**

RFFA ID	RFFA Description
RFFA1	Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development
RFFA2	Water Withdrawals for Municipal, Agricultural, and Industrial Uses
RFFA3	New and Alternative Energy Development
RFFA4	Increasing Use of Renewable Energy Sources, Industrial and Vehicle Emissions Reductions, and Decarbonization
RFFA5	Federal and State Wildlife and Lands Management
RFFA6	Increase in Demand for New Water Storage Projects
RFFA7	Fishery Management
RFFA8	Bycatch and Incidental Take
RFFA9	Bull Trout Passage at Albeni Falls
RFFA10	Ongoing and Future Habitat Improvement Actions for Bull Trout
RFFA11	Resident Fisheries Management
RFFA12	Fish Hatcheries
RFFA13	Tribal, State, and Local Fish and Wildlife Improvement
RFFA14	Lower Columbia River Dredged Material Management Plan
RFFA15	Snake River Sediment Management Plan
RFFA16	Seli'š Ksanka Qlispe'(SKQ) Dam (Formerly Kerr Dam) Operations
RFFA17	Invasive Species
RFFA18	Marine Energy and Coastal Development Projects
RFFA19	Climate Change
RFFA20	Clean Water Act-Related Actions
RFFA21	Idaho Power Hells Canyon Complex Mercury Contamination Issues/Remediation
RFFA22	Idaho Power Hells Canyon Complex Temperature Issues
RFFA23	Mining in Reaches Upstream of CRSO Dams

RFFA ID	RFFA Description
RFFA24	Hanford Site
RFFA25	Columbia Pulp Plant
RFFA26	Middle Columbia Dam Operations

129 The specific actions and trends are further described under each heading below.

130 **RFFA1 – Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural**
131 **Development.** Human populations are increasing primarily in urban metropolitan areas with
132 smaller increases in rural areas. This increase is expected to continue until at least 2030
133 (Independent Scientific Advisory Board [ISAB] 2007b). Population increases in the Columbia
134 River Basin are projected to continue although there is a wide range of estimates of the specific
135 number. Projections to 2040 of population growth rates for the interior Columbia River Basin
136 range from 0.3 percent per year to 1.6 percent per year. Lackey et al. (2006) concluded that if
137 the largely migration-driven population growth continues unabated, it will result in a threefold
138 to sevenfold increase in the population in the Columbia River Basin region. In Washington and
139 Oregon, many acres of forestlands are being converted to residential and commercial
140 development, a trend that is expected to continue.

141 Agricultural land is also being converted to nonagricultural uses. Like forestland, an important
142 factor influencing the conversion of agricultural land is the increase in land prices driven by
143 population growth. Urban development causes marked changes in the physical, chemical, and
144 ecological characteristics of stream ecosystems, which are in most cases detrimental to native
145 fish and wildlife. The rate of exurban (area just beyond denser suburbs) development also
146 seems to be increasing. This type of development tends to result in degraded habitat for fish
147 and wildlife through direct habitat conversion and loss. Human population growth and
148 development can be expressed as potential causes of increases in discharges of pollutants in
149 stormwater runoff from residential, commercial, industrial, agricultural, recreational, and
150 transportation land uses.

151 A variety of population-driven factors external to the Columbia River Basin can also cause
152 effects within the basin. International trade through shipping has led to modifications to the
153 lower river and estuary. Future channel deepening and other port modifications may result in
154 increasing numbers of ships and cargo tonnage on the river. Globalization of trade may have
155 contributed to the loss of some industries within the Columbia River Basin, such as aluminum,
156 and will continue to affect resource-based industries. Increased volumes of materials, especially
157 hazardous goods and fuels that power trains, vessels, and trucks, are moved through the
158 Columbia River Basin in response to the demands of a growing population. With increased
159 movement of goods via all three modes, more accidents and spills are likely. Mining, logging,
160 trade, and transportation projects also influence the hydrology, water quality, and use of the
161 CRS.

162 **RFFA2 – Water Withdrawals for Municipal, Agricultural, and Industrial Uses.** Freshwater
163 withdrawals for domestic, industrial, commercial, and public uses are increasing, whereas
164 withdrawals for irrigation purposes are decreasing due to the conversion of agricultural lands to

165 residential areas. Freshwater withdrawals for domestic and public uses are projected to
166 increase by 71 to 85 percent by 2050. Freshwater withdrawals for irrigation are projected to
167 decline but will be more than offset by increases in withdrawals for public, domestic, industrial,
168 and commercial uses (ISAB 2007b). Increased withdrawals have large implications for instream
169 flow and for maintenance of riparian and aquatic habitats for fish and wildlife. New water
170 withdrawals are typically subject to regulatory restrictions.

171 Many tributaries in the Columbia River Basin are substantially depleted by water diversions. In
172 1993, state, tribal, and conservation group experts estimated that 80 percent of 153 Columbia
173 tributaries had low flow problems, of which two-thirds were caused, at least in part, by
174 irrigation withdrawals (Oregon Water Resources Department [OWRD] 1993). The surface/live
175 flows of some tributaries in Oregon are already fully appropriated by state regulators (OWRD
176 2019). The Northwest Power and Conservation Council showed similar problems in many Idaho,
177 Oregon, and Washington tributaries (NW Council 1992). Diminished tributary stream flows have
178 been identified as an important limiting factor for most species in the Columbia River Basin
179 upstream of Bonneville Dam (National Marine Fisheries Service [NMFS] 2007). Tributary water
180 diversions are expected to continue in the future over the study period.

181 **RFFA3 – New and Alternative Energy Development.** Numerous wind, solar, and natural gas
182 energy projects in the Columbia River Basin that have yet to be constructed are either under
183 review or have been approved for construction. A full listing of applications and their statuses
184 are available from state energy departments such as the Oregon Department of Energy and the
185 Washington State Energy Office. Some of the larger future projects that overlap with the CRSO
186 EIS include:

- 187 • Bakeoven Solar Project in Wasco County, Oregon
- 188 • Mist Underground Natural Gas Storage Facility in Columbia County, Oregon
- 189 • Nolin Hills Wind Power Project in Umatilla County, Oregon
- 190 • Desert Claim Wind Power Project in Kittitas County, Washington
- 191 • Golden Hills Wind Project in Sherman County, Oregon
- 192 • Whistling Ridge Energy Wind Development in Skamania County, Washington
- 193 • Montague Wind Power Facility in Gilliam County, Oregon
- 194 • Summit Ridge Wind Farm in Wasco County, Oregon
- 195 • Ella Wind Project, in Morrow County, Oregon
- 196 • Jordan Butte Wind Project, in Gilliam County, Oregon
- 197 • Troutdale Grid Energy Storage, in Multnomah County, Oregon

198 **RFFA4 – Increasing Use of Renewable Energy Sources, Industrial and Vehicle Emissions**
199 **Reductions, and Decarbonization.** A basinwide trend exists within the Columbia River Basin

200 toward increased use of renewable energy and reduced greenhouse gas (GHG) emissions.
201 There is potential for an increase in lack-of-market/lack-of-turbine-capacity involuntary spill,
202 which could lead to higher total dissolved gas (TDG) levels. Conversely, decarbonizing and
203 electrifying transportation and other sectors could reduce involuntary spill from lack-of-market
204 spill. This trend is expected to continue into the future, largely because it is being driven by
205 multiple legislative factors designed to induce long-term change, including the following:

- 206 • Washington Clean Energy Transformation Act
- 207 • Federal Affordable Clean Energy Rule
- 208 • Oregon Clean Electricity and Coal Transition Plan
- 209 • Federal Cleaner Trucks Initiative
- 210 • Electric vehicle use and government incentive programs
- 211 • State and municipal emissions GHG reductions targets
- 212 • Coal power plant retirements
- 213 • Renewable Energy Portfolio Standards, including adjacent states and provinces

214 **RFFA5 – Federal and State Wildlife and Lands Management.** Throughout the study area, there
215 are numerous national wildlife refuges and other public lands managed for the benefit of
216 wildlife and other public uses. In regard to wildlife refuges, the analysis assumes that the state
217 agencies and the U.S. Fish and Wildlife Service would continue to implement management
218 activities consistent with management area and refuge goals and agency policies for the benefit
219 for fish and wildlife. Federal and state-owned wildlife lands are detailed in Section 3.6.2.3.
220 There are numerous other parcels of land that are managed for a multitude of uses, such as
221 resource extraction (logging, mining, etc.), recreation, grazing, and conservation. The way that
222 these lands are managed in the study area can have cumulative effects when added to the
223 actions proposed in this EIS. In particular, water management, soil management, vegetation
224 management, and fire management can have important additive effects, which could be
225 beneficial or adverse depending on the nature of the management action.

226 **RFFA6 – Increase in Demand for New Water Storage Projects.** A general trend of increased
227 water storage needs in the Columbia River Basin is projected to continue to encourage new
228 water storage projects. However, new water storage projects are typically subject to state and
229 federal regulatory requirements prior to being approved. Some of the larger future projects
230 that overlap with the CRSO EIS include the following:

- 231 • Switzler Reservoir Water Storage Project: The reservoir would have a peak storage capacity
232 of approximately 44,000 acre-feet through construction of a concrete-faced rockfill dam
233 approximately 325 feet in height and located approximately 1.1 miles upstream of the
234 confluence of the Switzler drainage with the Columbia River. This project would be located
235 in Benton County, Washington, just across the Columbia River from Hermiston, Oregon.

236 • Goldendale Closed Loop Pumped Storage Facility: The proposed Goldendale Energy Project
237 No. 14861 is a closed-loop pumped storage hydropower facility proposed by FFP Project
238 101, LLC. The proposed lower reservoir would be off-stream of the Columbia River at John
239 Day Dam, located on the Washington (north) side of the Columbia River at River Mile 215.6.
240 The project would be located approximately 8 miles southeast of Goldendale in Klickitat
241 County, Washington. The proposed project would use off-peak energy (i.e., energy available
242 during periods of low electrical demand) to pump water from the lower reservoir to the
243 upper reservoir and generate energy by passing the water from the upper to the lower
244 reservoir through generating units during periods of high electrical demand.

245 **RFFA7 – Fishery Management.** Pacific Salmon Fishery Management Plans are commercial-
246 harvest fisheries plans that are prepared by the Pacific Fishery Management Council (PFMC)
247 and are implemented and enforced by the NMFS in Federal waters (e.g., 3 to 200 miles
248 offshore). The main salmon species that PFMC manages are Chinook, coho, and pink salmon.
249 NMFS promulgates regulations for how many salmon can be caught offshore based on these
250 PFMC plans. PFMC, including NMFS, is examining ways to better manage the catch of salmon in
251 offshore ocean waters. Currently, PFMC has established a Southern Resident Killer Whale
252 Workgroup to reassess the effects of Federal ocean salmon fisheries on Southern Resident killer
253 whales and to potentially recommend conservation measures or management that better limit
254 fisheries effects on Chinook salmon in Federal waters. The workgroup is comprised of
255 representatives from West Coast tribes; the states of California, Idaho, Oregon, and
256 Washington; PFMC; and NMFS. The workgroup is scheduled to provide recommendations for
257 ocean salmon fisheries management via a final report to PFMC members in March 2020. Such
258 recommendations (e.g., time and area ocean salmon fishing closures) could result in a benefit
259 for anadromous species and Southern Resident killer whales.

260 Another important fishery management plan is the 2018–2027 *United States v. Oregon*
261 Management Agreement. The purpose of the agreement is to rebuild weak runs to full
262 productivity and fairly share the harvest of upper river runs between treaty Indian and non-
263 treaty fisheries in the ocean and Columbia River Basin. As a means to accomplish this purpose,
264 the parties use habitat protection authorities, enhancement efforts, artificial production
265 techniques, and harvest management.

266 **RFFA8 – Bycatch and Incidental Take.** This refers to incidental take or bycatch of fish species
267 such as bull trout by recreational anglers and incidental take of eulachon by shrimp fishing.
268 Bycatch and incidental take are forecast to continue alongside recreational and commercial
269 fishing.

270 **RFFA9 – Bull Trout Passage at Albeni Falls.** The proposed action is to construct an upstream
271 “trap and haul” fish passage facility at Albeni Falls Dam; downstream passage will occur through
272 the spillway and powerhouse. Once bull trout enter the trap and are captured, they will be
273 sorted from non-target species for transport via truck to a release location approximately 5
274 miles upstream of the dam. Non-target species will either be returned below Albeni Falls Dam,
275 be routed directly to the forebay upstream of the dam, or euthanized by the resource

276 managers. The construction schedule assumes a 2-year construction period centered on two
277 low-flow periods required for installation and removal of the cofferdam systems. The
278 implementation time frame is uncertain, because it requires an appropriation of funding, but
279 this action is considered reasonably foreseeable during the time period of analysis given the
280 continued support of the project by the U.S. Army Corps of Engineers (Corps). The Corps
281 continues to demonstrate capability for this project during the annual budget process.

282 **RFFA10 – Ongoing and Future Habitat Improvement Actions for Bull Trout.** A common goal
283 among these actions is the improvement of aquatic habitat and water quality to benefit native
284 salmonids, especially bull trout. Overlap varies, but these actions are generally ongoing. A
285 comprehensive list of activities that contribute to the recovery of bull trout in the Columbia
286 River Recovery Unit and Lake Pend Oreille area is not available because of the multitude of
287 federal, state, tribal, and non-governmental organizations that conduct activities in the region.
288 Some of the important activities that are ongoing or have been recently completed within the
289 region are as follows:

- 290 • Construction of upstream fish passage facility at Box Canyon Dam (construction began in
291 2016, facility expected to be operational in 2019; Pend Oreille Public Utility District)
- 292 • Lake trout removal in Lake Pend Oreille (Idaho Department of Fish and Game)
- 293 • Tributary habitat restoration, enhancement, and passage
- 294 • Kalispel resident fish project (Kalispel Natural Resources Department)
- 295 • Non-native species suppression projects, such as the Kalispel Tribe Non-Native Fish
296 Suppression Project in Pend Oreille River
- 297 • Road abandonment and bank stabilization (Kalispel Natural Resources Department)
- 298 • Bull trout research and monitoring
- 299 • Genetic inventory of bull trout in the Pend Oreille River subbasin (Kalispel Natural
300 Resources Department)
- 301 • Mainstem Pend Oreille River water quality
- 302 • Temperature total maximum daily load (TMDL) implementation for the Pend Oreille River
303 (Washington Department of Ecology and stakeholders)
- 304 • Water quality monitoring (Kalispel Natural Resources Department)

305 **RFFA11 – Resident Fisheries Management.** The state and tribal fish and game agencies
306 manage, for recreational, ceremonial, and subsistence, fisheries in the Columbia River Basin
307 and regulate private and public hatchery releases. The agencies modify and publish recreational
308 fishing regulations on an annual basis. Currently, recreational anglers may not target bull trout
309 in most areas, but may incidentally catch and release bull trout. Other resident fisheries include
310 kokanee and burbot in the upper basin.

311 **RFFA12 – Fish Hatcheries.** In addition to hatcheries already considered under the No Action
312 Alternative, there are more than 100 other hatchery programs funded through different
313 sources and operated by federal entities, tribes and tribal entities, state agencies, and/or public
314 utility districts. Many of these hatchery programs are intended to mitigate for lost habitat, for
315 mortality of juvenile and adult fish, and/or other effects related to the existence and operation
316 of Federal and non-Federal dams. It is anticipated that the co-lead agencies and other entities
317 would continue to fund the operation and maintenance of most existing hatchery programs,
318 except perhaps for MO3 that are associated with the operation of the lower Snake dams under
319 the Lower Snake Compensation Plan.

320 There are numerous hatcheries in the Columbia River Basin that focus on conservation of rare
321 species and/or maintaining the abundance of recreational species. Hatchery programs in the
322 Columbia River Basin are implemented to augment harvest, to help conserve a population, or for
323 both purposes. Of the 177 hatchery programs in the Columbia River Basin, 62 (35 percent) are
324 funded wholly or in part by the Mitchell Act. NMFS, part of NOAA within the U.S. Department of
325 Commerce, currently distributes Mitchell Act appropriations to the operators of these 62
326 hatchery programs that annually produce more than 63 million fish. The most common species
327 produced are fall Chinook salmon, coho salmon, and spring Chinook salmon in the lower
328 Columbia River and fall Chinook salmon, spring Chinook salmon, and summer steelhead in the
329 interior Columbia River. Chum salmon, sockeye salmon, and summer Chinook salmon are the
330 least common species produced. The hatchery programs' geographic scope includes rivers,
331 streams, and hatchery facilities where hatchery origin salmon and steelhead occur or are
332 anticipated to occur in the Columbia River Basin, as well as the Snake River and all other
333 tributaries of the Columbia River. The program area also includes the Columbia River estuary
334 and plume.

335 **RFFA13 – Tribal, State, and Local Fish and Wildlife Improvement.** These actions include non-
336 Federal habitat actions supported by state and local agencies, tribes, environmental
337 organizations, and private communities. Projects supported by these entities focus on
338 improving general habitat and ecosystem function or species-specific conservation objectives.
339 Actions and programs contributing to these benefits include, but are not limited to, growth
340 management programs, various stream and riparian habitat projects, watershed planning and
341 implementation, acquisition of water rights for instream purposes and sensitive areas, instream
342 flow rules, stormwater and discharge regulation, TMDL implementation, tribal activities to
343 improve Pacific lamprey passage, and hydraulic project permitting.

344 **RFFA14 – Lower Columbia River Dredged Material Management Plan (DMMP).** Currently, an
345 integrated DMMP and EIS is being developed due to the need for additional placement
346 locations with sufficient capacity to maintain the congressionally authorized, deep draft,
347 Federal navigation channel for the next 20 years. The deep draft, Federal navigation channel
348 extends from River Mile 3 to 105.5 of the lower Columbia River. The forecasted average annual
349 dredging needed to maintain the lower Columbia River Federal Navigation Channel is currently
350 6.5 million cubic yards (mcy) (130 mcy total over 20 years). Existing dredged material placement
351 sites were assessed in a Preliminary Assessment and found to have insufficient capacity for the

352 next 20 years. The plan is also evaluating needs for future upland and in-water placement of
353 dredged material, as well as construction and repair of channel training features. It is assumed
354 that potentially affected resources from the new DMMP would be identified and analyzed in
355 the integrated EIS. The following measures would be evaluated:

- 356 • Beneficial use of dredged material
- 357 • In-water placement of dredged material
- 358 • Shallow water placement of dredged material
- 359 • Shoreline placement of dredged material
- 360 • Upland placement of dredged material
- 361 • Pile dikes
- 362 • Other channel training features

363 **RFFA15 – Snake River Sediment Management Plan.** The Snake River Sediment Management
364 Plan is intended to maintain the lower Snake River projects by managing, and preventing if
365 possible, sediment accumulation in areas of the lower Snake River reservoirs that interfere with
366 the authorized purposes. The selected alternative from the Snake River Plan provides a suite of
367 all available dredging, system management, and structural sediment management measures for
368 the Corps to use to address sediments that interfere with the existing authorized project
369 purposes of the lower Snake River projects. The Snake River Sediment Management Plan is
370 anticipated to be implemented under all of the MOs with the exception of MO3 due to dam
371 breaching. The following measures are available under the lower Snake River projects:

- 372 • Navigation-objective reservoir operation (on temporary basis until dredging is
373 implemented)
- 374 • Navigation channel and other dredging
- 375 • Dredging to improve conveyance capacity
- 376 • Beneficial use of dredged material
- 377 • In-water placement of dredged material
- 378 • Upland placement of dredged material
- 379 • Reservoir drawdown to flush sediments (drawdown)
- 380 • Reconfigure affected facilities
- 381 • Relocate affected facilities
- 382 • Raise Lewiston levees to manage flood risk
- 383 • Bendway weirs

- 384 • Dikes and dike fields
- 385 • Agitation to resuspend sediments
- 386 • Trapping upstream sediment (in reservoir)

387 **RFFA16 – Seli’s Ksanka Qlisper’ Dam (formerly Kerr Dam).** Operations of the Seli’s Ksanka
388 Qlisper’ Dam (SKQ) dam primarily affect habitat downstream in the lower Flathead River and
389 cause entrainment of fish out of Flathead Lake. A matrix of RFFAs as relates to potentially
390 affected resources is provided in Table 6-2.

391 **RFFA17 – Invasive Species Management.** Non-native and invasive plants and animals are
392 currently damaging biological diversity and ecosystem integrity across the Columbia River Basin
393 and within the study area. Aquatic species are of particular concern because they spread
394 rapidly and can quickly alter the function of an ecosystem. Throughout the study area, the co-
395 lead agencies, as managers of the lands and waters within their jurisdiction, are involved with
396 cooperative weed management efforts, invasive species prevention and eradication, and
397 vegetation treatments. Common invasive species and the types of effects they have on the
398 environment are described in Section 3.6.2.2.

399 **RFFA18 – Marine Energy and Coastal Development Projects.** Coastal development occurs
400 along the Pacific Northwest coastline. Potential effects include vessel strikes from increased
401 shipping traffic, noise from increased vessel traffic, and non-point source pollution from coastal
402 areas (e.g., stormwater runoff). During the past two decades, there has been growing interest
403 in developing sites to explore wave and tidal energy technologies along the West Coast,
404 especially along Oregon and Washington where wave energy potential is the highest in the
405 lower 48 states (Bedard 2005). Examples of such tidal energy projects in planning stages are the
406 Pacific Marine Energy Test Center – South Energy Test Site Wave Test Center of the Oregon
407 coast and the Admiralty Inlet Tidal Energy Project in Puget Sound. These technologies,
408 depending on where they are located, could include effects via entrainments of fish, collisions
409 with marine mammals (e.g., orcas), and obstruction of migration routes for salmonids and
410 marine mammals. In addition, there has been growing interest in developing liquid natural gas
411 (LNG) terminals in coastal areas. Construction and operation of LNG terminals (including effects
412 resulting from LNG shipping traffic) would affect resources within the ocean environments.
413 Leaks, spills, explosions, and release of contaminants could impair water quality or cause
414 physical effects to fish, marine mammals, and other wildlife. It is noted that any tidal energy or
415 LNG projects are speculative at this time but are potentially feasible within the temporal scope
416 of this analysis. Other actions could potentially affect marine mammals, including quantity and
417 quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound
418 and vessels. Oil spills are also a risk factor.

419 **RFFA19 – Climate Change.** Chapter 4 provides a detailed assessment of the potential effects of
420 climate change on the Columbia River Basin, including the results of a 4-year research project
421 completed by the University of Washington and Oregon State University, with resource support
422 and technical expertise provided by the River Management Joint Operating Committee

423 (RMJOC) agencies (Corps, Bonneville Power Administration [Bonneville], and U.S. Bureau of
424 Reclamation). The RMJOC-II report (2018) found the following for the 2020 to 2049 time period
425 (referred to as the 2030s):

- 426 • Temperatures in the region have already warmed about 1.5 degrees Fahrenheit since the
427 1970s. Temperatures are expected to warm another 1 to 4 degrees Fahrenheit by the
428 2030s.
- 429 • Warming in the region is likely to be greatest in the interior with a greater range of possible
430 outcomes. Less pronounced warming is projected near the coast.
- 431 • Future precipitation trends are more uncertain, but a general upward trend is likely for the
432 rest of the twenty-first century, particularly in the winter months. Already dry summers
433 could become drier.
- 434 • Average winter snowpacks are very likely to decline over time as more winter precipitation
435 falls as rain instead of snow, especially on the U.S. side of the Columbia River Basin.
- 436 • By the 2030s, higher average fall and winter flows, earlier peak spring runoff, and longer
437 periods of low summer flows are very likely. The earliest and greatest streamflow changes
438 are likely to occur in the Snake River Basin, although that is also the basin with the greatest
439 modeling uncertainty.
- 440 • The incidence of large forest fires has increased since the early 1980s and is projected to
441 continue increasing as temperatures rise. Wildfire alters the land surface and can have
442 strong influences on runoff generation, vegetation dynamics, erosion and sediment
443 transport, and ecosystem processes. Strong seasonality and dependence on spring
444 snowmelt positions the basin to be at risk for increased fires due to the effects of climate
445 change.

446 The RMJOC-II report (2018) concludes, "...such precipitation increases, along with a warming
447 climate, could have profound implications on both the magnitude and seasonality of future
448 streamflows for hydroregulation operations and planning."

449 **RFFA20 – Clean Water Act–Related Actions.** In addition to maintaining or improving water
450 quality through numerous smaller permitting actions, there are also a number of ongoing
451 specific actions related to Clean Water Act (CWA) compliance that are anticipated to maintain
452 or improve water quality. Some of the important efforts include the following:

- 453 • Columbia-Snake River Water Temperature TMDL – The U.S. Environmental Protection
454 Agency (EPA) is working with the States of Oregon, Idaho, and Washington; the Columbia
455 River Basin tribal governments; Federal agencies; public utility districts; and industrial and
456 municipal dischargers to develop a temperature TMDL for the Columbia and lower Snake
457 Rivers. The TMDL is focused on sources of heat that contribute to temperature impairments
458 in the Columbia and lower Snake Rivers.

- 459 • Idaho Power Hells Canyon Complex Water Quality Certification and Settlement Agreement
460 – Water quality certification for the Idaho Power Hells Canyon Complex (Brownlee, Oxbow,
461 and Hells Canyon Dams on the Snake River in the southern part of Hells Canyon along the
462 Oregon-Idaho border) were issued in mid-2019. The certifications, meant to ensure
463 compliance with water quality standards, include actions aimed at improving fish habitat
464 and water quality in the Snake River and its tributaries. In addition to habitat restoration
465 and fish placement, operational improvements will aim to cool water in the river for
466 spawning and increased survival. These operational changes could have a cumulative
467 beneficial effect on lower Snake River water quality temperatures. For example, Idaho
468 Power will operate Brownlee Dam to reduce the temperature of water released from the
469 dam, which is expected to reduce stress on all fish and aquatic life.

470 **RFFA21 – Idaho Power Hells Canyon Complex Mercury Contamination Issues/Remediation.**

471 The Hells Canyon Complex has legacy mercury contamination and atmospheric deposition that
472 is currently being studied. Research suggests that the dams combined with certain water
473 quality conditions may be creating an environment that is efficient at converting inorganic
474 mercury to methylmercury. Based on recent data collected, methylmercury concentrations and
475 mercury in the form of methylmercury found in both sediments and deeper in the water
476 column are substantially elevated compared to other natural waters and reservoirs in Idaho,
477 Oregon, and Washington. Methylmercury concentrations in fish tissue generally increase
478 downstream through the Hells Canyon Complex, followed by a decrease downstream of Hells
479 Canyon Dam toward the confluence of the Snake and Salmon Rivers (USGS 2016). Remediation
480 actions are possible to overlap in time and space with the CRS, but it is unclear at this point of
481 what the timing and extent of remediation would be. As stated in the Hells Canyon Complex
482 Section 401 certification, “the downstream effect of the methyl mercury values will be
483 evaluated if a pump system or any temperature control structure that accesses Brownlee
484 Reservoir hypolimnion water is proposed.”

485 **RFFA22 – Idaho Power Hells Canyon Complex Temperature Issues.** There are known
486 temperature water quality standard exceedances caused in the fall coming out of the HCC.
487 Brownlee Reservoir drafts also have potential to exceed desired temperatures during summer
488 migration.

489 **RFFA23 – Mining in Reaches Upstream of CRS Dams.** Canadian mining operations continue to
490 increase, creating water quality problems in the U.S. rivers downstream due to the discharge of
491 heavy metals such as arsenic, cadmium, mercury, and lead. In a case brought by the
492 Confederated Tribes of the Colville Reservation (Colville Tribes), the U.S. Court of Appeals for
493 the Ninth Circuit recently held that Canadian mining company Teck is responsible for
494 discharging thousands of tons of heavy metals that have flowed downstream into Washington
495 State and Lake Roosevelt. There are also ongoing remediation projects related to mining on the
496 Spokane arm of Lake Roosevelt, including the Midnight Mine cleanup.

497 **RFFA24 – Hanford Site.** The Hanford Site is a former nuclear production facility located along
498 the Columbia River near Richland, Washington, upstream of the confluence with the Snake
499 River. Cleanup of the Hanford Site started in 1989 and is anticipated to continue.

500 **RFFA25 – Columbia Pulp Plant.** This straw pulp plant was recently constructed in Lyons Ferry
501 near Starbuck, Washington. The company’s start-up process began in October 2019, and the
502 company expects to reach full commercial production midyear in 2020. Once in full service, it
503 will process 140,000 tons of straw per year, taking what has historically been a waste product
504 and turning it into pulp used to make paper and other products, such as specialty papers,
505 tissue, and packaging products. The plant employs around 100 persons. In addition to
506 producing pulp from straw and alfalfa, it is expected to produce up to 95,000 tons per year of
507 lignin and sugar, which can be used for transportation and agricultural purposes such as
508 deicing, dust control, and spray adjuvants. Columbia Pulp selected this location because it is
509 one of the densest wheat-farming regions in North America, and states that it has growth plans
510 for the future, saying that further mills might be built in the region. The site is a minor source of
511 air emissions. It will not funnel any wastewater back into the water table. The mill uses natural
512 gas and co-generates its own steam and electricity.

513 **RFFA26 – Middle Columbia Dam Operations.** These dams include the five middle Columbia
514 River dams between Chief Joseph Dam and the Snake River confluence. Changes in flows from
515 the middle Columbia River dams affect power generation and aquatic species and their habitat
516 on the lower river. All five dams have fish passage structures and fish passage survival rates are
517 similar to CRS dams.

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519 **Table 6-2. Reasonably Foreseeable Future Actions and Potentially Affected Resources Matrix**

RFFA ID	Hydrology and Hydraulics	River Mechanics	Water Quality	Anadromous Fish	Resident Fish	Wildlife	Vegetation, Wildlife, Wetlands, and Floodplains *	Power and Transmission	Air Quality and GHG	Power and Transmission	Flood Risk Management	Navigation and Transportation	Recreation	Fisheries	Water Supply	Environmental Justice	Visual Resource	Noise	Fisheries	Cultural Resources	Indian Trust Assets, Tribal Perspectives, and Tribal Interests	Environmental Justice
RFFA1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
RFFA2	X	X	X	X	X	X	X	-	-	X	X	X	X	X	X	X	-	-	X	X	X	X
RFFA3	X	-	X	X	X	X	X	X	X	X	X	-	-	-	-	X	X	X	-	X	X	X
RFFA4	X	-	X	-	-	X	X	X	X	X	X	-	-	-	-	X	-	X	-	X	X	X
RFFA5	-	X	-	X	X	X	X	-	X	-	-	-	-	X	-	X	-	-	X	X	X	X
RFFA6	X	X	-	X	X	X	X	-	-	-	X	-	X	-	X	X	-	-	-	X	X	X
RFFA7	-	-	-	X	X	X	X	-	-	-	-	-	X	X	-	X	-	-	X	-	X	X
RFFA8	-	-	-	X	X	-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-
RFFA9	-	-	-	-	X	-	-	-	-	-	-	-	-	X	-	X	-	-	X	X	X	X
RFFA10	-	-	-	-	X	-	-	-	-	-	-	-	-	X	-	X	-	-	X	X	X	X
RFFA11	-	-	-	-	X	-	-	-	-	-	-	-	X	X	-	-	-	-	X	-	X	X
RFFA12	-	-	-	X	X	X	X	-	-	X	-	-	X	X	-	X	-	-	X	X	X	X
RFFA13	-	-	-	X	X	X	X	-	-	-	-	-	X	X	-	X	-	-	X	X	X	X
RFFA14	-	X	X	X	X	X	X	-	-	-	-	X	X	-	-	X	-	-	-	-	X	X
RFFA15	-	X	X	X	X	X	X	-	-	-	-	X	-	-	-	X	-	-	-	X	X	X
RFFA16	X	-	-	-	-	-	X	-	-	X	-	-	-	-	-	X	-	-	-	-	X	X
RFFA17	-	-	-	X	X	X	X	-	-	-	-	-	-	X	-	-	-	-	X	X	X	X
RFFA18	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-	X	-	-	X	-	X	X
RFFA19	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-	-	X	X	X	X
RFFA20	-	X	X	X	X	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	X	X
RFFA21	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X
RFFA22	-	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
RFFA23	-	X	X	X	X	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	X	X
RFFA24	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	X
RFFA25	-	-	X	-	-	-	X	-	-	-	-	-	-	-	X	-	X	X	-	X	X	X
RFFA26	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	X	X

520 * For Vegetation, Wildlife, Wetlands, and Floodplains: Not every RFFA affects each resource; please see Resource section below for more information.

521 ** For Indian Trust Assets, Tribal Perspectives, and Tribal Interests: Not every RFFA affects each resource; please see Resource section below for more information

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524 **6.3 CUMULATIVE EFFECTS ANALYSIS**

525 This section identifies affected resources; briefly summarizes their direct and indirect effects as
526 analyzed in Chapter 3; identifies applicable cumulative actions and trends that may be additive;
527 and, finally, analyzes the potential cumulative effects to the resources.

528 **6.3.1 Analyses**

529 **6.3.1.1 Hydrology and Hydraulics**

530 RFFAs with potential to affect the hydrology and hydraulics in the CIAA are listed in Table 6-3
531 along with a description of the effects of these actions.

532 **Table 6-3. Reasonably Foreseeable Future Actions Relevant to Hydrology and Hydraulics**

RFFA ID	RFFA Description	Impact Description
RFFA1	Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development	Overall, there would be an adverse cumulative effect from reduced availability of water from increased demand and thus consumptive use. Increased consumer demands for power could change the shape of hydropower generation patterns.
RFFA2	Water Withdrawals for Municipal, Agricultural, and Industrial Uses	Overall, there could be an adverse cumulative effect from reduced availability of water from increased demand. Increased demands for power could change the shape of hydropower generation from existing patterns.
RFFA3	New and Alternative Energy Development	Increased generation from wind, solar, and natural gas projects could decrease the demand for average hydropower generation, though wind and solar projects would increase the demand for hydropower flexibility. Changes in generating resources and new transmission line projects would shift power flows through the transmission system.
RFFA4	Increasing Use of Renewable Energy Sources, Industrial and Vehicle Emissions Reductions, and Decarbonization	There would be possible adverse effects due to the potential for an increase in lack-of-market/lack-of-turbine-capacity spill, which could lead to higher TDG levels. Conversely, decarbonizing and electrifying transportation and other sectors could reduce involuntary spill from lack of market.
RFFA6	Increase in Demand for New Water Storage Projects	With new storage projects there would be potential changes to the timing of delivery and quantity of water in different locations.
RFFA19	Climate Change	In general, there is potential for higher average fall and winter flows, earlier peak spring runoff, and longer periods of low summer flows in the Columbia River Basin. A detailed description of the potential effects on hydrology and hydraulics from climate change is presented in Section 4.2.1.

533 Humans require water for urban, rural, commercial, industrial, and agricultural development.
534 As land development intensifies, so will the demands for water. Water withdrawals will in turn
535 increase to support these uses. Continuous population growth in the Columbia River Basin will
536 therefore place increased demands and heighten competition for limited water supplies (ISAB
537 2007b). The effects of increasing water demand will be exacerbated by climate change effects

538 on the quantity and temperature of summer stream flows in many subbasins (ISAB 2007a).
539 Hurd et al. (1999) conclude that consumptive uses of water in the western United States are
540 relatively vulnerable to climate change. They note that intensive water use is associated with
541 intensive development. In the Columbia River Basin, curtailment of consumptive water uses in
542 favor of instream uses is possible, especially if the watershed is susceptible to drought and
543 extreme events (ISAB 2007a). Increases in surface water use are expected to be accompanied
544 by increases in groundwater use from rural development. Increased ground or surface water
545 withdrawals could be required by state or federal laws to offset their effect by conserving water
546 or providing storage water during times it is beneficial to the waterbody.

547 Energy development as part of a trend of increased use of new and alternative energy sources
548 (such as wind, solar, and natural gas projects) also has the potential to impact hydrology and
549 hydraulics by shifting electric power consumption demands and thus changing the nature of
550 flows that are associated with hydropower production.

551 The general trend in increased water storage needs in the Columbia River Basin also has the
552 potential to impact hydrology and hydraulics through impoundment of additional water in the
553 future, making less water available downstream.

554 **NO ACTION ALTERNATIVE**

555 There could be substantial effects to hydraulics and hydrology (changes from existing condition)
556 under the No Action Alternative from cumulative actions such as climate change. However, the
557 contribution of the No Action Alternative to these combined cumulative effects would be
558 negligible on its own, because the No Action Alternative operations do not appreciably change
559 the hydrology and hydraulics in the Columbia River Basin from the existing conditions as
560 described in Chapter 3. The existing condition is strongly influenced by the construction and
561 operation of numerous dams—both Federal and non-Federal—that were authorized and built
562 throughout the basin for flood control, hydropower, fish and wildlife conservation, navigation,
563 recreation, irrigation, municipal and industrial water supply, and water quality.

564 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

565 RFFAs with the potential to contribute cumulative effects to hydrology and hydraulics are
566 described in Table 6-3. The direct and indirect effects of MO1 compared to the No Action
567 Alternative are summarized in Table 6-4.

568 **Table 6-4. Hydrology and Hydraulics Direct/Indirect Effects from Multiple Objective**
569 **Alternative 1 Compared to the No Action Alternative**

Project	MO1
Libby	At the Libby project, there would be higher water levels in the summer through December and lower levels in April. There would also be higher releases from Libby for much of the winter, but lower releases in December, May, and August.
Hungry Horse	At Hungry Horse, there would be lower water levels for most months in average and below-average water years. There would also be a reduction in releases for most of the year except for higher releases in the summer.
Grand Coulee	At Grand Coulee, there would be lower water levels from December through April, increased outflow in December, and decreased outflow from February through September.
Dworshak	At Dworshak, there would be changes in late summer releases with increases in June, July, and September, and a decrease in August.
Lower Snake River	In the lower Snake River projects, there would be higher elevations from April through August and increase in flows in June, July, and September.
Lower Columbia River	At the John Day project, there would be higher elevations in April through May. There would also be increased flows in December and decreased flows from February through September. There would be lower winter peak flows below Bonneville Dam.

570 At Libby, higher water levels in the reservoir in the summer may partially be offset by projected
571 decreased volumes of water in the summer from cumulative actions, including climate change.

572 At Hungry Horse, projected lower water levels in the reservoir and a general reduction in
573 releases may be partially offset by higher winter and spring water volumes from climate
574 change, but exacerbated in the summer by decreased volumes of water from cumulative
575 actions, such as new water uses.

576 At Grand Coulee, lower reservoir elevations in the spring may be offset by increased spring
577 runoff as a consequence of climate change. Reduced summer flows, on the other hand, could
578 be reduced even further as a result of cumulative actions, such as increasing water
579 withdrawals. At Dworshak, increased releases in late summer could offset lower summer base
580 flows; however, the lower flows in August may be lower when considered in light of the effects
581 of cumulative actions.

582 In the lower Snake River projects, slightly higher reservoir elevations in the spring may be even
583 higher when combined with cumulative effects. However, predicated higher reservoir
584 elevations may be reduced in summer months because of lower water volumes from
585 cumulative actions.

586 In the lower Columbia River projects, higher April, May, and December flows may be increased
587 further by higher climate change–related spring flows and winter flows. Decreased February to
588 September flows may be even lower with the addition of the effects of cumulative actions.

589 Combined with the effects of the cumulative actions identified in Table 6-3, there could be
590 moderate effects (changes from No Action Alternative) under MO1 in circumstances where

591 MO1 causes higher volumes in the winter and spring and lower volumes of water in the
592 summer.

593 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

594 RFFAs with the potential to contribute to cumulative effects to hydrology and hydraulics are
595 described in Table 6-3. The direct/indirect impacts of MO2 compared to the No Action
596 Alternative are summarized in Table 6-5.

597 **Table 6-5. Hydrology and Hydraulics Direct/Indirect Effects from Multiple Objective**
598 **Alternative 2 Compared to the No Action Alternative**

Project	MO2
Libby	At Libby, there would be higher water levels in the summer through October; the reservoir would be lower in November and December and from January through April in drier years. There would also be higher flows in November through December and lower releases from January through May, and in August.
Hungry Horse	At Hungry Horse, there would be lower water levels for most months in average and below-average water years. There would be a reduction in releases for most of the year except in August and September.
Grand Coulee	At Grand Coulee, the reservoir would be lower from December through May in wet and dry years and deeper in September. Flows below the dam would be higher in December and lower in February for average years and higher in wet years. There would be lower flows from March through August.
Dworshak	Deeper drafts from January through April; increases in flow in January and February; less flows in March and April
Lower Snake River	In the Lower Snake River there would be increased flows (but in normal operating range).
Lower Columbia River	There would be variations in McNary and John Day flows and lower winter peak flows below Bonneville Dam.

599 At Libby, higher water levels in the reservoir in the summer may be partially offset by projected
600 decreased volumes of incoming water in the summer from cumulative actions, such as climate
601 change. Projected lower reservoir levels in drier years in the winter and spring may also be
602 partially offset by higher winter and spring runoff due to climate change. Higher outflows in
603 November and December may be increased by higher winter and spring runoff, and periods of
604 lower releases in the summer may be made lower by the effects of climate change, including
605 lower summer inflows, combined with other cumulative actions. At Hungry Horse, projected
606 lower water levels in the reservoir and a general reduction in releases may be partially offset by
607 higher incoming winter and spring water volumes from climate change, but exacerbated in the
608 summer by decreased volumes of inflows from cumulative actions.

609 At Grand Coulee, deeper drafts from December through May in wet and dry years may be even
610 deeper due to increased winter and spring runoff. Lower flows in the summer may be even
611 lower from the effects of the cumulative actions.

612 At Dworshak, deeper drafts from January through April and increased flows in January and
613 February may both be more extreme as a result of an increase in winter and spring runoff. The
614 effects of lower flows in March and April may be partially offset by increased spring runoff.

615 In the lower Columbia River projects, lower winter peak flows below Bonneville Dam may be
616 partially offset by higher winter runoff.

617 Combined with the effects of the RFFAs on hydrology and hydraulics, there could be moderate
618 effects (changes from the No Action Alternative) under MO2 in circumstances where MO2
619 causes higher volumes of water in the winter and spring and lower volumes of water in the
620 summer.

621 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

622 RFFAs with the potential to contribute to cumulative effects to hydrology and hydraulics are
623 described in Table 6-3. The direct/indirect effects of MO3 compared to the No Action
624 Alternative are summarized in Table 6-6.

625 **Table 6-6. Hydrology and Hydraulics Direct/Indirect Effects from Multiple Objective**
626 **Alternative 3 Compared to the No Action Alternative**

Project	MO3
Libby	At Libby, there would be higher water levels in the reservoir in summer through October and the reservoir would be deeper in November through April in drier years. There would be higher flows below the dam in November and December and lower releases in January through May and August.
Hungry Horse	At Hungry Horse, there would be lower water levels in the reservoir for most months in average and below average water years. There would be a reduction in releases from the dam for most of the year except for August and September.
Grand Coulee	At Grand Coulee, water levels in the reservoir would be higher in winter. Flows below the dam would be higher in November and December and lower from April through September.
Lower Snake River	There would be substantial fluctuations in elevations—up to a 100-foot decrease in the Lower Snake River. Flows would increase with drawdown, and then after breach is complete, flows would return to natural river-like flows.
Lower Columbia River	In the lower Columbia River, John Day would continue to operate at full pool.

627 At Libby, higher water levels in the reservoir in the summer and fall may partially offset
628 decreased volumes of water in the summer resulting from cumulative actions, including climate
629 change. Lower releases and therefore greater storage in January and May due to MO3 may
630 partially offset decreased volumes of water due to cumulative actions.

631 At Hungry Horse, projected lower water levels in the reservoir and a general reduction in
632 releases may be partially offset by higher winter and spring water volumes from climate
633 change, but exacerbated in the summer by decreased volumes of water from cumulative
634 actions.

635 At Grand Coulee, higher water levels in the reservoir in winter may be increased further
636 through increased winter precipitation due to climate change.

637 Combined with the effects of the cumulative actions identified in Table 6-3, there could be
638 moderate cumulative effects (changes from the No Action Alternative) on hydrology and
639 hydraulics under MO3 in circumstances where MO3 causes higher volumes of water in the
640 winter and spring and lower volumes of water in the summer. Volume shifts are due to changes
641 in storage project operations. MO3 has major direct and indirect effects to hydraulics and
642 hydrology from the breach of the Snake River dams. These changes would be the largest
643 influence on hydrology and hydraulics in this area rather than cumulative actions.

644 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

645 RFFAs with the potential to cause cumulative effects to hydrology and hydraulics are described
646 in Table 6-3. The direct/indirect effects of MO4 compared to the No Action Alternative are
647 summarized in Table 6-7.

648 **Table 6-7. Hydrology and Hydraulics Direct/Indirect Effects from Multiple Objective**
649 **Alternative 4 Compared to the No Action Alternative**

Project	MO4
Libby	At Libby, there would be higher reservoir water levels in summer through December in above average precipitation years, but lower water levels in below average years. Below the dam, there would be higher releases in winter and July, but lower releases in December, April, and May.
Hungry Horse	At Hungry Horse, there would be lower reservoir water levels (10 to 15 feet) in the drier half of years. There would be reduced releases below the dam most of year, except for higher releases from July through September.
Albeni Falls	Lake Pend Oreille would be up to 2.7 feet lower in summer months during dry years.
Grand Coulee	Water levels in Lake Roosevelt would be 5 to 8 feet lower during drawdown (December through March) and during refill (May through June), and larger decreases (up to 20 feet) in July and August during low water years. Most months have a reduction in releases from the dam, except December and January, and the drier half of years in May through July.
Lower Snake River	Water levels would be higher during minimum operating pool (MOP) from April to August. Under MO4, MOP starts and ends earlier than in the No Action Alternative.
Lower Columbia River	Water levels at Lake Umatilla would be slightly lower, with other projects at substantially lower elevations. There would be increased flows in December and January with decreases in February and November, except from May through July in dry years. There would be lower winter peak flows below Bonneville Dam.

650 At Libby, higher water levels in the reservoir in the summer during average years may partially
651 be offset by projected decreased volumes of water in the summer from cumulative actions,
652 including climate change. Higher releases in winter may be increased due to an increase in
653 winter and spring runoff resulting from climate change.

654 At Hungry Horse, projected lower water levels in the reservoir and a general reduction in
655 releases may be partially offset by higher winter and spring water volumes from climate change

656 and exacerbated in the summer by decreased volumes of water from cumulative actions.
 657 Behind Albeni Falls Dam in Lake Pend Oreille, a decrease in elevation up to 2.7 feet in the
 658 summer months during dry years would be further exacerbated by lower summer volumes due
 659 to the effects of cumulative actions. Cumulative actions would have a similar effect at Grand
 660 Coulee, where water levels are also projected to be lower under MO4.

661 In the lower Snake and lower Columbia River projects, winter flows may be higher, during some
 662 years, but spring flows are more likely to be lower, except in dry years when storage projects
 663 draft additional water. Recovery of the additional draft may be harder in the future due to
 664 climate change, increased water withdrawals, and other cumulative actions that reduce the
 665 amount of water. Combined with the effects of the cumulative actions identified in Table 6-3
 666 and climate change, there could be moderate cumulative effects (changes from the No Action
 667 Alternative) under MO4 in circumstances where MO4 causes lower spring flows.

668 **6.3.1.2 River Mechanics**

669 RFFAs with potential to affect the geomorphology and sediment transport in the CIAA are listed
 670 in Table 6-8 along with a summary of the effects of these actions.

671 **Table 6-8. Reasonably Foreseeable Future Actions Relevant to Geomorphology and Sediment**

RFFA ID	RFFA Description	Impact Description
RFFA1	Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development	There would be reduced availability of water from increased development. More frequent or more severe drawdowns (or both) could lead to increased head-of-reservoir sediment mobilization and shoreline exposure/erosion. An increase in development projects has the potential to increase sediment input during construction and operation.
RFFA2	Water Withdrawals for Municipal, Agricultural, and Industrial Uses	Overall, there is potential for reduced availability of water from increased demand. More frequent or more severe drawdowns (or both) could lead to increased head-of-reservoir sediment mobilization and shoreline exposure/erosion.
RFFA5	Federal and State Wildlife and Lands Management	Public land management practices can influence the type and amount of sediment entering the system.
RFFA6	Increase in Demand for Water Storage Projects	An increase in water storage projects in the upper Columbia River Basin has the potential to trap additional sediment.
RFFA14	Lower Columbia River Dredged Material Management Plan	This project maintains the federally authorized navigation channel by removing accumulated sediment and depositing it in upland locations or other locations in the river. Other measures, such as channel training device construction, are potentially available.
RFFA15	Snake River Sediment Management Plan	This project maintains the federally authorized navigation channel by removing accumulated sediment and depositing in upland locations or other locations in the river. Other measures such as reservoir drawdowns are potentially available.

RFFA ID	RFFA Description	Impact Description
RFFA19	Climate Change	Changes in climate have the potential to influence erosion, transport of sediment, and sediment deposition. More frequent or more severe drawdowns could lead to increased head-of-reservoir sediment mobilization and shoreline exposure/erosion. A detailed description of the potential effects on geomorphology and sediment transport from Climate Change is presented in Section 4.2.2.
RFFA20	Clean Water Act–Related Actions	Minimizes sediment inputs in areas sensitive to sedimentation through continuation of stormwater permit actions for construction projects and programs related to reducing non-point sources of excess sediment.
RFFA23	Mining Upstream of CRS Dams	Similar to other development projects, mining projects have the potential to increase sediment input during construction and operations.

672 Land use and precipitation are important drivers for sediment erosion and yield into the river
673 system. Land use is anticipated to follow similar patterns as currently experienced, with
674 discrete population centers in some areas, but with a large portion of the watershed held as
675 public lands. Sources of sediment such as agricultural fields are expected to continue cultivation
676 in a manner similar to current conditions. There is a potential for lower availability of water in
677 the summer from the effects of future human development and water withdrawals combined
678 with the effects of climate change. This effect has the potential to increase the instances of
679 reservoir drawdowns that could leave reservoir deltas exposed during high-flow periods. In
680 these instances, the upper layer of reservoir deltas would be eroded and transported farther
681 into the reservoir, potentially increasing turbidity and downstream sediment deposit thickness.
682 Changes in storage project elevations or changes to the flow of water and sediment into a
683 reservoir can result in changes to head-of-reservoir erosion and deposition patterns. Changes in
684 the hydraulic conditions within run-of-river reservoirs and river reaches can change the ability
685 of the river to transport sediment high in the water column, potentially changing the size of
686 material passing through or settling in a run-of-river reservoir or free-flowing reach. Lower
687 summer flows due to future water demand and climate change could exacerbate changes in
688 sediment transport character of affected reaches.

689 New agricultural, industrial, mining, and commercial and rural construction projects have the
690 potential to increase the amount of sediment inputs into the system. The effects from these
691 types of projects would continue to be minimized through CWA–related permitting actions. The
692 general trend in increased water storage needs in the Columbia River Basin also has the
693 potential to affect sediment transport through impoundment of additional water in the future,
694 resulting in less available sediment downstream. Large-scale sediment management projects in
695 the Snake River and lower Columbia River would lessen the impact of excess sedimentation in
696 these reaches through sediment removal and placement actions.

697 **NO ACTION ALTERNATIVE**

698 Combined with the effects of the RFFAs and climate change, there would likely be additional
699 effects to sediment processes (changes from existing condition) under the No Action

700 Alternative. As discussed in Section 3.3.3.2, the effects of the No Action Alternative do not
701 appreciably change the geomorphology and sediment processes, or the closely related
702 hydrology and hydraulics, of the CRS from the existing conditions.

703 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

704 RFFAs with the potential to contribute to cumulative effects to geomorphology and sediment
705 transport are described in Table 6-8. The direct/indirect impacts of MO1 compared to the No
706 Action Alternative are summarized in Table 6-9.

707 **Table 6-9. Multiple Objective Alternative 1 Direct/Indirect Effects Compared to the No Action**
708 **Alternative**

Location	MO1
Storage Projects (Libby, Hungry Horse, Albeni Falls, Grand Coulee, John Day, Dworshak)	There would be negligible change (from existing conditions) in head-of-reservoir sediment mobilization with the exception of the Columbia River entering Lake Roosevelt. There is a small change in depositional patterns with temporary head-of-reservoir deposits shifting downstream caused by the Winter System FRM Space measure at Grand Coulee. There would be negligible change in trap efficiency and shoreline exposure.
Run-of-River Reservoirs and Free-Flowing Reaches (Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, The Dalles, Bonneville)	There would be negligible change in potential for sediment to pass run-of-river reservoirs and free-flowing reaches with the exception of lower Clearwater River above the Snake River confluence. There is potential for a small decrease in the amount of sediment passing the Clearwater River at the Snake-Clearwater confluence due to the Modified Dworshak Summer Draft measure operation. There would be negligible change in processes that supply, transport, and deposit sediment in the system, with the exception of Lake Roosevelt upper reach on the Columbia River. There is potential for a small amount of coarsening of bed sediment at the head of Lake Roosevelt caused by the Winter System FRM Space measure at Grand Coulee. There would be negligible change in the overall geomorphic character of the rivers. There would be less than 1 percent change from the No Action Alternative in the average annual volume of sediment deposited in the Snake River and Columbia River navigation channel.

709 At storage projects, direct and indirect effects to sediment processes would be negligible
710 except for the Columbia River entering Lake Roosevelt. There is a minor effect in depositional
711 patterns with temporary head-of-reservoir deposits shifting downstream caused by the Winter
712 System FRM Space measure at Grand Coulee. There could be increases in drawdowns in the
713 future from the effects of climate change and increased demand for water that could cause
714 detectable changes to sediment processes at other storage projects and could increase the
715 small changes in reservoir sediment mobilization at Grand Coulee.

716 In run-of-river projects and river reaches, there would be negligible effects in sediment
717 processes except for potential small decreases in the amount of sediment passing the
718 Clearwater River at the Snake River confluence. Similar to storage projects, there is potential for
719 cumulative actions such as climate change and increased water withdrawals that could increase

720 these effects in the future and cause detectable effects to sediment processes in other run-of-
721 river projects and river reaches.

722 It is unknown to what magnitude climate change, increased demand for water, and other
723 cumulative actions identified in Table 6-8 may impact future sediment processes. However,
724 given that MO1 effects are predicted to be minor or negligible, the contribution to these
725 cumulative effects from MO1 would likely not be substantial. Combined with the effects of the
726 cumulative actions and climate change, there could be increased effects under MO1 in
727 circumstances where MO1 is projected to cause minor changes on its own, and there could be
728 detectable changes where MO1 is currently projected to cause negligible effects.

729 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

730 RFFAs with the potential to contribute to cumulative effects to sediment processes are
731 described in Table 6-8. The effects of MO2 compared to the No Action Alternative are
732 summarized in Table 6-10.

733 **Table 6-10. Direct/Indirect Effects of Multiple Objective Alternative 2 Compared to the No**
734 **Action Alternative**

Location	MO2
Storage Projects (Libby, Hungry Horse, Albeni Falls, Grand Coulee, John Day, Dworshak)	There would be a negligible impact to erosion or deposition processes and patterns at the head of storage project reservoirs, except at Dworshak Reservoir, where there is a minor impact to depositional patterns with temporary head-of-reservoir deposits shifting downstream. There would be negligible change in trap efficiency and shoreline exposure, except at Dworshak Reservoir, where there is a minor change in shoreline exposure from lower reservoir levels.
Run-of-River Reservoirs and Free-Flowing Reaches (Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, The Dalles, Bonneville)	There would be negligible change in potential for sediment to pass run-of-river reservoirs and free-flowing reaches. There would be negligible change in processes that supply, transport, and deposit sediment in the system with the exception of a small amount of fining of bed sediment in the reach of the Flathead River immediately upstream of SKQ Reservoir, and a small amount of coarsening of bed sediment at the head of Grand Coulee Reservoir. There would be negligible change in the overall geomorphic character of the rivers. There would be less than 1 percent change from the No Action Alternative in average annual volume of sediment deposited in the Snake River and Columbia River navigation channel.

735 At storage projects, direct and indirect effects to sediment processes would be negligible,
736 except at Dworshak Reservoir, where there are potential small changes in deposition with
737 head-of-reservoir deposits shifting downstream and small changes in shoreline exposure. There
738 could be increases in drawdowns in the future from the effects of climate change and increased
739 demand for water that could cause detectable changes to sediment processes at other storage
740 projects and could increase the extent of changes in reservoir sediment mobilization and
741 reservoir shoreline exposure at Dworshak.

742 In run-of-river projects and river reaches, there would be negligible change in sediment
743 processes except for potential small amount of fining of bed sediments in the Flathead River

744 upstream of SKQ Reservoir, and a small amount of coarsening at the head of Grand Coulee.
745 Similar to storage projects, there is potential for cumulative actions such as climate change and
746 increased water withdrawals could increase these effects in the future and cause detectable
747 effects to sediment processes in other run-of-river projects and river reaches.

748 It is unknown to what magnitude climate change, increased demand for water, and other
749 cumulative actions identified in Table 6-8 may impact future sediment processes. However,
750 given that MO2 effects are predicted to be small or negligible, it is likely the contribution of
751 MO2 to the overall cumulative effect would not be substantial. Combined with the effects of
752 the cumulative actions and climate change, there could be increased effects in conjunction with
753 MO2 in circumstances where MO2 is projected to cause minor changes on its own, meaning
754 there could be detectable changes where MO2 is currently projected to cause negligible effects.

755 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

756 RFFAs with the potential to contribute to cumulative effects to geomorphology and sediment
757 processes are described in Table 6-8. The direct/indirect effects of MO3 compared to the No
758 Action Alternative are summarized in Table 6-11.

759 **Table 6-11. Direct/Indirect Effects of Multiple Objective Alternative 3 Compared to the No**
760 **Action Alternative**

Location	MO3
Storage Projects (Libby, Hungry Horse, Albeni Falls, Grand Coulee, John Day, Dworshak)	There would be negligible change in erosion or deposition processes and patterns at the head of storage project reservoirs. There would be negligible change in trap efficiency and shoreline exposure.

Location	MO3
Run-of-River Reservoirs and Free-Flowing Reaches (Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, The Dalles, Bonneville)	<p>There would be little change in the potential for sediment to pass run-of-river reservoirs and free-flowing reaches, except for the Snake River from the upstream extents to Lower Granite Reservoir downstream to the Columbia River and the Clearwater River backwatered by Lower Granite Reservoir. There could be large temporary increases in the size and amount of sediment passing these reaches caused by dam breach. There could also be large temporary increases in the amount of sediment passing from the Snake River into the Columbia River from the Snake River confluence downstream.</p> <p>Current processes that supply, transport, and deposit sediment in the system will continue at historical rates except at the Snake River from the upstream extents to Lower Granite Reservoir downstream to the Columbia River and the Clearwater River backwatered by Lower Granite Reservoir. There is potential for a large amount of coarsening of bed sediment through these reaches. There is also potential for a large increase in the amount of material depositing in McNary Reservoir. The bed material size would be fine in the short term and coarsen in the long term due to upstream dam breach.</p> <p>There would be negligible change in width-to-depth ratios except for the Snake River from the upstream extents to Lower Granite Reservoir downstream to the Columbia River and the Clearwater River backwatered by Lower Granite Reservoir. There would be a major impact in geomorphic character in these reaches with the river becoming much shallower relative to its wetted width because of dam breach.</p> <p>Navigation maintenance is assumed to stop on the Snake River due to dam breach. There would be a 1 percent decrease from the No Action Alternative in average annual volume of sediment depositing in the lower Columbia River.</p>

761 There would be negligible changes at storage projects from implementation of MO3. In run-of-
 762 river projects and river reaches, there would be a negligible change in sediment processes
 763 except for potentially large effects from dam breach on the lower Snake River. The effects from
 764 dam breaching would be major and would be the largest influence on sediment process effects.

765 It is unknown to what degree climate change, increased demand for water, and other
 766 cumulative actions may impact future sediment processes. However, given that MO3 effects
 767 are predicted to be major in some reaches, the cumulative effect would likely be major in areas
 768 impacted by dam breach. Combined with the effects of the cumulative actions and climate
 769 change, there could be increased effects than those previously described in Chapter 3 under
 770 MO3.

771 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

772 RFFAs with the potential to contribute to cumulative effects to geomorphology and sediment
 773 processes are described in Table 6-8. The effects of MO4 compared to the No Action Alternative
 774 are summarized in Table 6-12.

775 **Table 6-12. Effects of Multiple Objective Alternative 4 Compared to No Action Alternative**

Location	MO4
Storage Projects (Libby, Hungry Horse, Albeni Falls, Grand Coulee, John Day, Dworshak)	<p>There would be a negligible change in erosion or deposition processes and patterns at the head of storage project reservoirs, except at the Columbia River and Spokane River entering Grand Coulee Reservoir, where there is potential for a small change in depositional patterns with temporary head-of-reservoir deposits shifting downstream.</p> <p>There is also potential for a small change in head-of-reservoir sediment mobilization with deposits becoming coarser in the Columbia River entering John Day Reservoir.</p> <p>There would be a negligible change in trap efficiency and shoreline exposure, except at Hungry Horse Reservoir, where there is potential for a small change in shoreline exposure.</p>
Run-of-River Reservoirs and Free-Flowing Reaches (Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, The Dalles, Bonneville)	<p>There would be negligible change in potential for sediment to pass run-of-river reservoirs and free-flowing reaches except the Columbia River upstream of Kettle Falls, Washington, to the U.S.-Canada border, where there is potential for a small increase in the amount of sediment passing through the upper reach of Lake Roosevelt.</p> <p>There would be negligible change in the processes that supply, transport, and deposit sediment in the system except at the Columbia River between Grand Coulee Dam and the U.S.-Canada border, where there is potential for a small amount of bed sediment coarsening in Lake Roosevelt and reaches upstream to the border. There is also potential for a small amount of sediment coarsening in the Snake River downstream of Ice Harbor, the Columbia River from the Snake River confluence to Wallula, Washington, the Columbia River at the upstream end of John Day reservoir, and the Columbia River between John Day Dam and Skamania, Washington.</p> <p>The estimated average annual volume of sediment depositing in the Snake River navigation channel and lower Columbia River would be less than a 1 percent change from the No Action Alternative.</p>

776 Small changes in head-of-reservoir sediment deposition at the Columbia River and Spokane
 777 River entering Grand Coulee Reservoir and the Columbia River entering John Day Reservoir may
 778 be exacerbated by the effects of cumulative actions and climate change if additional reservoir
 779 drawdowns occur in the future. Similarly, changes in shoreline exposure at Hungry Horse may
 780 increase. Minor effects in the processes that supply, transport, and deposit sediment in the
 781 system as described in Table 6-12 may also increase.

782 It is unknown to what degree climate change, increased demand for water, and other
 783 cumulative actions may impact future sediment processes. However, given MO4 effects are
 784 predicted to be small or negligible, it is likely the contribution of MO4 to the cumulative effect
 785 to geomorphology and sediment transport would not be substantial. Combined with the effects
 786 of the cumulative actions and climate change, there could be increased effects than those
 787 previously described in Chapter 3.

788 **6.3.1.3 Water Quality**

789 RFFAs with potential to affect the water quality in the CIAA are listed in Table 6-13 along with a
790 description of the effects of these actions.

791 **Table 6-13. Reasonably Foreseeable Future Actions Relevant to Water Quality**

RFFA ID	RFFA Description	Cumulative Impact Description
RFFA1	Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development	There would be adverse effects from increased volumes of pollution in response to a growing population, as human population growth brings potential increases in discharges of pollutants in stormwater runoff from residential, commercial, industrial, agricultural, recreational, and transportation development.
RFFA2	Water Withdrawals for Municipal, Agricultural, and Industrial Uses	There could be adverse effects from increased volumes of water withdrawals for domestic, industrial, commercial, and public uses. Increased withdrawals have implications for instream water temperatures, which is typically the cause of adverse effects by increasing water temperature.
RFFA3	New and Alternative Energy Development	There would be possible adverse effects due to the potential for an increase in lack-of-market/lack-of-turbine-capacity spill, which could lead to higher TDG levels.
RFFA4	Increasing Use of Renewable Energy Sources, Industrial and Vehicle Emissions Reductions, and Decarbonization	There would be possible adverse effects due to the potential for an increase in lack-of-market/lack-of-turbine-capacity spill, which could lead to higher TDG levels. Conversely, decarbonizing and electrifying transportation and other sectors could reduce involuntary spill from lack-of-market spill.
RFFA14	Lower Columbia River Dredged Material Management Plan	In-water and shoreline placement of dredged materials, as well as construction associated with channel training structures, may affect water quality by releasing suspended sediments into the water column and increased turbidity. Effects could be minimized by sediment removal best management practices.
RFFA15	Snake River Sediment Management Plan	Dredging effects on water quality could include the release of suspended sediments into the water column and increased turbidity. Effects could be minimized by sediment removal best management practices.
RFFA19	Climate Change	There would be possible adverse effects from increased air surface temperatures resulting in increased water temperatures. In addition, there is potential for higher winter and spring volumes and lower summer volumes of Columbia River Basin water. Refer to section 4.2.3 for more information.
RFFA20	Clean Water Act–Related Actions	This would likely result in the potential to maintain or improve water quality.

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RFFA ID	RFFA Description	Cumulative Impact Description
RFFA21	Idaho Power Hells Canyon Complex Mercury Contamination Issues/Remediation	This could result in remediation and cleanup actions, as well as lead to a reduction or elimination of fish consumption advisories for mercury in fish tissue, but it is unclear what the timing and extent of remediation would be.
RFFA22	Idaho Power Hells Canyon Complex Temperature Issues	There would likely be ongoing adverse effects due to temperature threshold exceedances in the fall.
RFFA23	Mining in Reaches Upstream of CRS Dams	There would be ongoing adverse effects to both water quality and fish (tissue contamination) due to the release of contaminants downstream from mining activities that are occurring upstream.
RFFA24	Hanford Site	This could result in remediation and cleanup actions, but it is unclear what the timing and extent of remediation would be.
RFFA25	Columbia Pulp Plant	This could increase potential adverse effects due to chemical discharges, water use, and spills.

792 Direct and indirect effects to water quality as a result of the effects analysis in Chapter 3 are
793 listed in Table 6-13 along with a description of the effects.

794 Water quality issues in the Columbia River Basin are linked to water temperature, TDG, and
795 contaminants suspended in both water and sediment. In general, cumulative impact concerns
796 within the CIAA related to water quality are dominated by actions that increase the additive
797 effects of increasing air surface temperatures, which in turn increases water surface
798 temperatures. The main influencing factor in increasing temperatures in the basin is climate
799 change. These temperature effects are described in detail in Chapter 4. In summary, under all
800 MOs including the No Action Alternative, air temperature is projected to continue an ongoing
801 warming trend, resulting in higher temperatures throughout the Columbia River Basin over the
802 study period.

803 Climate change also is very likely to increase the higher winter and spring volumes and lower
804 summer volumes of water runoff throughout the Columbia River Basin. Fall water temperatures
805 are likely to remain warmer for longer. Warmer air temperatures combined with projected
806 decreased summer and fall flow volume could lead to increased riverine and reservoir surface
807 water temperatures. This could exacerbate algal and nutrient problems, cyanobacterial blooms,
808 microbial activity at swim beaches, increase pH, or reduce dissolved oxygen within the region's
809 reservoirs and river reaches. This warming could also increase the prevalence of invasive
810 species (Table 6-14).

811 **Table 6-14. Summary of Direct and Indirect Effects to Water Quality**

Region	MO1	MO2	MO3	MO4
A (Libby)	There is potential for a small increase in TDG downstream of Libby Dam, too warm river water temperatures in winter, and in-reservoir and downstream river water temperatures being colder in the spring/early summer.	There is potential for reduced reservoir productivity and river water temperatures downstream of Libby Dam being warmer in the winter.	Same as MO2	There is potential for a small increase in TDG downstream of Libby Dam, too warm river water temperatures in winter, downstream river water temperatures colder in the spring/early summer, and reduced reservoir productivity.
A (Hungry Horse)	No change from NAA	There is potential for reduced reservoir productivity.	Same as MO2	Same as MO2
A (Albeni Falls)	No change from NAA	No change from NAA	No change from NAA	There is potential for greater amounts of macrophyte and periphyton growth (reduced water quality).
B (Grand Coulee)	Elevated turbidity is possible due to greater reservoir fluctuations. There could be increased mercury methylation from longer reservoir drawdowns. Reduced dissolved oxygen is expected in the reservoir near the Spokane River confluence. Water temperatures downstream of Grand Coulee are expected to be similar to NAA, with conditions that exceed water quality standards in late summer and fall. These warm conditions are likely to be exacerbated by climate change, with a longer period of warm water conditions and likely higher maximum temperatures.	Same as MO1	Same as MO1	Same as MO1
B (Chief Joseph)	In-reservoir and downstream water temperatures would likely be warmer in some summers.	Same as MO1	Same as MO1	Same as MO1

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Region	MO1	MO2	MO3	MO4
C (Dworshak)	Water temperatures downstream of Dworshak would likely be warmer in August to provide cooling to the Lower Snake River.	Decreased spill discharges could create lower amounts of TDG downstream of Dworshak Dam.	No change from NAA	No change from NAA
C (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor)	Water temperatures downstream of Dworshak would likely be warmer in August to provide cooling to the lower Snake River. Increased harmful algae blooms are possible due to high August water temperatures.	No change from No Action	High suspended sediment could create reduced and/or anoxic conditions in Lower Monumental Reservoir under the first year of dam breaching. Dam breaching would resuspend contaminants and increase the biological uptake of contaminants. Contaminated groundwater flows may increase pollution in the lower Snake River once embankments have been breached. Warmer early summer in-river water temperatures are expected.	Higher TDG
D (Four Lower Columbia River Projects)	No change from NAA	No change from NAA	No change from NAA	No change from NAA

813 Water quality issues in the Columbia River Basin are linked to water temperature, TDG, and
814 contaminants suspended in both water and sediment. In general, cumulative impact concerns
815 within the CIAA related to water quality are dominated by actions that increase the additive
816 effects of rising air surface temperatures, which in turn increases water surface temperatures.
817 In general, there are minimal cumulative effects in the basin related to TDG that are not short
818 term and/or minimal. Contaminant pollution from both new and legacy sources are expected to
819 create additive concerns within the basin, in particular when sediments are disturbed, or water
820 surface level fluctuations occur.

821 The main influencing factor in increasing temperatures in the basin is climate change. These
822 temperature effects are described in detail in Chapter 4. In summary, under all MOs, including
823 the No Action Alternative, air temperature is projected to continue an ongoing warming trend,
824 resulting in higher temperatures throughout the Columbia River Basin over the study period.

825 Climate change also is very likely to increase the higher winter and spring volumes and lower
826 summer volumes of water runoff throughout the Columbia River Basin. Fall water temperatures
827 are likely to be higher and remain warmer for longer. Warmer air temperatures combined with
828 projected decreased summer and fall flow volume could lead to increased riverine and
829 reservoir surface water temperatures. This could exacerbate algal and nutrient problems,
830 cyanobacterial blooms, and microbial activity at swim beaches; increase pH; and reduce
831 dissolved oxygen within the region's reservoirs and river reaches. This warming could also
832 increase the prevalence of invasive species.

833 In terms of TDG, there are few additive effects expected within the CIAA. It is possible that the
834 increase in renewable energy development and a reduction in reliance on fossil fuel energy
835 sources could also lead to higher spill (at times when hydropower is taken offline or ramped
836 down to accommodate increasing wind and solar energy, for example). In this case, increasing
837 TDG levels could result. That said, it is unknown how often this would occur or the magnitude of
838 the effect.

839 Within the Columbia River Basin, sediment and water quality vary by location. The uppermost
840 end of the system, such as the area near Hungry Horse Dam, tends to have fewer human
841 influences and thus less pollution. As one moves downstream to more populous areas, sediment
842 pollution is more common, reflecting the land uses occurring in proximity to the reservoir or
843 river reach. Polluted runoff enters the CIAA from adjacent urban, agricultural, and industrial
844 areas as a result of the use of chemicals, pesticides, fertilizers, and herbicides, as well as via
845 contaminants from both historical and new mining and industrial areas, and natural sources,
846 such as mercury in volcanic soils. The contaminants of concern can be detected in sediment, the
847 water column, and aquatic organisms and include metals, arsenic, mercury, PCBs, dioxins,
848 pesticides, and other organic compounds (mostly from human sources). In addition, some
849 reservoirs and reaches, such as Lake Roosevelt and the lower Snake River, have known sediment
850 and water pollution problems related to past industrial discharges and legacy contaminant
851 issues that have not been remediated, as well as new discharges from new mining upstream.

852 Under all MOs, these polluted releases are expected to continue, resulting in additional
853 pollutant loads moving through the river and reservoir system, carried by water and in fine
854 sediments and eventually dispersing downstream through the dams to the riverbeds and the
855 estuary. It is possible that remediation of known contaminated sites will occur; however, at
856 present, this is not reasonably foreseeable to occur and, even if it does occur, may be offset by
857 future increases in mining or other land use changes that disturb soils. New and continued
858 releases of mining-related contaminants such as mercury (which then gets converted to
859 methylmercury) are expected to continue and perhaps even increase under all MOs, especially
860 in Lake Roosevelt as elevated mercury contamination from mining activities upstream is
861 expected to continue over the planning period.

862 **NO ACTION ALTERNATIVE**

863 Under the No Action Alternative, as described above, increasing temperatures are expected to
864 continue to play a large role in terms of additive effects to water quality. Continued and
865 increased pollutant and nutrient loading is expected, due in large part due to population
866 growth, which increases agricultural, industrial, and urban runoff. Continued pollutant and
867 nutrient loading are expected in the lower Snake and Columbia Rivers due to farming activities,
868 industry, and urban and agricultural runoff. Mining-related contaminants such as mercury into
869 Lake Roosevelt are also expected to continue and perhaps increase. Thus, it is expected that the
870 current water quality impairments would continue under the No Action Alternative and could
871 perhaps worsen. It is possible that remediation of known contaminated sites will occur;
872 however, at present, this is not reasonably foreseeable to occur and, even if it does occur, may
873 be offset to some degree by future increases in mining or land use changes that disturb soils.

874 Under the No Action Alternative, winter flows and the frequency of winter flood events are
875 projected to increase in the mainstem and lower Columbia River because of climate change.
876 This could lead to increases in TDG through the winter and early spring due to increased
877 involuntary spill. The lower Columbia River contains a variety of human-sourced compounds,
878 including metals and organic compounds. Portions of the reach from The Dalles to Bonneville
879 Dams are on the Washington or Oregon CWA 303(d) lists for high pH and/or dissolved oxygen.
880 Additionally, some portion of all four reservoirs contain other water quality impairments that
881 manifest as fish advisories or TMDLs for mercury, PCBs, and dioxins. These issues are expected
882 to persist under the No Action Alternative, because changes to the CWA and remediation
883 actions are not at this point reasonably foreseeable.

884 Under the No Action Alternative, decreases in summer flow volumes through the dams on the
885 lower Snake River are expected. The water quality characteristics of the lower Snake River are
886 largely influenced by the local and upstream flows and the inflowing upper Snake River. This
887 includes temperatures exiting the Hells Canyon Complex out of Brownlee Reservoir that exceed
888 water quality standards, creating cumulative temperature effects during summer migration on
889 the lower Snake River. In addition, legacy naturally occurring, and atmospheric deposition of
890 mercury, and other contaminant issues in the Hells Canyon Complex continue to affect the
891 quality of water flowing into the lower Snake River. Adverse conditions could increase potential

892 contaminants in the lower Snake River from the Hells Canyon Complex via selective intake
893 structures.

894 Over the study period, the Hells Canyon Complex relicensing process (certified in 2019) will likely
895 influence future CRS operations, including Dworshak Dam water releases. The certifications,
896 meant to ensure compliance with water quality standards, include actions aimed at improving
897 fish habitat and water quality in the Snake River and its tributaries. In addition to habitat
898 restoration and fish placement, operational improvements will aim to cool water in the river for
899 spawning and increased survival. Cooling water from Dworshak Reservoir is routinely used by
900 the co-lead agencies to mitigate the influx of warm water into the lower Snake River. Under the
901 new certification, however, Idaho Power will operate Brownlee Dam to reduce the temperature
902 of water released from the dam, which is expected to reduce stress on all fish and aquatic life.
903 This could also relieve some of the actions co-lead agencies currently take to mitigate for high
904 temperatures coming out of the Hells Canyon Complex through Dworshak releases. These
905 combined operational changes could have a cumulative beneficial effect on lower Snake River
906 water quality temperatures.

907 Winter flows and the frequency of winter flood events are projected to increase in the lower
908 Snake River and at Dworshak Reservoir under the No Action Alternative. In response to this
909 change, Dworshak Dam could store and evacuate inflow volumes for system winter flood
910 events more frequently than during the historical period. The projected higher volumes and
911 variability in flows could result in increased spill leading to increased TDG from lack-of-market
912 and lack-of-turbine-capacity spill and turbidity during winter months. During spring, the freshet
913 is projected to occur earlier, resulting in an earlier fill period for Dworshak Reservoir and higher
914 outflows in April, which could result in higher TDG in spring and increased reservoir
915 productivity.

916 Under the No Action Alternative for Grand Coulee and Chief Joseph, periods of higher
917 temperatures have the potential to occur earlier in the year and last for longer durations than
918 historically. This could exacerbate algal, nutrient, pH, and dissolved oxygen issues. In the spring,
919 water temperatures could warm earlier in the year because of the projected increase in air
920 temperature. Grand Coulee creates a lagged effect on downstream seasonal water temperature
921 change because the outflow temperature is less than inflow. This thermal lagging from the dam
922 is likely to persist under projected climate change conditions. Flow volume is projected to
923 increase during winter months, which could result in higher outflows and higher spill. Increased
924 inflow and spill volume is likely to result in higher TDG than historical levels during winter. In the
925 summer, TDG could be decreased as a result of projected lower flow volumes.

926 Under the No Action Alternative, nutrients or pollution would remain relatively low in Hungry
927 Horse Reservoir. It is expected that coal production in the Kootenai River watershed above
928 Libby Dam will continue to increase as it has over the past 20 years. This increase will lead to
929 greater selenium and nitrate loadings into Lake Kooconusa and the Kootenai River downstream
930 of Libby Dam. Under the No Action Alternative, the additive effects of higher winter flows and
931 runoff anticipated under climate change may cause suspended solids (nutrients, selenium) to

932 move farther down into the reservoir and downstream of Libby Dam in the Kootenai River.
 933 Runoff in combination with an expected increase in coal production is expected to increase
 934 pollutants in both the reservoir and the river. The continued increase in nitrate loadings to Lake
 935 Kooncanusa could make the lake susceptible to increased algal blooms, including potential
 936 nuisance species, under the No Action Alternative.

937 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

938 In general, water temperature responses at Hungry Horse and Chief Joseph projects under MO1
 939 are expected to be similar to the No Action Alternative. Overall negligible water quality effects
 940 are anticipated for Regions A, B, and D, with the exception of major reductions in TDG below
 941 Grand Coulee Dam in Region B. Minor increase in spill and associated TDG levels are expected
 942 at Libby Dam due to the project’s draft and refill operations.

943 There are no changes to operations expected at Albeni Falls Dam under MO1, so the water
 944 quality in Lake Pend Oreille and the Pend Oreille River is expected to remain unchanged and
 945 reflect conditions as described in the No Action Alternative (see Table 6-15). In Region C under
 946 MO1, moderate adverse effects to water temperature and negligible effects to TDG and other
 947 water quality parameters would likely occur.

948 **Table 6-15. Water Quality Direct/Indirect Effects from Multiple Objective Alternative 1**
 949 **Compared to the No Action Alternative**

Region	MO1
A (Libby)	Effects are expected to be similar to the No Action Alternative, with the exception of a minor increase in spill and associated TDG levels at Libby Dam due to the project’s draft and refill operations.
A (Hungry Horse)	Effects are expected to be similar to the No Action Alternative.
A (Albeni Falls)	Effects are expected to be similar to the No Action Alternative.
B (Grand Coulee)	Effects are expected to be similar to the No Action Alternative, with the exception of major reductions in TDG below Grand Coulee Dam in Region B. Increased seasonal water surface elevations are anticipated to result in an increased amount of mercury that is converted to methylmercury upon rewatering of shorelines. Methylmercury is the more toxic form of mercury that bioaccumulates in fish tissue.
B (Chief Joseph)	Effects are expected to be similar to the No Action Alternative.
C (Dworshak)	Effects are expected to be similar to the No Action Alternative.
C (Lower Snake River)	The Dworshak Temperature Control measure results in significantly higher water temperature than NAA in August and early September. These effects are greatest at Lower Granite and decrease downstream.
D (Lower Columbia River)	Effects are expected to be similar to the No Action Alternative.

950 Under MO1, slightly higher water temperatures would be expected in the lower Snake River
 951 during August due to the Modified Dworshak Summer Draft measure. Under MO1, cool water
 952 would be discharged into the lower Snake River from June 21 to August 1. This measure results
 953 in substantially higher water temperatures than No Action Alternative in August and early

954 September. These effects are greatest at Lower Granite and decrease downstream. This
955 measure could exacerbate potential warming water temperatures from Climate Change.

956 At Grand Coulee, increased seasonal water surface elevations are anticipated to result in an
957 increased amount of mercury that is converted to methylmercury upon rewatering of
958 shorelines. Methylmercury is the more toxic form of mercury that bioaccumulates in fish tissue.
959 This could be exacerbated over the study period if more inflows of mercury into Lake Roosevelt
960 were to occur due to RFFA23, Mining in Reaches Upstream of CRS Dams.

961 In addition, increases in spill and associated TDG levels at Libby Dam are anticipated due to the
962 project’s draft and refill operations. It is not well understood how RFFAs could cumulatively
963 affect this condition, whether adverse or beneficial. Major reductions in TDG below Grand
964 Coulee do not have associated cumulative effects.

965 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

966 Cumulative effects to water quality from MO2 are described in Table 6-16 and discussed in the
967 text below. In general, water temperature response at Grand Coulee, Chief Joseph, and Albeni
968 Falls projects and in the Lower Snake River are expected to be similar to the No Action
969 Alternative. In Region A, negligible to minor improvements to water quality would occur. In
970 Region B, negligible water quality effects would occur, with the exception of major reductions
971 in TDG below Grand Coulee Dam. In Region C, moderate to minor increases in summer water
972 temperatures would occur, while in Region D water temperature effects would be negligible. In
973 Regions C and D, frequency of exceeding state TDG water quality standards would decrease.

974 **Table 6-16. Water Quality Direct/Indirect Effects from Multiple Objective Alternative 2**
975 **Compared to the No Action Alternative**

Region	MO2
A (Libby)	There would likely be adverse effects due to higher outflows, potentially resulting in suspended solids moving farther down into the reservoir and downstream of Libby Dam, and increased downstream water temperature.
A (Hungry Horse)	The Slightly Deeper Draft for Hydropower measure would allow for greater operational flexibility and results in deeper winter drawdowns at Hungry Horse Reservoir. This, in turn, reduces spring outflows and spill in some cases. As a result, the number of days that TDG below the dam is greater than 110 percent under MO2 is expected to be lower than the No Action Alternative in most years.
A (Albeni Falls)	Effects are expected to be similar to the No Action Alternative.
B (Grand Coulee)	Effects are expected to be similar to the No Action Alternative, with the exception of major reductions in TDG below Grand Coulee Dam.
B (Chief Joseph)	Effects are expected to be similar to the No Action Alternative.
C (Dworshak)	Beneficial negligible decreases in TDG are expected at Dworshak in addition to colder water temperatures from April through June, alongside moderate to minor increases in summer water temperatures.
C (Lower Snake River)	Decreases in TDG levels are expected, alongside moderate to minor increases in summer water temperatures.
D (Lower Columbia River)	Decreases in TDG levels are expected.

976 Hungry Horse would experience deeper winter drawdowns under MO2. This, in turn, could
977 reduce spring outflows and spill, thereby potentially reducing TDG below the dam to lower than
978 No Action Alternative levels in most years.

979 Under MO2, a deeper drawdown of Libby Reservoir may help to mitigate for higher inflows
980 anticipated in the winter as a result of climate change. However, deeper reservoir drafts and
981 higher outflows may result in suspended solids (nutrients, selenium) moving farther down into
982 the reservoir and downstream of Libby Dam, and increased downstream water temperatures in
983 the Kootenai River. This, combined with the additive effects of mining and coal extraction
984 upstream, would likely adversely affect contaminant levels in Libby Reservoir and the Kootenai
985 River. In addition, there would be a slight decrease in TDG releases from Grand Coulee dam in
986 average flow years.

987 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

988 Cumulative effects to water quality from MO3 are described in Table 6-17 and discussed the
989 text below.

990 **Table 6-17. Water Quality Direct/Indirect Effects from Multiple Objective Alternative 3**
991 **Compared to the No Action Alternative and Multiple Objective Alternatives 1 and 2**

Region	MO3
A (Libby)	Similar to MO2, a deeper drawdown of Libby Reservoir may help to mitigate for higher inflows anticipated in the winter under climate change. However, deeper reservoir drafts and higher outflows may result in suspended solids (nutrients, selenium) moving farther down into the reservoir and downstream of Libby Dam, as well as increased downstream water temperatures.
A (Hungry Horse)	Effects are expected to be similar to MO1.
A (Albeni Falls)	Effects are expected to be similar to the No Action Alternative.
B (Grand Coulee)	Effects are expected to be similar to the No Action Alternative.
B (Chief Joseph)	Effects are expected to be similar to the No Action Alternative.
C (Dworshak)	Effects are expected to be similar to the No Action Alternative.
C (Lower Snake River)	Major short-term adverse impact on water quality due to the mobilization of sediment during dam breaching. Long-term beneficial effect on water quality in Region C, including major reductions in TDG and fall water temperatures. MO3 is expected to result in warmer water temperature in the spring and increased air temperatures under climate change could exacerbate this impact.
D (Lower Columbia River)	Minor reductions in fall water temperatures are expected as compared to the No Action Alternative. Moderate short-term adverse effect on water quality, particularly in McNary Reservoir due to the mobilization of sediment during dam breaching. Long-term negligible to minor beneficial effect on water quality in Region D.

992 The primary water quality concern under MO3 from dam breach is the exposure of chemical
993 contaminants that have been contained in reservoir sediment. Chemicals of concern include
994 total DDT, dioxin, manganese, and un-ionized ammonia. DDT could potentially affect the
995 biological system, and un-ionized ammonia concentrations may exceed EPA water quality
996 criteria for the protection of aquatic life. This, combined with the additive effects of legacy

997 contaminant issues upstream, would likely increase contaminant levels in the lower Snake and
 998 Columbia Rivers, culminating in a larger impact to sediment contamination in the McNary
 999 reservoir. This will likely be higher in the short term following breach and continue
 1000 intermittently with high-flow events that reach areas that were previously mud flats. Breach of
 1001 the lower Snake River dams would result in sediment being transported downstream to the
 1002 McNary forebay, particularly in the years immediately following dam breach (near term). As a
 1003 result, near-term, adverse effects associated with the sediment transport would be expected in
 1004 the McNary Reservoir. Dissolved oxygen, light attenuation, phytoplankton, zooplankton, and
 1005 productivity would likely be depressed, while total suspended solids, turbidity, nutrients,
 1006 organics, and metals would likely increase.

1007 Under MO3, elevated river TDG due to dam spill operations would not occur. An initial
 1008 reduction of primary and secondary production is likely to occur while suspended solids are
 1009 concentrated and turbidity is elevated. As compared to the No Action Alternative, MO3 is
 1010 expected to result in warmer water temperature in the spring, similar water temperatures in
 1011 the summer, and cooler water temperatures in the fall with the overall duration of warm water
 1012 reduced. Furthermore, the shallower free flowing river condition of MO3 will lead to greater
 1013 diurnal fluctuations in water temperature, including nighttime cooling. Daily low temperatures
 1014 (occurring at night) are projected to warm faster than daily high temperatures. The effects of
 1015 projected increasing nighttime temperatures could reduce nighttime cooling of the river.
 1016 Cumulatively, increased air temperatures under climate change could exacerbate this impact. In
 1017 addition, the river would likely cool more at night, providing more refuge for fish. These
 1018 temperature changes could be adverse or beneficial depending on the season or time of day. In
 1019 the case of beneficial effects (such as nighttime temperature drops), the additive cumulative
 1020 sources of heat in the Columbia River Basin (such as climate change) would have less of an
 1021 impact under MO3, resulting in less of a need to draft Dworshak to add cold water to the
 1022 system. In the case of adverse effects (such as daytime temperature increases), the additive
 1023 sources of heat in the basin could make it harder to cool the river in times of extreme heat
 1024 under MO3. This would encourage early (starting in July) Dworshak water temperature
 1025 management to mitigate warming in the lower Snake River.

1026 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

1027 Cumulative effects to water quality from MO4 are described in Table 6-18 and discussed the
 1028 text below.

1029 **Table 6-18. Water Quality Direct/Indirect Effects from Multiple Objective Alternative 4**
 1030 **Compared to the No Action Alternative and Multiple Objective Alternative 1**

Region	MO4
A (Libby)	Reduced productivity is expected in the reservoir. This operation and resultant impact may increase in frequency as streamflow volumes are likely to shift to occur earlier in the year and late spring/summer flow declines (Section 4.1.2.4).
A (Hungry Horse)	Effects are expected to be similar to MO1.
A (Albeni Falls)	Effects are expected to be similar to the No Action Alternative.

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Region	MO4
B (Grand Coulee)	Effects are expected to be similar to MO1, with the exception of major reductions in TDG below Grand Coulee Dam. Water temperatures downstream of Grand Coulee are expected to continue to exceed water quality standards in late summer and early fall, which could be exacerbated in dry years.
B (Chief Joseph)	Effects are expected to be similar to MO1.
C (Dworshak)	Increased TDG is expected in this part of the river.
C (Lower Snake River)	Increased TDG is expected in this part of the river.
D (Lower Columbia River)	Increased TDG is expected in this part of the river.

1031 Under MO4, in low water years, the *McNary Flow Target* measure would allow the following
 1032 maximum releases: 534,000 acre-feet from Libby, 232,000 acre-feet from Hungry Horse,
 1033 234,000 acre-feet from Albeni Falls, and 1 million acre-feet from Grand Coulee. These releases
 1034 would in turn result in lower reservoir elevations at each project, which could reduce
 1035 productivity in the reservoir and impact fish growth. As a result of the additive effect of climate
 1036 change, this operation may need to increase in frequency as streamflow volumes are likely to
 1037 shift to occur earlier in the year and as late spring/summer flow declines. Water temperatures
 1038 downstream of Grand Coulee are expected to continue to exceed water quality standards in
 1039 late summer and early fall, and this could be exacerbated in dry years by the early release of
 1040 flows and missed refill due to the *McNary Flow Target* measure. Cumulative effects such as
 1041 climate change would only increase air surface temperatures in this region, thus increasing
 1042 water temperatures as well.

1043 **6.3.1.4 Anadromous Fish**

1044 RFFAs with potential to impact anadromous fish in the CIAA are listed in Table 6-19 and Table
 1045 6-20, along with a summary of the effects of these actions.

1046 **Table 6-19. Reasonably Foreseeable Future Actions Relevant to Anadromous Fish**

RFFA ID	RFFA Description	Impact Description
RFFA1	Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development	There would be an adverse effect from loss of riparian habitat and fragmentation through new development projects.
RFFA2	Water Withdrawals for Municipal, Agricultural, and Industrial Uses	There could be an overall adverse effect from reduced availability of water from increased demand. In addition, tributaries that are substantially depleted by water diversions will continue to be an important limiting factor for most species in the Columbia River Basin upstream of Bonneville Dam.
RFFA3	New and Alternative Energy Development	There could be a possible adverse effect from increase in lack-of-market or lack-of-turbine-capacity spill in the future and higher TDG levels if shifting away from hydropower to other sources occurs.
RFFA5	Federal and State Wildlife Lands Management	Land management practices are anticipated to continue to include watershed improvement projects that can benefit fish.
RFFA6	Increase in Demand for New Water Storage Projects	There is potential for adverse effects from changes to timing, delivery, and quantity of water in different locations from new storage projects.
RFFA7	Fishery Management Plans	The goal of Pacific Salmon Fishery Management Plans is to better manage catch of salmon in ocean waters offshore. This could lead to a trend of beneficial effects to salmon numbers by reducing commercial catch for these species. The <i>United States v. Oregon</i> Fishery Management Agreement has the overall goal of rebuilding weak runs to full productivity through habitat protection authorities, enhancement efforts, artificial production techniques, and harvest management. Implementation of this agreement could lead to a trend of beneficial effects to target species.
RFFA8	Bycatch and Incidental Take	Bycatch of Endangered Species Act (ESA)-listed species and incidental take would continue to have an adverse effect.
RFFA12	Fish Hatcheries	Hatcheries would continue to benefit overall anadromous populations that are increased through stocking. There are also adverse effects that would continue to occur from interactions between hatchery and naturally reproduced fish.
RFFA13	Tribal, State, and Local Fish and Wildlife Improvement	New tribal, state, and local fish and wildlife improvement projects are projected to restore, maintain, create, or enhance fish and wildlife habitat. Many of these projects are focused on benefiting anadromous species.
RFFA14	Lower Columbia River Channel Improvement Plan	In-water and shoreline placement of dredged materials, as well as construction associated with channel training structures, may temporarily disrupt aquatic habitat.
RFFA15	Snake River Sediment Management Plan	Dredging effects on fish are generally localized and include possible entrainment, increased turbidity, noise, and changes to habitat such as substrate and depth. Effects on salmonids would continue to be minimized by conducting work during the approved in-water work period when many fish species are at lower densities.

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RFFA ID	RFFA Description	Impact Description
RFFA17	Invasive Species	There is a projected increase in northern pike and other species that prey on salmonids. Non-native fishes such as walleye, smallmouth bass, and channel catfish are also present in slower-moving areas throughout the Columbia River Basin.
RFFA19	Climate Change	Projected changes in air temperature, precipitation, hydrology and stream temperature have adverse implications for the freshwater, estuarine, and marine environments of many fish species in the Pacific Northwest. For salmon and steelhead in the Columbia River Basin, climate change may affect the timing of spawning, emergence, and migration; cause changes in growth and development; increase predation rates; increase ocean temperatures; and affect the availability of critical habitat. These biological changes could impact species productivity and abundance. A detailed description of the potential effects on anadromous fish from Climate Change is presented in Section 4.2.3.
RFFA20	Clean Water Act–Related Actions	CWA-related permitting and actions related to temperature and other water quality parameters would continue to benefit anadromous species.
RFFA22	Idaho Power Hells Canyon Complex Temperature Issues	There is potential for temperature effects during summer migration if Brownlee Reservoir is drafted.
RFFA23	Mining in Reaches Upstream of CRS Dams	There would be potential adverse effects due to pollutants and bioaccumulation.
RFFA26	Middle Columbia Dam Operations	Passage rates are similar to CRS dams, however, Columbia River salmon, steelhead, and lamprey must pass these five additional dams before they reach other tributaries.

1047 **Table 6-20. Direct and Indirect Effects on Anadromous Species Compared to the No Action Alternative**

Fish Type	MO1	MO2	MO3	MO4
Upper Columbia Salmon and Steelhead	Effects would be similar to the No Action Alternative. Structural and operational measures designed to provide incremental improvements in juvenile survival and adult returns would have negligible to minor benefits based on fish modeling results.	Lower spill would, generally increase travel time, transportation, and the number of powerhouse encounters for outmigrating juveniles. CSS model results show major adverse effects while NOAA LCS model results show minor adverse effects to juvenile survival and adult abundance. There would also be lower TDG exposure.	There would be negligible to minor beneficial effects due to increases in juvenile survival and adult returns with fewer powerhouse encounters. There would also be slightly higher TDG exposure.	CSS model results show major beneficial effects while NOAA LCS model results show moderate adverse effects to juvenile survival and adult abundance. There would also be higher TDG exposure, which may also reduce passage success of adults.

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Fish Type	MO1	MO2	MO3	MO4
Snake River Salmon and Steelhead	Effects would be similar to the No Action Alternative. Structural and operational measures would provide incremental, small improvements and the fish models show negligible to minor benefits. The Modified Dworshak Summer Draft measure intended to improve thermal conditions for adults would result in adverse water temperatures and reduce adult migration success.	There would be decreases in juvenile survival metrics based on reduced spill during downstream passage. Adult abundance may vary depending on latent mortality assumptions. Adult abundance results vary by model; minor increases if more transported fish contributes to higher returns or major decreases due to more powerhouse encounters and reduced ocean survival. There would also be lower TDG exposure.	Snake River anadromous species would experience short-term, major adverse effects immediately post-breath, then major beneficial effects after sediment movement returns to No Action Alternative levels.	CSS model results show major beneficial effects while NOAA LCS model results show moderate adverse effects to juvenile survival and adult abundance. There would be higher TDG exposure with increased spill, which may also reduce passage success of adults.
Other Anadromous Fish	There would be minor adverse effects to chum salmon. There would be minor beneficial effects to lamprey from expanding the network of lamprey passage structures. Eulachon, shad, and green sturgeon effects would be similar to the No Action Alternative.	There would be decreased overall juvenile survival. There would be moderate adverse effects to chum salmon, minor beneficial effects to lamprey, and minor adverse effects to Eulachon and green sturgeon. There would also be lower TDG exposure.	Effects to coho and chum salmon would be similar to the No Action Alternative. There would be minor adverse effects to eulachon and green sturgeon. There would be minor beneficial effects to lamprey.	There would be lower chum flows and survival. Minor adverse effects to eulachon and green sturgeon would occur. There would be minor beneficial effects to lamprey

1048

1049 **NO ACTION ALTERNATIVE**

1050 As described in Section 3.5.5.2, a variety of factors, including project structures, surface passage
1051 modifications, natural mortality, and predation affect juvenile migration and survival at the
1052 lower Columbia River and lower Snake River Projects. Adult migration is affected by dam
1053 passage, predation, and temperature and flow conditions. The measures in the No Action
1054 Alternative are not expected to change these factors, although temperature and flow
1055 conditions under the No Action Alternative may be impacted by climate change and other
1056 actions.

1057 There are a number of cumulative actions that could have beneficial and adverse effects to
1058 anadromous species under the No Action Alternative as described in Table 6-20.

1059 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

1060 MO1 creates small overall improvements for upper Columbia River salmon and steelhead and
1061 Snake River salmon and steelhead through structural measures and flow modifications. In the
1062 future, these improvements may be offset by projected changes in flows and temperature.
1063 Under MO1, there would also be adverse effects to Snake River salmon and steelhead from the
1064 Dworshak flow measure, which would limit the ability of the CRS to mitigate high temperature
1065 inflows, resulting in temperature increases later in the summer. Flows for chum salmon would
1066 be met in 2 percent less years than the No Action Alternative. The most influential effect of
1067 MO1 on Columbia River sockeye would be the substantial reduction in nesting habitat for the
1068 birds that prey on outmigrating juvenile fish. There would be an incremental benefit to lamprey
1069 from lamprey measures. Mitigation measures under MO1 include temporary extension of
1070 performance standard spill levels which would reduce effects from increased spill levels in
1071 Regions C and D. Cumulative actions that have the potential to further reduce water levels in
1072 the future, such as population growth and development, water withdrawals, new storage
1073 projects, and climate change, could increase adverse effects identified from the Dworshak
1074 measure and could increase the number of years that chum salmon flows are not met, but it is
1075 uncertain to what degree. In addition, there are a number of other cumulative actions that
1076 could have beneficial and adverse effects to anadromous species in the basin under MO1 as
1077 described in Table 6-19. Considering the beneficial effects of MO1 combined with other actions
1078 with the goal of improving conditions for anadromous species in the Columbia River Basin, it is
1079 anticipated that there would be a cumulative benefit to anadromous species with MO1
1080 contributing to these beneficial effects. These cumulative benefits are uncertain, however,
1081 because the effects of environmental factors such as climate change could have adverse effects
1082 to anadromous species that would outweigh benefits from measures in MO1 and other
1083 cumulative actions intended to benefit anadromous species, such as tribal, state, and local fish
1084 and wildlife improvement projects.

1085 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

1086 MO2 includes structural measures to improve survival of juvenile salmon and steelhead, but
1087 lower spill would, generally speaking, increase travel time and the number of powerhouse

1088 encounters for juvenile outmigrants. Anadromous juveniles outmigrating in the Snake River
1089 would be transported at a higher rate than under the No Action Alternative, which could result
1090 in more reaching Bonneville Dam sooner than in-river fish. Depending on ocean survival
1091 dynamics, more or less adults could return, and returning adults would likely have higher rates
1092 of straying and migration delays due to higher rates of transported juveniles. There would also
1093 be decreased juvenile steelhead and salmon survival in the middle and lower Columbia River
1094 reaches and minor adverse effects to eulachon and green sturgeon. However, the lower spill
1095 may decrease steelhead kelt survival but would lower TDG overall. Juvenile sockeye salmon
1096 would experience lower survival during outmigration in the river than under the No Action
1097 Alternative. The most important change for Columbia River sockeye from MO2 is the potential
1098 for transportation of juveniles, which can improve short-term survival of juveniles but may have
1099 adverse consequences when they return as adults. Additionally, higher temperatures compared
1100 to the No Action Alternative would have additional adverse effects for adults.

1101 Similar to MO1, cumulative actions that have the potential to further increase temperatures and
1102 reduce water levels in the future, such as population growth and development, water
1103 withdrawals, new storage projects, and climate change, could increase adverse effects identified
1104 due to hydropower measures and decreased spill, but it is uncertain to what degree. Some of
1105 these adverse effects could be partially offset by other actions that have the goal of benefiting
1106 anadromous species as identified in Table 6-19. Overall, because MO2 has predominantly
1107 adverse effects to anadromous species, when combined with adverse effects from cumulative
1108 actions, it is anticipated that there could be a substantial adverse cumulative impact under MO2.

1109 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

1110 Under MO3, modeling results indicate there would be minor increases in juvenile survival and
1111 adult returns and fewer powerhouse encounters for upper Columbia River salmon and
1112 steelhead. MO3 would involve breaching the lower Snake projects, which would end juvenile
1113 fish transportation at the collector projects, and would also have effects on both juvenile
1114 outmigration and adult upstream migration. Hatchery fish production in the basin would be
1115 reduced with the elimination of the Snake River Compensation Plan hatcheries. With the
1116 breaching of Snake River dams, there would no longer be the commitment to mitigate for those
1117 dams, so the hatchery programs funded by the Lower Snake River Compensation Plan would no
1118 longer produce smolts. These fish account for 80 to 90 percent of all juvenile Snake River fish
1119 passing CRS projects. COMPASS and CSS models do not account for this dramatic reduction in
1120 juvenile fish production. Adverse effects from increased spill levels would be minimized through
1121 performance standard spill in Region D and adverse effects from dam breaching in Region C
1122 would be minimized by trapping and transporting affected populations and raising additional
1123 hatchery fish to address fish lost from dam breaching. Modification of the Tucannon River
1124 channel at the delta would minimize anticipated passage effects to anadromous fish on the
1125 Tucannon River due to breaching. Breaching of the lower Snake River dams would have
1126 downstream benefits to sockeye salmon related to turbidity and reducing predation plus added
1127 safety in numbers for outmigrating juveniles. There would also be minor increases in middle and
1128 lower Columbia River salmon and steelhead. Coho and chum salmon would experience effects

1129 similar to the No Action Alternative, and there would be minor adverse effects to eulachon and
1130 green sturgeon. Considering the beneficial effects of MO3 combined with other actions with the
1131 goal of improving conditions for anadromous species in the Columbia River Basin as described in
1132 Table 6-19, it is anticipated that there would be a cumulative benefit to anadromous species
1133 under MO3, with MO3 dam breaching on the lower Snake River contributing to these beneficial
1134 effects. The degree of cumulative benefits is uncertain, however, there are other factors such as
1135 climate change (higher water temperatures, decreased in-river water flow, etc.) that could have
1136 adverse effects to anadromous species that outweigh benefits from measures in MO3 and other
1137 actions intended to benefit anadromous species.

1138 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

1139 Under MO4, for upper Columbia River salmon and steelhead, there would be minor increases in
1140 juvenile survival and adult returns, shorter travel time, and fewer powerhouse encounters from
1141 increased spill. However, there would be higher TDG exposure. For Snake River salmon and
1142 steelhead, there would be increased juvenile survival and much higher TDG exposure. There
1143 would also be increased juveniles in the middle and lower Columbia River. There would be lower
1144 chum salmon flows and survival, and temperature effects for lamprey in the middle Columbia
1145 River. The most notable adverse effects of this MO for Snake River sockeye would be increased
1146 nesting habitat for predatory birds and greater TDG exposure. There could be an increase in
1147 northern pike spreading downstream in the Columbia River due to increased entrainment out of
1148 Lake Roosevelt. Under MO4 there would be a temporary extension of performance standard
1149 spill in Regions C and D that would minimize adverse effects from increased spill levels. In Region
1150 C, the Little Goose raceway infrastructure would be modified to minimize effects from higher
1151 spill levels. Benefits to upper Columbia River and Snake River fish due to increased spill may be
1152 partially offset by adverse effects from cumulative actions that reduce water levels, such as
1153 climate change and increased future water withdrawals, but it is uncertain to what extent. These
1154 same actions may increase adverse effects on chum salmon, sockeye salmon, and lamprey.
1155 Considering the beneficial effects of MO4 combined with other actions with the goal of
1156 improving conditions for anadromous species in the Columbia River Basin as described in Table
1157 6-19, it is anticipated that there would be a cumulative benefit to anadromous species under
1158 MO4 possibly with the exception of lamprey and chum salmon. The degree of cumulative
1159 benefits is uncertain, however, because there are also other factors, such as climate change,
1160 that could have adverse effects to anadromous species that outweigh benefits from measures in
1161 MO4 and other actions intended to benefit anadromous species.

1162 **6.3.1.5 Resident Fish**

1163 RFFAs with potential to impact resident fish in the CIAA are listed in Table 6-21 along with a
1164 summary of the effects of these actions.

1165 **Table 6-21. Reasonably Foreseeable Future Actions Relevant to Resident Fish**

RFFA ID	RFFA Description	Impact Description
RFFA1	Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development	There would be an adverse effect from loss of riparian habitat, fragmentation, and water pollution through new development projects.
RFFA2	Water Withdrawals for Municipal, Agricultural, and Industrial Uses	There could be an overall adverse effect from reduced availability of water from increased demand. In addition, tributaries that are substantially depleted by water diversions will continue to be a major limiting factor for most species in the Columbia River Basin upstream of Bonneville Dam.
RFFA3	New and Alternative Energy Development	There would possibly be an adverse effect from increase in lack-of-market/lack-of-turbine-capacity spill in the future and higher TDG levels if shifting away from hydropower to other sources occurs.
RFFA5	Federal and State Wildlife Lands Management	Land management practices are anticipated to continue to include watershed improvement projects that can benefit fish.
RFFA6	Increase in Demand for New Water Storage Projects	Potential adverse effects from changes to timing, delivery, and quantity in different locations.
RFFA7	Fishery Management Plans	The goal of Pacific Salmon Fishery Management Plans is to better manage catch of salmon in ocean waters offshore. This could lead to a trend of beneficial effects to salmon numbers by reducing commercial catch for these species. The <i>United States v. Oregon</i> Fishery Management Agreement has the overall goal of rebuilding weak runs to full productivity through habitat protection authorities, enhancement efforts, artificial production techniques, and harvest management. Implementation of this agreement could lead to a trend of beneficial effects to target species.
RFFA8	Bycatch and Incidental Take	Bycatch of ESA-listed species and incidental take would continue to have an adverse effect.
RFFA9	Bull Trout Passage at Albeni Falls	The proposed action is to construct an upstream “trap and haul” fish passage facility at Albeni Falls; downstream passage will occur through the spillway and powerhouse.
RFFA10	Ongoing and Future Habitat Improvement Actions for Bull Trout	A common goal among these plans is the improvement of aquatic habitat and water quality to benefit native salmonids, especially bull trout.
RFFA11	Bull Trout Fisheries Management	The state fish and game agencies manage fisheries in the Columbia River Basin and regulate private and public hatchery releases. The agencies modify and publish recreational fishing regulations on an annual basis. Currently, recreational anglers may not target bull trout in most areas but may incidentally catch and release bull trout.

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RFFA ID	RFFA Description	Impact Description
RFFA12	Fish Hatcheries	Hatcheries would continue to benefit resident fish populations that are increased through stocking. There would also be continued adverse effects from interactions between hatchery-produced and naturally reproduced fish.
RFFA13	Tribal, State, and Local Fish and Wildlife Improvement	New tribal, state, and local fish and wildlife improvement projects are projected to restore, maintain, create, or enhance fish and wildlife habitat. Many of these projects are focused on resident species of concern.
RFFA14	Lower Columbia River Dredged Material Management Plan	Channel training and in-water and shoreline placement of dredged materials may temporarily disrupt aquatic habitat.
RFFA15	Snake River Sediment Management Plan	Dredging effects on fish are generally localized and include possible entrainment, increased turbidity, noise, and changes to habitat such as substrate and depth. Effects on fish would continue to be minimized by conducting work during the approved in-water work period.
RFFA16	SKQ Dam Operations	Adverse effects to bull trout would continue to occur from entrainment through SKQ Dam out of Flathead Lake.
RFFA17	Invasive Species	Non-native fishes such as northern pike, walleye, smallmouth bass, and channel catfish would continue to be present in reservoirs and slower-moving riverine areas throughout the Columbia and Snake River Systems.
RFFA19	Climate Change	Potential effects of climate change, such as warmer air temperatures and changes to hydrology, could have effects on the ecosystem. Warming air temperatures coupled with changing rainfall amounts and timing affects soil conditions, plant communities, insects, and wildlife. A warming climate could affect the distribution and abundance of many resident fish, increasing the range of some species while reducing the range of others.
RFFA20	Clean Water Act–Related Actions	CWA-related permitting and actions related to temperature and other water quality parameters would continue to benefit fish.
RFFA22	Idaho Power Hells Canyon Complex Temperature Issues	There is potential for temperature effects during summer migration.
RFFA23	Mining in Reaches Upstream of CRS Dams	There would be potential adverse effects due to pollutants and bioaccumulation.

1166 Table 6-22 below provides a summary of direct and indirect effects identified for resident fish.

1167 **Table 6-22. Summary of Direct and Indirect Effects to Resident Fish from Alternatives**

Region	MO1	MO2	MO3	MO4
Region A Resident Fish	<p>In the Kootenai area, there would be mixed benefits to food production in the reservoir and minor adverse effects to burbot and Kootenai River White Sturgeon.</p> <p>In the Hungry Horse area, there would be minor to moderate adverse effects from changes in reservoir elevations and outflows to bull trout and other native fish, food availability, the varial zone, fish entrainment, and habitat.</p> <p>Effects in the Lake Pend Oreille basin would be similar to the No Action Alternative.</p>	<p>In the Kootenai area, there would be minor adverse effects to riparian and sturgeon recruitment, however, there would be a minor beneficial increase to river habitat for bull trout and other native fish.</p> <p>In the Hungry Horse area, there would be moderate to major adverse effects to food availability, the varial zone, entrainment, and habitat.</p> <p>In the Lake Pend Oreille basin, there would be reduced entrainment risk.</p>	<p>In the Kootenai area, there would be moderate adverse effects to food availability and minor adverse riparian and sturgeon recruitment effects; however, there would be a minor beneficial increase to river habitat for bull trout and other native fish.</p> <p>In the Hungry Horse area, there would be minor to moderate adverse effects to bull trout, food availability, the varial zone, entrainment, and habitat.</p> <p>Effects in the Lake Pend Oreille basin would be similar to the No Action Alternative.</p>	<p>In the Kootenai area, there would be minor beneficial effects to the riparian habitat; however, there would be a minor to moderate adverse effects to reservoir habitat and tributary access.</p> <p>In the Hungry Horse area, there would be moderate to major adverse effects to bull trout, food availability, the varial zone, entrainment, and habitat (especially in dry years).</p> <p>In the Lake Pend Oreille basin, there would be minor adverse effects to riparian and reservoir habitat and tributary access (especially in dry years).</p>
Region B Resident Fish	<p>There would be minor to moderate effects in Lake Roosevelt to bull trout and other resident fish including increased entrainment and varial zone effects. Overall effects in river reaches would be similar to the No Action Alternative except for minor reduction in sturgeon recruitment.</p>	<p>There would be moderate adverse effects in Lake Roosevelt such as increased entrainment and varial zone effects. River effects and sturgeon recruitment would be similar to No Action Alternative.</p>	<p>There would be minor adverse effects to sturgeon above Lake Roosevelt and minor adverse effects due to entrainment of Lake Roosevelt fish.</p> <p>In the McNary reservoir there would be increased sturgeon recruitment and connectivity. There would be minor short-term adverse effects from breaching the four lower Snake River dams.</p>	<p>There would be moderate to major adverse effects in Lake Roosevelt, such as increased entrainment and varial zone effects (especially in dry years). Sturgeon recruitment would be similar to the No Action Alternative.</p>

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Region	MO1	MO2	MO3	MO4
Region C Resident Fish	Minor increases in water temperature in August would favor non-native fish (Dworshak Summer Draft measure) and result in minor adverse effects to native species, otherwise effects would be similar to the No Action Alternative.	There would be minor to moderate adverse entrainment effects to Dworshak bull trout and kokanee. Snake River fish would have increased mortality during dam passage but would be exposed to lower TDG.	There would be moderate to major adverse short-term construction effects from dam breaching. There would be a major beneficial effect to bull trout and white sturgeon, due to reconnection of fragmented populations and increased spawning habitat for white sturgeon.	There would be a minor to moderate adverse effects, due to higher TDG exposure.
Region D Resident Fish	Effects would be similar to the No Action Alternative with negligible adverse effects to flows and water temperatures and potential stranding of white sturgeon larvae.	Effects to Bull trout and other resident fish would be similar to the No Action Alternative.	Effects to Bull trout and other resident fish would be similar to the No Action Alternative.	There would be a minor to moderate adverse effects, due to higher TDG exposure.

1168

1169 **NO ACTION ALTERNATIVE**

1170 As described in Section 3.5.5.2, the effects of the No Action Alternative are anticipated to be
1171 similar in nature to the existing conditions. Resident fish species would continue to be impacted
1172 by the dams and their operations as described in the *Affected Environment* section of Chapter
1173 3. There are a number of cumulative actions that could both beneficially and adversely affect
1174 resident species under the No Action Alternative as described in Table 6-21.

1175 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

1176 In Region A, MO1 causes a reduced food supply, higher entrainment, and varial zone adverse
1177 effects in Hungry Horse Reservoir, and higher summer flows reduce habitat for resident fish in
1178 the Flathead River. To minimize these effects there would be vegetation planting and structural
1179 habitat components installed around Hungry Horse Reservoir. In the Kootenai River, there
1180 would be a minor increase in bull trout and redband rainbow trout and westslope cutthroat
1181 trout river habitat. Mitigation measures implemented under MO1, including cottonwood
1182 planting near Bonners Ferry, would minimize adverse effects to Kootenai River White Sturgeon.
1183 In Region B, there would be increased entrainment and reduced productivity in Lake Roosevelt
1184 and increased stranding of kokanee and burbot eggs along with affects to redband rainbow
1185 trout from lower water levels. To minimize these effects, additional spawning habitat at Lake
1186 Roosevelt would be identified and established. In Region C, warmer temperatures from
1187 Dworshak would adversely impact native fish and benefit non-native warmwater fish. In Region
1188 D, a drop in the John Day reservoir could strand larvae. Overall, cumulative actions that have
1189 the potential to further reduce water levels in the future, such as population growth and
1190 development, water withdrawals, new storage projects, and climate change, could increase
1191 adverse effects identified, but it is uncertain to what degree. Adverse cumulative effects would
1192 be partially offset by actions that have the goal of benefitting resident species as identified in
1193 Table 6-22. Mitigation actions under MO1 intended to benefit resident species, as identified in
1194 Chapter 5, could further offset adverse cumulative effects.

1195 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

1196 In Region A, MO2 causes reduced food supply and increased winter entrainment at Hungry
1197 Horse. Winter habitat in the Flathead River would be substantially reduced. In the Kootenai
1198 River, there would be a decrease in spring freshets and sturgeon river habitat. There would be
1199 an increase in bull trout and redband and westslope cutthroat trout river habitat. These effects
1200 would be minimized by planting cottonwoods near Bonners Ferry and vegetation planting and
1201 installation of structural habitat components around Hungry Horse Reservoir. In Region B at
1202 Lake Roosevelt, there would be adverse effects similar to those described for MO1. These
1203 effects would be minimized by identifying and developing additional spawning habitat at Lake
1204 Roosevelt. In Region C, there would be increased entrainment of kokanee and reduced survival
1205 of fish through the turbines. Similar to MO1, actions that have the potential to further reduce
1206 water levels in the future, such as population growth and development, water withdrawals,
1207 new storage projects, and climate change, could increase adverse effects identified due to
1208 hydropower measures, but it is uncertain to what degree. There are also other factors that

1209 could have unquantified adverse effects to resident species as described in Table 6-21. Adverse
1210 cumulative effects would be partially mitigated by actions that have the goal of benefitting
1211 resident species as identified in Table 6-21. Mitigation actions intended to benefit resident
1212 species, as identified in Chapter 5, could further offset adverse cumulative effects.

1213 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

1214 In Region A, effects of MO3 at Hungry Horse Dam and Pend Oreille River would be similar to the
1215 No Action Alternative. These effects would be minimized by vegetation planting and installation
1216 of habitat structures around Hungry Horse Reservoir, and cottonwood planting near Bonners
1217 Ferry. In the Kootenai River, there would be minor increases in lake productivity and habitat.
1218 There would be an increase in bull trout river habitat and westslope and redband cutthroat
1219 habitat. In Region B at Lake Roosevelt, there would be adverse effects due to increased
1220 entrainment and reduced productivity, but there would also be decreased stranding of kokanee
1221 and burbot eggs. These effects would be minimized by identifying and developing additional
1222 spawning habitat at Lake Roosevelt. In Region C on the Snake River, there would be short-term
1223 construction effects from dam breaching, but long-term beneficial effects shifting to more
1224 native fish with conversion of reservoirs to river habitat. Adverse effects would be minimized by
1225 modifying the Tucannon River channel to improve passage and haul and trap of white sturgeon
1226 on the Snake River in areas impacted by dam breaching. In Region D, the higher John Day
1227 reservoir provides more habitat for sturgeon but could strand larvae, and the lower May and
1228 June flows could increase predation. Overall, considering the beneficial effects of MO3
1229 combined with other actions with the goal of improving conditions for resident species in the
1230 Columbia River Basin as described in Table 6-21, it is anticipated there would be a cumulative
1231 benefit to resident species under MO3 with dam breaching on the lower Snake River
1232 contributing substantially to these beneficial effects. The degree of cumulative benefits is
1233 uncertain, however, because the effects of environmental factors such as climate change could
1234 have larger adverse effects to resident species in the future. There are also other factors that
1235 could have unquantified adverse effects to resident species as described in Table 6-22.

1236 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

1237 Under MO4, there would be reduced food supply, higher entrainment, and varial zone adverse
1238 effects at Hungry Horse. These effects would be minimized by vegetation planting and
1239 installation of habitat structures around Hungry Horse. The high summer flows would reduce
1240 habitat in the Flathead River. At Lake Pend Oreille, lower reservoir elevations limit access to
1241 tributaries and reduce shallow habitat. On the Kootenai River, there would be minor decreases
1242 in bull trout lake and river habitat. There would also be a decrease in redband and westslope
1243 cutthroat trout river habitat. In Region B at Lake Roosevelt, there would be major increases in
1244 entrainment and reduced productivity. There would be large increases in stranding of kokanee
1245 and burbot eggs and large varial zone effects to redband rainbow trout and kokanee. These
1246 effects would be minimized by identifying and developing additional spawning habitat at Lake
1247 Roosevelt. Northern pike invasion downstream into the Columbia River would likely increase
1248 due to higher entrainment risk of northern pike. In Region C, higher TDG would affect bull trout

1249 and other resident fish. In Region D, TDG would be higher at all dams, and drawdowns at lower
1250 Columbia River reservoirs could reduce habitat. Actions that have the potential to further
1251 reduce water levels in the future, such as population growth and development, water
1252 withdrawals, new storage projects, and climate change, could increase adverse effects
1253 identified due to hydropower measures, but it is uncertain to what degree. There are also other
1254 factors that could have adverse effects to resident species as described in Table 6-22. Adverse
1255 cumulative effects would be partially offset by actions that have the goal of benefitting resident
1256 species as identified in Table 6-22. Mitigation actions intended to benefit resident species, as
1257 identified in Chapter 5, could further offset adverse cumulative effects.

1258 **6.3.1.6 Vegetation, Wildlife, Wetlands, and Floodplains**

1259 RFFAs with potential to impact vegetation, wetlands, wildlife, and floodplains in the CIAA are
1260 listed in Table 6-23 along with a summary of the effects of these actions. The table is followed
1261 by a description of cumulative effects of the different MOs by region. Effects from the No
1262 Action Alternative are expected to be similar to existing conditions as described in Section
1263 3.6.3.2.

1264 **Table 6-23. Reasonably Foreseeable Future Actions Relevant to Vegetation, Wildlife, Wetlands, and Floodplains**

RFFA ID	RFFA Description	Impact Description
RFFA1	Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development	There would be an adverse effect from loss of habitat and fragmentation and increased water use leading to reduced instream flows through new development projects potentially affecting floodplain inundation timing.
RFFA2	Water Withdrawals for Municipal, Agricultural, and Industrial Uses	There would be an adverse effect from less available water in the future that may lead to conversion of wetland habitat into drier habitat types and reduced instream flow potentially affecting floodplain inundation timing.
RFFA3	New and Alternative Energy Development	There is a potential loss of habitat from new construction projects. Wind turbines can also impact birds, bats, and insects.
RFFA4	Increasing Use of Renewable Energy Sources, Industrial and Vehicle Emissions Reductions, and Decarbonization	There would be possible adverse effects due to the potential for an increase in lack of market/lack of turbine capacity spill, which could lead losses in vegetation, wetland, and floodplains that could adversely affect wildlife.
RFFA5	Federal and State Wildlife Lands Management	Continued public ownership of land and land management for fish and wildlife purposes is projected to be beneficial by maintaining native habitat types and wetlands on these lands.
RFFA6	Increase in Demand for New Water Storage Projects	New water storage projects have the potential to inundate riparian vegetation, creating an adverse impact and reduced instream flow potentially affecting floodplain inundation timing.
RFFA7	Pacific Salmon Management Plans	Plan implementation may have a beneficial impact to orcas, sea lions, avian predators, and other wildlife that eat salmon and steelhead.
RFFA12	Fish Hatcheries	May have a beneficial impact to orcas, sea lions, avian predators, and other wildlife that eat salmon and steelhead.
RFFA13	Tribal, State, and Local Fish and Wildlife Improvement	New tribal, state, and local fish and wildlife improvement projects are projected to restore, maintain, create, or enhance native vegetation types and wetlands and, potentially, have beneficial effects on floodplains if the projects enhance floodplain function.
RFFA14	Lower Columbia Dredged Material Management Plan	There would be a localized adverse effect on plankton and benthic organisms during dredging operations.
RFFA15	Snake River Sediment Management Plan	There would be a localized adverse effect on plankton and benthic organisms during dredging operations.
RFFA16	SKQ Dam Operations	SKQ operations can have the adverse effect of limiting cottonwood regeneration in the river below the Dam.
RFFA17	Invasive Species	Invasive plants are currently damaging biological diversity and ecosystem integrity across the Columbia River Basin. They are on a trajectory to increase and can outcompete and cause displacement of native plants.

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RFFA ID	RFFA Description	Impact Description
RFFA18	Marine Energy and Coastal Development Projects	Coastal development has the potential effects include non-point source pollution from coastal areas (e.g., stormwater runoff) that would affect vegetation, wetlands, wildlife and floodplains.
RFFA19	Climate Change	Potential effects of climate change, such as warmer air temperatures and changes to hydrology, could have adverse effects on the ecosystem, including effects to vegetation, wetlands, and floodplains. Warming air temperatures coupled with changing rainfall amounts and timing affects soil conditions, plant communities, insects, and wildlife.
RFFA25	Columbia Pulp Plant	There would be a potential localized adverse effect through loss of vegetation and wetlands in the project area.

1265 Table 6-24 below provides a summary of direct and indirect effects identified for vegetation, wetlands, wildlife, and floodplains.

1266 **Table 6-24. Vegetation, Wetlands, Wildlife, and Floodplains Direct and Indirect Effects Summary**

Region	MO1	MO2	MO3	MO4
Region A				
Vegetation, Wetlands, Wildlife, and Floodplains	There would be some areas of habitat conversion to drier types at Lake Koochanusa and the Kootenai River which could impact wildlife supported by wetland habitats. The current probability of inundation for the existing active floodplains would continue.	There would be an overall negligible effect under MO2 compared to the No Action Alternative. Notable effects include an expanded drawdown zone at Lake Koochanusa, and lower outflow from Libby Dam and Hungry Horse in the spring. The current probability of inundation for the existing active floodplains would continue.	There would be some areas of habitat conversion to drier types at Lake Koochanusa. There is potential for effects to grebes downstream of Albeni Falls Dam from changes in water surface elevations. Floodplain effects would be the same as for MO1.	There would be an expansion of barren areas in Lake Koochanusa and Hungry Horse Reservoirs which would cause a loss of wetland structure and extent. Same as MO1 for floodplains.

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Region	MO1	MO2	MO3	MO4
Region B				
	<p>Large decrease in water surface elevation at Lake Roosevelt which would cause a shift to upland habitats and cause an overall minor adverse effect to wildlife supported by wetland habitats. The current probability of inundation for the existing active floodplains would continue.</p>	<p>There would be minor effects to wildlife on Lake Roosevelt from decreasing reservoir elevations. The current probability of inundation for the existing active floodplains would continue.</p>	<p>There would be little to no effect to the quantity, quality, and distribution of habitats under MO3. Floodplain effects would be the same as for MO1.</p>	<p>Lower reservoir elevations at Grand Coulee and Chief Joseph during the majority of the growing season would result in a shift to upland plant communities in some areas. Same as MO1 for floodplains.</p>
Region C				
Riparian, Wetlands, Aquatic, Invasive Vegetation and Floodplains	<p>There would be a larger barren area at Dworshak Reservoir that could cause drying of amphibian eggs. Portions of the Clearwater River would experience a marginal increase in inundation in June and July which would be a benefit to amphibians and birds. Overall, MO1 would have minor (Dworshak) and negligible (lower Snake River) changes in vegetation, habitat, and wildlife. The current probability of inundation for the existing active floodplains would continue.</p>	<p>There would be drying of shoreline habitat and larger barren areas in Dworshak Reservoir. Floodplain effects would be the same as for MO1.</p>	<p>There would be short-term perched tributaries from dam breaching. There would be a long-term conversion of deep water to wetland islands and mudflats, and conversion/erosion of riparian habitat and increased exposed sediments. Floodplain effects would be negligible across the basin, with the exception of the Snake River below Dworshak Dam, where the floodplain would ultimately return to a more natural condition with major beneficial effects on floodplain values.</p>	<p>Negligible change from the No Action Alternative. Floodplain effects would be the same as for MO1.</p>

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Region	MO1	MO2	MO3	MO4
Region D				
Riparian, Wetlands, Aquatic, Invasive Vegetation and Floodplains	<p>Changes would be within the natural variability and daily fluctuations would be similar to the No Action Alternative. Overall negligible effect compared to the No Action Alternative.</p> <p>The current probability of inundation for the existing active floodplains would remain unchanged from current conditions in most of the basin, with minor reductions in inundation frequency below Bonneville Dam and below John Day Dam (for MO4), which could have minor effects on floodplain benefits in those reaches.</p>	<p>Negligible change from the No Action Alternative. Floodplain effects would be the same as for MO1.</p>	<p>There would be increased sediment deposition after dam breaching which could support development of new wetlands. Floodplain effects would be negligible across the basin.</p>	<p>There would be an increase in mudflats and drying of wetlands regionwide due to decreased reservoir elevations on the lower Columbia River reaches above Bonneville Dam during the growing season.</p> <p>The current probability of inundation for the existing active floodplains would remain unchanged from current conditions in most of the basin, with minor reductions in inundation frequency below John Day Dam (for MO4), which could have minor effects on floodplain benefits in those reaches.</p>

1268 **Regions A and B.** Under MO1 and MO4, some areas of habitat conversion to drier types, and
1269 some loss of wetland spatial extent and structure are possible in areas affected by lower water
1270 levels due to deeper drafts. Under MO3 there could be increased exposure of mudflats that
1271 would result in establishment of invasive plant species. RFFAs that could potentially decrease
1272 the amount of water in the future, such as increased development and associated water
1273 withdrawals, climate change, and increases in future storage projects, would increase this
1274 effect. These cumulative actions would also increase habitat conversion, potential for increased
1275 colonization of invasive species and the expansion of barren areas in reservoirs, loss of wildlife
1276 access, and increase invasive species. These effects are also associated with lower water levels
1277 due to the MOs, which can lead to adverse effects to floodplain inundation timing. Adverse
1278 effects from the MOs and from cumulative actions would be partially offset by habitat
1279 improvement projects such as Federal and state wildlife land management and tribal, state, and
1280 local fish and wildlife improvements. Mitigation actions intended to benefit wildlife and
1281 vegetation as well as wetlands, as identified in Chapter 5, such as vegetation planting and
1282 updating and implementing invasive species plans, could further offset adverse cumulative
1283 effects in Region A. Overall, under all of the Alternatives there would be both beneficial and
1284 adverse cumulative effects to vegetation, wetlands, wildlife, and negligible and minor effects to
1285 floodplains in Regions A and B.

1286 **Region C.** In Region C, drying of shoreline habitat and larger barren areas in Dworshak Reservoir
1287 are caused by deeper drafts for hydropower under MO1 and MO2. This adverse effect would be
1288 increased by the same cumulative actions described for Regions A and B. MO3 would cause
1289 adverse effects to wetlands along the existing shorelines, particularly at tributary inflow
1290 locations due to major decreases in water levels. In the long term, dam breaching would
1291 convert deep water to a riverine environment with wetlands, islands, mudflats, riparian habitat,
1292 and exposed sediments and shoreline. Additionally, after breaching the four lower Snake River
1293 dams, the floodplain would ultimately return to a more natural condition with major beneficial
1294 effects on floodplain values. Mitigation actions implemented under MO3, such as vegetation
1295 planting, and updating and implementing invasive species plans would minimize adverse effects
1296 from dam breaching. Similar to Regions A and B, habitat improvement programs and projects
1297 have the potential to positively affect vegetation, floodplains, and wildlife in this region.
1298 Overall, there would be both beneficial and adverse cumulative effects to vegetation, wetlands,
1299 wildlife, and floodplain values under all of the Alternatives in Region C, with major long-term
1300 beneficial effects to floodplains after breaching the four lower Snake River dams under MO3.

1301 **Region D.** In Region D, there would be minor reductions in floodplain inundation frequency
1302 below Bonneville Dam for MO1 and MO2, and John Day under MO4, but negligible effects
1303 would occur under MO3. In Region D, there would be negligible direct and indirect effects and
1304 negligible cumulative effects under MO1 and MO2 in comparison to the No Action Alternative.

1305 Under MO3, there would be substantial changes with drawdown of reservoirs, dam breaching,
1306 and mobilization of sediment. Sediment mobilization immediately following dam breach lasting
1307 2 to 7 years would result in notable changes, including sediment deposition in Lake Wallula
1308 above McNary Dam and suspended washload moving through the downstream projects to the

1309 estuary at the Pacific Ocean. Additional sediment deposition in Region D could create
1310 conditions favorable for establishment of new wetlands. Cumulative actions that have the goal
1311 of increasing wetland habitat could add to this beneficial effect.

1312 Under MO4, the drawdown to MOP measure would have effects on wetland habitat as a
1313 function of decreased reservoir elevations on the lower Columbia River reaches above
1314 Bonneville Dam during the growing season. RFFAs that could potentially decrease the amount
1315 of water in the future (as identified under Regions A and B) could cause additional loss of
1316 wetlands and an increase in mudflats. Cumulative actions that have the goal of increasing
1317 wetland habitat could partially offset this effect by creating new wetlands.

1318 Major cumulative floodplain effects, arising primarily from past human development actions
1319 and water withdrawals, would be expected to continue into the future, with potential minor
1320 adverse contributions to cumulative floodplain effects from MO1, MO2, and MO4.

1321 **6.3.1.7 Power and Transmission**

1322 RFFAs with potential to impact the power or transmission or both in the CIAA are listed in Table
1323 6-25, along with a description of the effects of these actions.

1324 The planned retirement of several coal-plants in the region affect power and transmission. For
1325 transmission, changes in generation affect the flow of power across different transmission
1326 paths in the Federal transmission system. The impact to power stems from the fact that power
1327 generation from Federal and non-federal projects are shared through a wholesale spot-market.
1328 Thus, the Federal and non-federal power supply are used to serve the regional demand for
1329 power. If hydropower generation is reduced in some of the alternatives, then non-federal
1330 power might be used to serve some of Bonneville's load obligation. However, the retirement of
1331 additional coal plants reduces the availability of non-Federal power. For power and
1332 transmission effects analysis, the cumulative effects of other non-Federal hydroelectric projects
1333 and projected scenarios for coal power plant retirements are captured within the analysis of
1334 direct and indirect effects. The power analysis in Section 3.7 assesses both CRS hydropower and
1335 the reliability of regional power supply. The extent of future coal plant retirements was a key
1336 factor influencing the direct and indirect effects analysis. This is because the availability of coal-
1337 fired power plants to serve regional demand for power (primarily by the region's investor-
1338 owned utilities) influenced how effectively replacement power resources could compensate for
1339 lost hydropower generation, and the base analysis relied on base case coal retirement
1340 assumptions formed in 2017. Two scenarios – one being more coal plant retirements based on
1341 updated information and one being the retirement of all coal plants in the region – provided an
1342 understanding of the differences between the CRSO EIS alternatives and costs of zero-carbon
1343 replacement portfolios via modeling the difference in coal plant retirements into the future.
1344 See Section 3.7 for more information.

1345 **Table 6-25. Reasonably Foreseeable Future Actions Relevant to Power and Transmission**

RFFA ID	RFFA Description	Cumulative Impact Description
RFFA1	Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development	Population growth and development would likely result in an increased demand for power; but it is uncertain how or by what entity that need would be met.
RFFA3	New and Alternative Energy Development	Increased generation from wind, solar, and natural gas projects could decrease the demand for average hydropower generation, though wind and solar projects would increase the demand for hydropower flexibility. Changes in generating resources and new transmission line projects would shift power flows through the transmission system.
RFFA4	Increasing Use of Renewable Energy Sources, Industrial and Vehicle Emissions Reductions, and Decarbonization	This combination could adversely affect Bonneville’s ability to assure an adequate, efficient, economical and reliable power supply to its firm power customers. Changes in generating resources and the loads would shift power flows through the transmission system. Increased renewable development and associated transmission may result in more difficulty of facility siting.
RFFA19	Climate Change	Changes in temperature, precipitation, snowpack, and streamflow would likely adversely affect hydropower generation and load in the Columbia River Basin, increase the potential for wildland fire, which could impact transmission, and increased uncertainty in the magnitude of hydropower generation. Refer to section 4.2.5 for more information.

1346 Table 6-26 below provides a summary of direct and indirect effects identified for Power and Transmission.

1347
1348

Table 6-26. Summary of Direct and Indirect Effects to Power and Transmission (Power & Transmission Effects are Columbia River Basin-wide)

MO1	MO2	MO3	MO4
<p>Hydropower generation from the CRS projects would decrease by about 130 aMW (roughly enough to power 100,000 households annually). The FCRPS, which includes the CRS, would lose 290 aMW of firm power available for long-term, firm power sales to preference customers under critical water conditions. There would be a potential for reduced winter hydropower production flexibility and lost energy production May - September due to increased juvenile fish passage spill, additional water supply withdrawals, and the modified Dworshak summer draft measure. The reduction in power generation would reduce power system reliability, requiring replacement power resources (about 1,200 MW of solar power or 560 MW of single-cycle natural gas turbines under the base case) that could cost up to \$160 million per year. A small amount of increased transmission congestion on some paths, particularly some west-to-east (such as Hemingway to Summer Lake) and north-to-south paths would occur.</p>	<p>Hydropower generation from the CRS projects would increase by 450 aMW (roughly enough to power 360,000 households annually), and the FCRPS would gain 370 aMW of firm power available for long-term firm power sales. This would improve power system reliability and reduce electricity costs. Several power measures would substantially increase within-day flexibility allowing for integrating higher amounts of renewable generation. Shifts in transmission congestion would occur on some paths, particularly some west-to-east, depending on runoff conditions.</p>	<p>Hydropower generation from the CRS projects would decrease by 13%, or 1,100 aMW (roughly enough to power 900,000 households annually). Within-day flexibility would be substantially reduced. The FCRPS would lose 730 MW of firm power available for long-term firm power sales. The reduction in generation would reduce power system reliability, requiring replacement power resources (about 1,120 MW of combined cycle natural gas turbines or about 2,250 MW of solar power resources, 1,125 MW battery, and 600 MW of demand response) in the base case analysis. To replace the lost flexibility and generating capability of the Lower Snake River projects that would be lost under MO3, and additional resources beyond the 2,250 MW of solar power and battery storage would be required. The loss of hydropower generation at Ice Harbor would require that a transmission reinforcement project be in place prior to breaching of the dams. Transmission congestion hours for some north-to-south paths could increase under some runoff conditions and there would be an improvement in congestion hours on some west-to-east paths.</p>	<p>Hydropower generation from the CRS projects would decrease by 16%, or 1,300 aMW (roughly enough to power 1 million households annually). The FCRPS would lose 870 MW of firm power available for long-term firm power sales. The large decrease in hydropower generation from increased spill and other measures would reduce within-day flexibility, flexibility that would be useful for integrating wind and solar generation. The reduction in generation (especially from spill and the August reduction from the McNary Flow Augmentation measure) would reduce power system reliability, resulting in risks of power shortages in about one in every three years. To restore reliability would require replacement power resources (about 3,240 MW of single-cycle natural gas turbines or about 5,000 MW of solar power resources and 600 MW demand response) in the base case analysis. Transmission congestion hours for some north-to-south paths could increase under some runoff conditions and there would be an improvement in congestion hours on some west-to-east paths.</p>

1349

1350 **NO ACTION ALTERNATIVE**

1351 For power and transmission under the No Action Alternative the following RFFAs follow a
1352 theme of increased demand for hydropower generation and/or flexibility effects: Population
1353 Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development; New and
1354 Alternative Energy Development; and Increasing Use of Renewable Energy Sources, Industrial
1355 and Vehicle Emissions Reductions, and Decarbonization. New generation resources would
1356 affect both Federal and non-Federal generation likely in similar ways. Some of the generation
1357 would be in Bonneville's balancing area and some would be in non-Federal balancing areas.
1358 Generally, an increase in variable renewables added to the power mix (renewable integration)
1359 could place additional strain on the hydropower system if using the inherent flexibility in
1360 hydropower to integrate and follow renewable resources. Hydropower is considered a base
1361 load resource, which means that its firm energy and capacity production is used to supply
1362 electric power to meet the retail loads of the region's utilities. Because renewables are not
1363 considered base load resources but rather intermittent generating plants due to their
1364 unpredictable external fuel availability (such as wind and sunlight), they rely on base load
1365 generating resources to ramp up or down in response to their changing power generation.
1366 Because of the trends related to emissions reductions in the region, base load generating
1367 resources such as coal-fired power plants are being retired, and the likelihood of new natural
1368 gas plants being built to replace the retired plants is presently unlikely. As a whole, the region
1369 would have more variable generation with more need for flexibility from the base-load
1370 resources like hydropower and existing gas-fired power plants.

1371 Increasing use of variable renewable energy sources, changes in energy usage patterns, and
1372 population growth may shift flow patterns on the transmission system. Bonneville would
1373 continue to meet its transmission system reliability requirements but may experience shifts in
1374 regional congestion patterns or need to add reinforcements to accommodate changes in power
1375 generation or loads beyond that identified in the planning base cases captured within the
1376 analysis of direct and indirect effects for power and transmission. Additionally, as more variable
1377 renewable energy sources are developed, the competition for locations to site new generation
1378 and transmission could increase, which could increase costs and environmental effects.

1379 The increased mix of renewables could substantially change the regional import and export of
1380 power, for instance, by changing hourly demands, but it is uncertain how these demands would
1381 be met. Meeting demand would depend on where future resources are brought online. There
1382 may be a need for reserves that the hydro system may attempt to provide. There would likely
1383 be an increased need for within day/within hour hydropower generation flexibility (unless there
1384 are other sources of base load generation, which is unlikely because of the move toward a
1385 carbon-free energy sector in the region). This could adversely affect Bonneville's ability to meet
1386 its overarching obligation to assure an adequate, efficient, economical, and reliable power
1387 supply to its firm power customers.

1388 The cumulative effects to power and transmission resources as a result of climate change
1389 include the potential for less or more hydropower production, because changes in

1390 temperature, precipitation, snowpack, and streamflow would likely impact hydropower
1391 generation and load in the Columbia River Basin. Climate change could have substantial effects
1392 on hydropower; however, an uncertainty exists as to the annual and monthly magnitude of
1393 effects to hydropower generation in the region. Projected increasing temperatures would likely
1394 also impact loads and would affect non-Federal utilities similarly to the effect on Federal load.

1395 In addition, the additive effects from the increase in wildland fire as a result of climate change
1396 could have potential effects to system reliability. Maintenance costs could increase if
1397 transmission lines are lost due to fires.

1398 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

1399 Hydropower decreases from the CRS projects would require replacement resources to return
1400 the region to the No Action Alternative LOLP of 6.6 percent. The reduced spring generation and
1401 winter hydropower production flexibility from MO1 could cause a decrease in amounts of
1402 renewable generation integration supported by the CRS projects or require greater amounts of
1403 replacement resources to replace the energy and some of the peaking ability of the
1404 hydropower system causing upward rate pressure.

1405 Cumulative effects from RFFA1, RFFA3, RFFA4, and RFFA20, in combination with the power and
1406 transmission effects analyzed under MO1 are expected to be similar to that of the No Action
1407 Alternative. Regional utilities would be similarly impacted by the cumulative effects from
1408 RFFA1, RFFA3, and RFFA4 with upward rate pressure. If the region did not acquire additional
1409 resources to replace the reduction in hydropower generation, while loads and need for
1410 renewable resources are growing, then there would be an increase in the risk of power
1411 shortages (blackouts). Bonneville would continue to meet its transmission system reliability
1412 requirements, but may experience shifts in regional congestion patterns or need to add
1413 reinforcements to accommodate changes in power generation or loads beyond that identified
1414 in the planning base cases captured within the analysis of direct and indirect effects for power
1415 and transmission.

1416 The cumulative effects to power and transmission resources as a result of climate change
1417 include the potential for less or more hydropower production, because changes in
1418 temperature, precipitation, snowpack, and streamflow would likely affect hydropower
1419 generation and load in the Columbia River Basin. Projected changes from climate change are
1420 likely to affect generation under MO1 relative to the No Action Alternative roughly the same on
1421 an annual basis.

1422 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

1423 Hydropower increases from the CRS projects would increase power and system reliability.
1424 Other non-Federal regional hydropower projects would experience similar winter trends in
1425 hydropower generation to the CRS projects but would not be affected from changing spill at the
1426 CRS projects. The regional hydropower system (including these non-CRS projects) under MO2

1427 would generate 14,000 aMW in an average water year. This represents a 3 percent increase in
1428 power generation relative to the No Action Alternative.

1429 The increase in average and peak hydropower generation as well as increases in hydropower
1430 flexibility from various measures in MO2 would allow for higher amounts of renewable
1431 generation integration than under the No Action Alternative. This would decrease the
1432 cumulative effects from RFFA1, RFFA3, RFFA4, and RFFA20. As the LOLP (risk of power
1433 shortages) under MO2 would be lower than the No Action Alternative, no replacement
1434 resources would be needed, and no new interconnections or reinforcements would be required
1435 to add to the effects associated with the RFFAs.

1436 The cumulative effects to power and transmission resources as a result of climate change would
1437 likely affect generation under MO2 relative to the No Action Alternative roughly the same on an
1438 annual basis.

1439 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

1440 Major hydropower decreases from the CRS projects would decrease power and system
1441 reliability, which would require large amounts of replacement resources. Breaching the four
1442 lower Snake River dams would shift some flexibility requirements onto the remaining
1443 hydropower facilities - and some to other generation sources - decreasing the flexibility
1444 available to integrate renewable generating sources. Other non-Federal regional hydropower
1445 generation would not be impacted by the breach directly. However, the reduction in CRS
1446 project hydropower by over 10 percent would require large amounts of new capacity to bring
1447 the LOLP of MO3 to the No Action Alternative level. This would likely cause upward rate
1448 pressure and would affect the market price for power.

1449 As more variable renewable energy sources are being developed in the region under RFFA1,
1450 RFFA3, RFFA4, and RFFA20, available siting locations for generating resources and transmission
1451 lines could decrease. The lack of available siting locations would be exacerbated when
1452 combined with the large amount of resources needed to bring LOLP back to No Action
1453 Alternative levels under MO3. The use of less suitable sites would increase costs and
1454 environmental effects associated with the variable renewable energy and transmission
1455 development.

1456 In the summer, major cumulative effects from climate change with longer periods of low flows
1457 could exacerbate the loss in hydropower generation from lower Snake River dams, contributing
1458 to substantial reliability concerns of MO3. These RFFAs could also alter power generation and
1459 usage patterns which may further shift transmission flow patterns and associated regional
1460 congestion patterns or reinforcement needs.

1461 The cumulative effects to power and transmission resources as a result of climate change are
1462 likely to affect generation under MO3 relative to the No Action Alternative roughly the same on
1463 an annual basis.

1464 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

1465 Major hydropower decreases in generation from the CRS projects would decrease power, and
1466 system reliability would require large amounts of replacement resources. The decreased
1467 generation would decrease the flexibility available to integrate renewable generating sources.
1468 Other non-Federal regional hydropower generation would not be impacted by increased spill,
1469 but would be impacted by the change in outflows from the headwater projects, such as the
1470 flow change to meet McNary flow augmentation that shifts generation into the spring and out
1471 of late summer with potentially high regional loads, causing upward rate pressure.

1472 Cumulative effects from RFFA1, RFFA3, RFFA4, and RFFA20, in combination with the power and
1473 transmission effects analyzed under MO4, are expected to be similar to that of MO3. However,
1474 MO4 reduces generation even more than MO3, thus further increasing demand for existing
1475 hydropower and leaning more on non-federal generation in the region, thus exacerbating the
1476 potential for declines in system reliability, particularly in August. With this larger reduction in
1477 CRS generation under MO4, there would be a greater potential cumulative impact associated
1478 with variable renewable energy development siting in the region.

1479 As more variable renewable energy sources are being developed in the region, available siting
1480 locations for generating resources and transmission lines could decrease. The lack of available
1481 siting locations would be exacerbated when combined with the large amount of resources
1482 needed to bring LOLP back to No Action Alternative levels under MO4. The use of less suitable
1483 sites would increase costs and environmental effects associated with the variable renewable
1484 energy and transmission development.

1485 In the summer, when the loss of generation from higher spill requirements contributes to
1486 substantial reliability concerns, major cumulative effects from climate change could exacerbate
1487 the decrease in potential generation with longer periods of low flows over summer. These
1488 RFFAs could also alter power generation and usage patterns which may further shift
1489 transmission flow patterns and associated regional congestion patterns or reinforcement
1490 needs.

1491 The cumulative effects to power and transmission resources as a result of climate change are
1492 likely to affect generation under MO4 relative to the No Action Alternative roughly the same on
1493 an annual basis.

1494 **6.3.1.8 Air Quality and Greenhouse Gases**

1495 RFFAs with potential to impact air quality and GHGs in the CIAA are listed in Table 6-27, along
1496 with a description of the effects of these actions.

1497 **Table 6-27. Reasonably Foreseeable Future Actions Relevant to Air Quality and Greenhouse**
1498 **Gases**

RFFA ID	RFFA Description	Cumulative Impact Description
RFFA1	Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development	As the population grows and development increases, it would likely result in an additive adverse effect of increased GHG and air pollutant emissions.
RFFA3	New and Alternative Energy Development	A beneficial impact would likely be seen from the likelihood of reduced GHG and air pollutant emissions. However, generation could be replaced by gas or renewable sources. If it is replaced by gas, then there could be increased emissions.
RFFA4	Increasing Use of Renewable Energy Sources, Industrial and Vehicle Emissions Reductions, and Decarbonization	A beneficial impact would likely be seen from the likelihood of reduced GHG and air pollutant emissions. However, generation could be replaced by gas or renewable sources. If it is replaced by gas, then there could be increased emissions.
RFFA5	Federal and State Wildlife and Lands Management	This would likely result in an additive adverse effect of GHG, air pollutant emissions (including particulate matter from wildland fire).
RFFA19	Climate Change	Potential increase in wildfires could increase GHG and air pollutant emissions, and reduce overall air quality. Reference section 4.2.6 for more information.

1499 Table 6-28 below provides a summary of direct and indirect effects identified for air quality and
1500 GHGs under the Action Alternatives as compared to the No Action Alternative. Impacts under
1501 the No Action Alternative are such that regional emissions are likely to be reduced over time
1502 due to current trends in decarbonization.

1503 Section 3.8.3 explains that the primary driver of potential future air pollutants and GHG
1504 emissions in the CIAA are directly related to anticipated future changes in power generation
1505 sources and transportation methods in the Pacific Northwest. Of the scenarios contemplated as
1506 reasonably foreseeable, all identified a trend toward increasing renewable generation sources
1507 while simultaneously reducing fossil fuels generation sources across the region. In addition,
1508 cleaner vehicle technologies are expected to continue the current trend of bringing electric and
1509 low-emission automobiles to market. This is a result of regional emissions reduction targets,
1510 economic incentives and tax breaks, and recently enacted Federal and state laws.

1511 Because of this, the overall cumulative forecast over the analysis timescale for both air quality
1512 and GHG emissions are an improvement in air quality and a reduction in GHG emissions. This is
1513 because, as the burning of fossil fuels decreases, so do the emissions of criteria air pollutants
1514 and GHGs. The No Action Alternative, MO1 (with renewable replacement power resources),
1515 and MO2 showed a decrease in air pollutants and GHG emissions. Cumulative impacts could
1516 increase the beneficial effects to air quality and GHG found under those alternatives. However,
1517 under MO3 and MO4, as well as MO1 with fossil-fuel replacement power resources, the direct
1518 and indirect analysis showed an increase in air pollutants and GHG emissions due to decreases
1519 in hydropower generation, so it is possible that the cumulative impacts could potentially offset
1520 the adverse effects found under those alternatives.

1521 **Table 6-28. Summary of Direct and Indirect Effects to Air Quality and Greenhouse Gases**

Region	MO1	MO2	MO3	MO4
All Regions	Air quality and GHG emissions would most likely be improved due to increased reliance on renewable resources and a reduction in fossil fuel generation (assuming zero-carbon resource replacement). If conventional least-cost resources, specifically gas-fired generation, replace reduced hydropower generation, then GHG emissions would likely increase slightly and air quality would be slightly degraded.	Minor beneficial air quality and GHG emissions effects from increased hydropower generation, with the exception of minor short-term adverse effects to air quality in Region C near Dworshak Dam.	Overall, effects of MO3 on GHG emissions would be moderate and adverse over the short and long term due to reduced hydropower generation, even assuming resources replacing hydropower are zero-carbon resources (i.e., solar power) and increased truck traffic to replace barge navigation. Addition minor and adverse effects over the short term due to construction activities including dam breaching.	Long-term, moderate, adverse effects on air quality and GHG emissions from increased fossil fuel power generation, even assuming resources replacing hydropower are zero-carbon resources (i.e., solar power). Short-term minor adverse effects to air quality and GHG emissions from construction activities and potential fugitive windblown dust near Hungry Horse.
A (Albeni Falls, Libby and Hungry Horse)	No change from No Action Alternative.	Increased hydropower generation could reduce regional fossil fuel power generation and improve air quality as well as reduce GHG emissions.	No change from No Action Alternative.	There is a small potential for short-term windblown fugitive dust emissions that cause adverse human health effects to occur during reservoir drawdowns. Short-term, minor, adverse effects from localized construction activities at Libby and Hungry Horse.
B (Grand Coulee and Chief Joseph)	No change from No Action Alternative.	Increased hydropower generation could reduce regional fossil fuel power generation and improve air quality as well as reduce GHG emissions.	No change from No Action Alternative.	No change from No Action Alternative.

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Region	MO1	MO2	MO3	MO4
C (Dworshak, Lower Granite, Little Goose, Lower Monumental & Ice Harbor)	No change from No Action Alternative.	<p>Increased hydropower generation could reduce regional fossil fuel power generation and improve air quality with reduced greenhouse gas emissions.</p> <p>Potential for seasonal, long-term, localized windblown dust from exposed sediments associated with reduced reservoir water surface elevation at Dworshak.</p>	<p>Potential increases in windblown dust from construction activities (on road and non-road) during dam breaching and from exposed river sediment in the lower Snake River region post-dam breaching. Increases in GHG and air pollutant emissions would occur from construction vehicles and equipment during breaching and increased truck transport of goods no longer shipped by barge. Breaching the lower Snake River Dams would require replacement of lost power generation and flexible capacity. Generation could be replaced by gas or renewable sources. If it is replaced by gas, then there could be increased emissions. However, even if zero-carbon renewable resources were used as replacements, GHG emissions would still likely increase because existing coal and gas fired generation could increase generation leading to elevated GHG and air pollutant emissions.</p>	<p>Hydropower generation would decrease substantially and require replacement of lost power generation. Generation could be replaced by gas or renewable sources. If it is replaced by gas, then there could be increased emissions. However, even if renewable sources were used as replacements, greenhouse gas emissions would still increase because existing coal and gas fired generation could increase leading to elevated emissions. Short-term air quality effects from construction and exposed sediments would most likely be localized to the project site during construction at Little Goose, Lower Monumental and Ice Harbor Dams.</p>

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Region	MO1	MO2	MO3	MO4
D (McNary, John Day, The Dalles & Bonneville)	Multiple structural projects at McNary may result in PM and other air pollutant emissions nearby an existing maintenance area for PM emissions, though the increased emissions are unlikely to exceed de minimis standards and risk the attainment status of this maintenance area.	Increased hydropower generation could reduce regional fossil fuel power generation and improve air quality with reduced GHG emissions.	Increase in GHG and air pollutant emissions from increased truck transport of goods no longer shipped by barge. Hydropower generation would decrease resulting in increased generation from existing gas and coal plants resulting in increased GHG and air pollutant emissions.	Hydropower generation would decrease resulting in increased generation from existing gas and coal plants resulting in increased GHG. Short-term air quality effects, including potential windblown dust (PM) and other pollutants that cause adverse health effects from construction and exposed sediments would most likely be localized to the project site during construction at McNary, The Dalles and Bonneville Dams.

1523 **ALL ALTERNATIVES**

1524 As described in Section 3.8.2, the Pacific Northwest generally has good air quality, with
1525 relatively few airsheds failing to attain ambient air quality standards, and recent air pollutant
1526 emission trends from the electricity generation and transportation sectors (the sources most
1527 relevant to this analysis) continue to improve under the No Action Alternative and MOs. Oregon
1528 requires coal resources to be eliminated from retail rates by 2030 and the Oregon legislature
1529 has been considering a cap-and-trade program to reduce GHG emissions across multiple
1530 sectors. Washington recently passed legislation eliminating costs associated with coal resources
1531 from retail rates by 2025 and requiring retail electricity sales to be GHG neutral by 2030, which
1532 overlap the CIAA.

1533 For air quality and GHGs, under the No Action and Action Alternatives, a recurring theme
1534 surfaced regarding the additive effects of cleaner air and carbon reduction in the region as a
1535 result of the following cumulative effects: New and Alternative Energy Development; Increasing
1536 Use of Renewable Energy Sources, Industrial and Vehicle Emissions Reductions; and Federal and
1537 State Lands Management. Generally, an increase in renewable energy sources being added to
1538 the power mix, the retirement of coal fired power plants, the low likelihood of new natural gas
1539 plants being built, the proliferation of the use of electric cars and potentially hydrogen fuel
1540 cells, as well as potential conservation measures would all result in the beneficial additive effect
1541 of cleaner air in the CIAA (lower emissions of particulates, pollutants, and GHGs). Federal and
1542 State Lands Management could either worsen or improve the cumulative outcomes of
1543 population growth and wildland fires, depending on the nature of the management action(s).

1544 Reasonably foreseeable future actions associated with Climate Change; Federal and State Lands
1545 Management; and Population Growth and Urban, Rural, Commercial, Industrial, and
1546 Agricultural Development could degrade air quality and increase GHGs for the No Action
1547 Alternative and MOs. These actions increase the likelihood that existing stagnant atmosphere
1548 could be worsened, thereby increasing summer ozone concentrations over time in the
1549 Columbia River Basin. In addition, wildland fires fueled by projected changes to climate (Section
1550 4.1.2.6) and increased population growth could become an increasing source of particulate
1551 matter emissions, thus degrading air quality adverse and also increasing GHGs across the basin.
1552 Federal and State Lands Management could either worsen or improve the cumulative outcomes
1553 of population growth and wildland fires, depending on the nature of the management action(s).
1554 However, the cumulative impact of a reduction in fossil fuels described above could combat
1555 these effects somewhat by curtailing emissions of ozone precursors, particulate matter, and
1556 GHGs.

1557 **NO ACTION ALTERNATIVE**

1558 Cumulative effects applicable to the No Action Alternative are detailed in the “all alternatives”
1559 summary above, and are most similar to the cumulative impacts under MO1 (with zero-carbon
1560 replacement power resources) and MO2. Air pollutants from power generation would be
1561 reduced from current levels under the No Action Alternative, assuming a continued reduction in
1562 coal generation over time. Additional clean fuel standards could lead to a decrease in emissions

1563 associated with transportation and navigation activities. The No Action Alternative includes
1564 nine project-specific structural measures that have the potential to generate air pollutant
1565 emissions from use of construction equipment. Under the base case for the No Action
1566 Alternative, predicted regional emissions would be relatively steady or reduced relative to 2016
1567 levels over time, reflecting continued generation from coal and natural gas resources, constant
1568 hydropower, and new regional renewable power.

1569 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

1570 Cumulative effects applicable to MO1 are detailed in the “All Alternatives” summary above, and
1571 the cumulative impacts under MO1 with zero-carbon replacement power resources are most
1572 similar to those found under the No Action and MO2. Decreased hydropower generation under
1573 MO1 could result in an increased reliance on, and associated air pollutant and GHG emissions
1574 from, existing fossil fuel plants. In addition, if additional fossil-fuel power resources replaced
1575 the decreased hydropower generation air quality could be degraded and GHG emissions
1576 increase. Air quality degradation would most likely occur in areas in the CIAA where existing
1577 fossil fuel plants are concentrated.

1578 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

1579 Cumulative effects applicable to MO2 (aside from RFFA 3 and RFFA4) are detailed in the “All
1580 Alternatives” summary above, and the cumulative impacts under MO2 are most similar to
1581 those found under the No Action Alternative and MO1 with zero-carbon replacement power
1582 resources. MO2 increases hydropower generation over the No Action Alternative, which could
1583 potentially reduce GHGs. Though climate change may slightly reduce that difference, MO2
1584 would still be beneficial to air quality relative to the No Action Alternative by reducing reliance
1585 on fossil fuel power plants. MO2 includes a relatively low level of construction activity given no
1586 new power generation resources would be needed to meet regional demand for power, which
1587 minimizes the effects of RFFAs 3 and 4 (New and Alternative Energy Development and
1588 Increasing Use of Renewable Energy Sources, Industrial and Vehicle Emissions Reductions, and
1589 Decarbonization). In Region C, potential exists for seasonal, localized fugitive dust emissions at
1590 Dworshak over the long term due to reduced water levels during reservoir drawdown.
1591 However, these emissions would not be near or within existing nonattainment or maintenance
1592 areas and may be mitigated by watering exposed sediment and limiting vehicle use in the
1593 exposed sediment areas (BMPs and/or mitigation).

1594 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

1595 Cumulative effects applicable to MO3 are detailed in the “All Alternatives” summary above, and
1596 the cumulative impacts under MO3 are most similar to those found under MO4.

1597 Exposed riverbed along the Snake River would increase potential for fugitive dust (PM)
1598 emissions in Region C and would occur adjacent to an existing maintenance area for PM
1599 (Wallula), risking the ability of this area to maintain adherence to NAAQS for PM. Overall, the
1600 effects of MO3 on air quality would most likely be moderate and adverse over the short and

1601 long term, primarily in Regions C and D. Fugitive dust increases under MO3 could be
1602 exacerbated by the following RFFAs: Population Growth and Urban, Rural, Commercial,
1603 Industrial, and Agricultural Development; Federal and State Wildlife and Lands Management;
1604 Federal and State Lands Management; and Climate Change. That said, the use of BMPs or
1605 mitigation measures to control fugitive dust could minimize the direct and indirect impacts of
1606 these activities, thus reducing or eliminating the cumulative effects.

1607 The reduction in hydropower generation under MO3 could increase the need for additional
1608 power resources. While the type (i.e., mix of renewables and natural gas) and location of
1609 additional power resources is uncertain, the analysis identifies increased power generation
1610 from fossil fuels, including both coal and natural gas, even under the zero-carbon resource
1611 replacement portfolio, degrading air quality and increasing GHG emissions. This is because the
1612 magnitude and timing of the reduction in hydropower generation would occur in particular
1613 times seasonally or daily (e.g., during peak demand) during which flexible resources would need
1614 to increase generation in order to maintain reliability (i.e., to meet the demand for power and
1615 avoid blackouts). Based on currently available technology, other renewable resources (e.g.,
1616 solar and wind) are intermittent; that is, they are not always able to be dispatched on demand
1617 because they are reliant on external factors, such as sun exposure or wind speed. Therefore,
1618 these sources of renewable generation must be used alongside other flexible (dispatchable)
1619 resources to maintain system reliability. With less clean hydropower to provide this flexible
1620 resource, the region would likely rely more on fossil-fuel-based resources, such as coal and
1621 natural gas, to balance renewable generation. Increased GHG emissions associated with modal
1622 shifts in freight transport from barge to relatively high emissions rail and truck would be long-
1623 term and adverse under MO3, which would conflict with the trend of decarbonization and
1624 increased electrical vehicle use described in RFFA4.

1625 Overall, effects of MO3 on GHG emissions would be moderate and adverse over the short and
1626 long term due to construction activities, modal shifts to truck transportation and increased
1627 fossil-fuel power generation. Short term adverse effects to air quality would occur due to
1628 construction and potential fugitive windblown dust. That said, the use of BMPs or mitigation
1629 measures could reduce the direct and indirect impacts of these activities, thus reducing or
1630 eliminating the cumulative impacts.

1631 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

1632 Cumulative effects applicable to MO4 are detailed in the “All Alternatives” summary above, and
1633 the cumulative impacts under MO4 are most similar to those found under the MO3. The
1634 reduction in hydropower generation under MO4, combined with climate change (which could
1635 also reduce regional hydropower generation by reducing available water), could increase the
1636 need for additional power resources. While the type (i.e., mix of renewables and natural gas)
1637 and location of additional power resources is uncertain, if natural gas were added, it would
1638 further degrade air quality relative to the No Action Alternative. Similar to MO3, even if zero-
1639 carbon power resources were added GHG emissions would increase and air quality would likely
1640 be degraded. This is because the magnitude and timing of the reduction in hydropower

1641 generation would occur in particular times seasonally or daily (e.g., during peak demand) during
 1642 which flexible resources would need to increase generation in order to maintain reliability (i.e.,
 1643 to meet the demand for power and avoid blackouts). With less clean hydropower to provide
 1644 this flexible resource, the region would likely rely more on fossil-fuel-based resources, such as
 1645 coal and natural gas, to balance renewable generation.

1646 Short-term air quality effects from construction activities and exposed sediments would most
 1647 likely be localized to the project site during construction of additional powerhouse surface
 1648 passage routes at Little Goose, Lower Monumental, McNary, The Dalles, Bonneville and Ice
 1649 Harbor. Construction activities at McNary and Ice Harbor Dams are close to the Wallula
 1650 maintenance area for PM10, however BMPs or mitigation measures could reduce the direct
 1651 and indirect impacts of these activities.

1652 **6.3.1.9 Flood Risk Management**

1653 RFFAs with potential to impact flood risk management in the CIAA and a summary of their
 1654 potential impact are listed in Table 6-29. Effects to Flood Risk Management from the No Action
 1655 Alternative are expected to be similar to existing conditions as described in Section 3.9.4.2.

1656 **Table 6-29. Reasonably Foreseeable Future Actions Relevant to Flood Risk Management**

RFFA ID	RFFA Description	Impact Description
RFFA1	Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development	As the population grows and development increases, it is possible that additional structures and populations may be located in flood-prone areas.
RFFA2	Water Withdrawals for Municipal, Agricultural, and Industrial Uses	There would be an overall reduced availability of water from increased demand. Increased demands for power could change the shape of generation from existing patterns.
RFFA3	New and Alternative Energy Development	Increased generation from wind, solar, and natural gas projects could decrease the demand for average hydropower generation, though wind and solar projects would increase the demand for hydropower flexibility. Changes in generating resources and new transmission line projects would shift power flows through the transmission system.
RFFA4	Increasing Use of Renewable Energy Sources, Industrial and Vehicle Emissions Reductions, and Decarbonization	There would be possible adverse effects due to the potential for an increase in lack of market/lack of turbine capacity spill, which could lead to higher total dissolved gas (TDG) levels. Conversely, decarbonizing and electrifying transportation and other sectors could reduce involuntary spill from lack-of-market.
RFFA6	Increase in Water Storage Projects	There would be potential changes to timing of delivery and quantity of water in different locations.
RFFA19	Climate Change	In general, there would be potential for higher winter and spring volumes and lower summer volumes. Refer to section 4.2.7 for more information.

1657 The Flood Risk Management analysis (Section 3.9) evaluated the MOs to determine if there
 1658 would be a change in flood hazards faced by communities, property, infrastructure or levees in
 1659 the Columbia River Basin under each of the alternatives. Anticipated future flood risk under the

1660 No Action Alternative is anticipated to be consistent with current conditions. Under MO1, MO2,
1661 MO3, and MO4, decreases in flood risk may occur in some areas, especially Region D under
1662 MO1, MO2, and MO4. New and alternative energy sources or the increasing use of renewable
1663 energy sources may change the timing and patterns of flows in the CRS. Actions outside of the
1664 alternatives, such as climate change (higher winter and spring runoff) and population growth
1665 and development, may adversely impact flood risk in the future as noted in Table 6-29, but
1666 there would be no adverse cumulative effect under any of the alternatives because none of the
1667 alternatives would cause direct or indirect adverse effects to flood risk management. It is
1668 possible that actions such as increases in water storage projects and lower overall water levels
1669 in the summer from climate change combined with benefits noted for MO1 through MO4 could
1670 have a cumulative benefit to flood risk management.

1671 **6.3.1.10 Navigation and Transportation**

1672 RFFAs with potential to impact navigation and transportation in the CIAA and a summary of
1673 their potential impact are listed in Table 6-30. Conditions under the No Action Alternative are
1674 expected to be similar to those described in the existing conditions presented in Section
1675 3.10.3.2.

1676 **Table 6-30. Reasonably Foreseeable Future Actions Relevant to Navigation and**
1677 **Transportation**

RFFA ID	RFFA Description	Impact Description
RFFA1	Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development	As the population grows and development increases, it is possible that there could be an increased demand for transportation of goods on the navigation channel.
RFFA2	Water Withdrawals for Municipal, Agricultural, and Industrial Uses	There would be a reduced availability of water from increased demand.
RFFA14	Lower Columbia River Dredged Material Management Plan	There would be a beneficial effect from removal of accumulated sediment in the navigation channel.
RFFA15	Snake River Sediment Management Plan	There would be a beneficial effect from removal of accumulated sediment in the navigation channel.
RFFA19	Climate Change	Navigation and transportation could be affected by climate change through its effects on seasonal patterns and variability of streamflow and consequences for riverbed profiles. Refer to section 4.2.8 for more information.

1678 Anticipated future navigation and transportation under the No Action Alternative is anticipated
1679 to be consistent with current conditions. Direct and indirect effects of the other alternatives are
1680 listed below in Table 6-31.

1681 Future higher spring runoff volumes due to climate change could increase the direct and
1682 indirect effects of the alternatives on the Inchelium-Gifford Ferry operations at Lake Roosevelt,
1683 but it is not known to what extent. Mitigation actions identified in Chapter 5 would include
1684 extending the ramp at the Inchelium-Gifford Ferry to minimize this impact. None of the other
1685 cumulative actions identified for navigation are expected to impact navigation in the upper

1686 Columbia River Basin. Alternatives would have negligible effects to navigation on the lower
 1687 Columbia River and lower Snake River, except MO3 and MO4 There are no anticipated
 1688 discernable cumulative effects to navigation on the lower Columbia and lower Snake Rivers
 1689 except under MO3. Mitigation actions under MO3 would include armoring piers on a limited
 1690 amount of bridges and armoring a limited amount of railroad and highway embankments that
 1691 could minimize adverse effects to infrastructure due to an increase in flow velocities. Loss of
 1692 the Federal Navigation Channel in Region D at the confluence of the lower Snake and Columbia
 1693 Rivers would require additional dredging actions. Mitigation actions under MO4 would also
 1694 include monitoring of tailrace conditions in Regions C and D to determine if structure
 1695 modifications are necessary to reduce damages and increased dredging as needed due to
 1696 shoaling caused by higher spill levels. Under MO3, navigation on the lower Columbia River
 1697 could be adversely affected by projected overall lower water levels in the summer due to
 1698 climate change and increased water demand in the future. Continued dredging in the lower
 1699 Columbia River would continue to offset the effects of sedimentation in this reach. Under MO3,
 1700 commercial navigation on the lower Snake River would be effectively eliminated by dam
 1701 breaching, and it is anticipated that dredging operations would cease in this reach.

1702 **Table 6-31. Summary of Direct and Indirect Effects to Navigation**

Location	MO1	MO2	MO3	MO4
Upper Columbia River Basin	There would be a reduction in Inchelium-Gifford Ferry Operations for an additional 9 days in wet years.	Same as MO1	There would be a reduction in Inchelium-Gifford Ferry Operations for an additional 2 days in wet years.	Same as MO1
Lower Columbia River	Negligible change from the No Action Alternative.	Negligible change from the No Action Alternative.	Commercial Navigation on the Columbia River shallow segment would be adversely affected at ports above McNary Dam due to sedimentation for 2 to 7 years. Some river ports on the Columbia River would experience a large volume increase. Cruise line operations would be curtailed and may stop. Loss of the Federal Navigation Channel in Region D at the confluence of the lower Snake and Columbia Rivers would require additional dredging actions.	High spill combined with tailrace conditions could result in increased infrastructure damage.
Lower Snake River	Negligible change from the No Action Alternative.	Negligible change from the No Action Alternative.	Commercial Navigation would be eliminated at four lower Snake River projects. All ports on the Snake River would be inaccessible without dredging. Shipping costs would increase and would vary widely depending on location. There would be elimination of access for commercial cruise operations.	High spill combined with tailrace conditions could result in increased infrastructure damage.

1703 **6.3.1.11 Recreation**

1704 RFFAs with potential to impact recreation in the CIAA and a summary of their potential effects
1705 are listed in Table 6-32.

1706 **Table 6-32. Reasonably Foreseeable Future Actions Relevant to Recreation**

RFFA ID	RFFA Description	Cumulative Impact Description
RFFA1	Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development	There would be an overall reduced availability of water from increased demand. Increased demands for power that could change shape of generation.
RFFA2	Water Withdrawals for Municipal, Agricultural, and Industrial Uses	There would be an adverse impact through reduced availability of water from increased demand.
RFFA6	Increase in Demand for New Water Storage Projects	There would be a beneficial impact through increased opportunity for reservoir-based recreation, possible adverse impact through reduction in river-based recreation.
RFFA7	Fishery Management Plans	The goal of Pacific Salmon Management plans is to better manage catch of salmon in ocean waters offshore. This could lead to a trend of beneficial effects to salmon numbers by reducing commercial catch for these species. The U.S. v Oregon Fishery Management Agreement has the overall goal of rebuilding weak runs to full productivity through habitat protection authorities, enhancement efforts, artificial production techniques and harvest management. Implementation of this agreement could lead to a trend of beneficial effects to target species important to recreational anglers.
RFFA11	Resident Fisheries Management	The state and tribal fish and game agencies manage, for recreational, ceremonial, and subsistence, fisheries in the Columbia River Basin and regulate private and public hatchery releases. The agencies modify and publish recreational fishing regulations on an annual basis. Currently, recreational anglers may not target bull trout in most areas but may incidentally catch and release bull trout. Other resident fisheries include Kokanee and Burbot in the upper basin.
RFFA12	Fish Hatcheries	There would be a beneficial effect from increasing fish populations through stocking.
RFFA13	Tribal, State, and Local Fish and Wildlife Management	New Tribal, State, and Local fish and wildlife improvement projects are projected to restore, maintain, create, or enhance fish and wildlife habitat. Many of these projects are focused on benefiting anadromous species.
RFFA14	Lower Columbia River Dredged Material Management Plan	There would be a beneficial effect from removal of accumulated sediment in the navigation channel.
RFFA19	Climate Change	Recreational opportunities could be impacted by climate change primarily by changing seasonal access for in-water activities. Climate change effects to other resources, for instance, fish and wildlife, could also affect recreational opportunities. Refer to section 4.2.9 for more information.

1707 Future recreation under the No Action Alternative is anticipated to be consistent with current
1708 conditions as described in Section 3.11.3.2. Direct and indirect effects of the MOs are listed
1709 below in Table 6-33.

1710 **Table 6-33. Summary of Direct and Indirect Effects to Recreation**

Location	MO1	MO2	MO3	MO4
Regions A and B	Overall effects of MO1 on recreational visitation are anticipated to be negligible to minor in the region. Effects to the quality of fishing, hunting, wildlife viewing, swimming, and water sports at river recreation sites in the region under MO1 would be negligible.	There would be a minor reduction in reservoir visitation at Lake Roosevelt, Hungry Horse, and Lake Koochanusa. There would be adverse effects to fishing quality in the region and minor adverse effects to the quality of hunting, wildlife viewing, swimming, and water sports in the region.	There would be negligible to minor reductions in reservoir visitation at Hungry Horse and Lake Koochanusa. There would be negligible adverse effects to fishing quality and to the quality of hunting, wildlife viewing, swimming, and water sports in the region.	There would be a minor reduction in reservoir visitation at Hungry Horse and Lake Koochanusa. There would be minor adverse effects to the quality of hunting, wildlife viewing, swimming, and water sports in the region.
Region C	Overall effects of MO1 on recreational visitation are anticipated to be negligible to minor in the region. Effects to the quality of fishing, hunting, wildlife viewing, swimming, and water sports at river recreation sites in the region under MO1 would be negligible.	There would be a minor reduction in reservoir visitation at Dworshak. There would be minor adverse effects to fishing quality, the quality of hunting, wildlife viewing, swimming, and water sports in the region.	There would be a potentially large reduction in reservoir visitation at the four lower Snake River Projects, but potential increases in river visitation. Adaptation to the new river environment is likely over time. There would be short-term adverse effects to the quality of hunting, wildlife viewing, swimming, and water sports.	There would be no reduction in reservoir visitation. There would be negligible to minor adverse effects to the quality of hunting, wildlife viewing, and swimming, and water sports at river recreation sites in the region.
Region D	Overall effects of MO1 on recreational visitation are anticipated to be negligible to minor in the region. Effects to the quality of fishing, hunting, wildlife viewing, swimming, and water sports at river recreation sites in the region under MO1 would be negligible.	There would be no reduction in reservoir visitation. There would be negligible to minor adverse effects to fishing quality, quality of hunting, wildlife viewing, swimming, and water sports in the region.	There would be potentially large reductions in reservoir visitation at Lake Wallula (McNary) due to sedimentation over 2 to 7 years with adaptation likely over time. There would be potential short-term adverse effects to the quality of hunting, wildlife viewing, swimming, and water sports.	There would be no reductions in reservoir visitation and minor benefits to the quality of hunting, wildlife viewing, swimming, and water sports in the region.

1711 **Regions A and B.** For each of the alternatives, negligible to small reductions in reservoir
1712 visitation at Lake Roosevelt, Hungry Horse, and Lake Kooconusa are driven by reduced boat
1713 ramp accessibility for some periods of time during the year. An overall reduced volume of
1714 available water from increased demand and from the effects of climate change, causing lower
1715 summer runoff volumes, has the potential to cumulatively increase these negligible to minor
1716 adverse effects under the MOs, especially during the summer.

1717 Adverse effects to fishing quality, hunting, wildlife viewing, swimming, and other water sports in
1718 the upper basin under MO2, MO3, and MO4 are caused by changes in reservoir elevations (mainly
1719 lower reservoir elevations) and river flows and associated water quality, water temperatures, and
1720 bird, wildlife, and fish habitat. Similar to visitation, the overall reduced volumes of water that
1721 could result from climate change in summer and from increased water demand due to
1722 development could cumulatively increase these adverse effects in the future. These same
1723 cumulative actions have the potential to decrease the minor benefits anticipated under MO1.

1724 An increase in water storage projects in the upper basin would be considered beneficial to
1725 reservoir-based recreation, but it could adversely affect river-based recreation in these areas.
1726 Fish propagation and stocking are anticipated to continue under each of the MOs, providing a
1727 benefit to recreation under all of the MOs through maintained or improved fish populations.

1728 **Region C.** Under MO1 and MO2, there would be negligible to minor reductions in reservoir
1729 visitation at Dworshak, while under MO4 there would be no reductions in reservoir visitation in
1730 the lower Snake River. The small reductions in MO1 and MO2 are caused by lower water levels
1731 making boat ramps temporarily inaccessible. Extending the boat ramp at Dworshak State Park
1732 to make it accessible in April would minimize adverse recreational effects for fishermen under
1733 MO2. Cumulative actions that also lower water levels, such as climate change and increased
1734 withdrawals, would likely increase this effect. Under MO3, there is a potentially large reduction
1735 in visitation at the four lower Snake River projects due to dam breach and sedimentation for 2
1736 to 7 years. After the river stabilizes, there would be benefits to river-based recreation that
1737 could be increased from cumulative actions such as fishery management and decreased from
1738 cumulative actions such as climate change, water withdrawals, and population growth and
1739 development. Adaptation to the new river environment over time would benefit river-based
1740 recreation, but would be a complete loss of reservoir-based recreation.

1741 Similar to the lower Columbia River, minor effects to the quality of hunting, wildlife viewing,
1742 swimming, water sports, and fishing under MO1, MO2, and MO4 are caused by changes in
1743 reservoir elevations and river flows and associated water quality, water temperatures, and fish
1744 and wildlife habitats as described in detail in Chapter 3. Effects from cumulative actions would
1745 be the same as described for the lower Columbia River. Under MO3, there would be short-term
1746 adverse effects to the quality of recreation caused by the dam breach and sedimentation. After
1747 the river stabilizes, there would be benefits to river-based recreation that could be increased
1748 from cumulative actions such as fishery management and decreased from cumulative actions
1749 such as climate change, water withdrawals, and population growth and development.

1750 **Region D.** There would be no effects to visitation under the MOs except for MO1 and MO3.
 1751 There would be a minor impact to visitation under MO1 from reduced reservoir levels. The
 1752 contribution of cumulative actions would be the same as described for the upper basin. MO3
 1753 would cause a potentially large reduction in reservoir visitation at Lake Wallula (McNary) due to
 1754 sedimentation over 2 to 7 years following dam breaching.

1755 Minor beneficial changes would be increased through continued fish propagation and stocking
 1756 (e.g. the U.S. v Oregon Fish Management Plan), and Pacific Salmon Management Plans for
 1757 recreational fishing, and dredging, which would continue to provide a benefit through
 1758 maintaining the navigation channel for boating. Minor adverse effects would be increased by
 1759 the effects of climate change and increased future water withdrawals due to population growth
 1760 and development.

1761 **6.3.1.12 Water Supply**

1762 RFFAs with the potential to impact water supply are primarily those that result in additional
 1763 water surface elevation changes and increased sedimentation in the CIAA and are listed in
 1764 Table 6-34, along with a description of the effects of these actions.

1765 **Table 6-34. Reasonably Foreseeable Future Actions Relevant to Water Supply**

RFFA ID	RFFA Description	Cumulative Impact Description
RFFA1	Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development	As the population grows and development increases, adverse effects may result from increased demands and heightened competition for limited water supplies. There could be reduced availability of water from increased development. An increase in development projects has the potential to increase sediment input during construction and operation.
RFFA2	Water Withdrawals for Municipal, Agricultural, and Industrial Uses	Overall, there is potential for reduced availability of water from increased demand. Adverse effects result from heightened competition for limited water supplies, including ongoing non-federal tributary-based water diversions.
RFFA6	Increase in Demand for New Water Storage Projects	With new storage projects there would be potential changes to the timing of delivery and quantity of water in different locations.
RFFA19	Climate Change	In general, there is potential for higher average fall and winter flows, earlier peak spring runoff, and longer periods of low summer flows in the Columbia River Basin.
RFFA25	Columbia Pulp Plant	This could increase potential adverse effects due to chemical discharges, water use, and spills.

1766 Anticipated future water supplies under the No Action Alternative are anticipated to be
 1767 consistent with current conditions. Direct and indirect effects of the MOs are listed below in
 1768 Table 6-35.

1769 **Table 6-35. Summary of Direct and Indirect Effects to Water Supply**

Region	MO1	MO2	MO3	MO4
A (Libby, Hungry Horse, Albeni Falls)	No change from No Action Alternative.	No change from No Action Alternative.	No change from No Action Alternative.	No change from No Action Alternative.
B (Grand Coulee, Chief Joseph)	No change from No Action Alternative.	No change from No Action Alternative.	No change from No Action Alternative.	No change from No Action Alternative.
C (Dworshak, Four Lower Snake River Projects)	No change from No Action Alternative.	No change from No Action Alternative.	Approximately 48,000 acres would no longer be irrigated from the reservoirs behind the Lower Snake Dams, 9,000 acre-feet of M&I delivery would likely be impacted, and approximately 63 wells may be adversely impacted by dropping water levels due to breach of lower Snake River dams.	No change from No Action Alternative.
D (Four Lower Columbia River Projects)	No change from No Action Alternative.	No change from No Action Alternative.	Small, private pumps may receive fine sediment that may impact pump filters and require more frequent maintenance due to these measures: Breach Snake Embankments, Lower Snake Infrastructure Drawdown, and Drawdown Operating Procedures.	No change from No Action Alternative.

1770 Effects to water supply resources are primarily related water surface elevation and
 1771 sedimentation because pumping from the river requires water elevations to be above the
 1772 pumps, and the pumps need to be bringing in clean enough water to not clog the pumps.
 1773 Effects to water supply resources are primarily related water surface elevation and
 1774 sedimentation because pumping from the river requires water elevations to be above the
 1775 pumps, and the pumps need to be bringing in clean enough water to not clog the pumps.
 1776 Therefore, most cumulative effects would be associated with similar effects (changes to water
 1777 surface elevation or releases of sediment that could affect pump operations).

1778 Under all alternatives, climate change has the potential to impact current water supply
 1779 practices for both surface and groundwater users. This is because reductions in summer and fall
 1780 surface water stream flows may reduce the amount of available surface water supply. The
 1781 decreased ability to rely on surface water could cause some water users to rely more on
 1782 groundwater, thus impacting groundwater supplies through increased pumping by users to
 1783 meet need. In addition, the decrease in snowpack and higher intensity winter storms as a result
 1784 of climate change may exacerbate this issue by decreasing the surface water available to
 1785 facilitate groundwater recharge. On the mainstem Columbia and Snake Rivers, the vast majority
 1786 of water diversions for irrigation and municipal and industrial water supply are captured in the
 1787 direct and indirect effects section, because these diversions are part of the alternatives.
 1788 However, the cumulative effects of smaller, tributary-origin water diversions are not part of the
 1789 alternatives and are therefore cumulative actions. The cumulative effects of tributary water

1790 diversions added to Federal water diversions are expected to continue in the future over the
1791 study period under all alternatives and will adversely affect water supply into the future by
1792 removing water supplies before they reach the mainstem of the Columbia and Snake Rivers,
1793 which is where the vast majority of federal water diversions occur.

1794 **NO ACTION ALTERNATIVE**

1795 As described in the cumulative effects analysis for hydrology and hydraulics (Section 6.3.1.1),
1796 Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development in
1797 the Columbia River Basin is expected to drive the conversion of existing agricultural lands to
1798 nonagricultural uses. This is true of all alternatives.

1799 The Columbia River Basin Project delivers 70,000 acre-feet of municipal and industrial water to
1800 project contractors. Some cities and industries divert water from the river system, but these
1801 diversions are small to the point of being immeasurable when compared to the total flow in the
1802 system. In the future, due to population growth, it is reasonably foreseeable that municipal and
1803 industrial water withdrawals will increase, whereas currently they are concentrated on or near
1804 the Lower Granite and McNary reservoirs.

1805 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

1806 MO1 does not have any measures that would affect the ability to deliver water to meet current
1807 water supply. As a result of climate change, water supply uses that rely on live/natural flow
1808 water rights for delivery may experience increased shortage in the summer or fall as flows
1809 decrease during this period. Changes to operations should not affect live/natural flow
1810 distributions because they are generally premised on the legal principle of prior appropriation.

1811 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

1812 MO2 does not have any measures that would affect the ability to deliver water to meet current
1813 water supply. Water flowing into Lake Roosevelt could be impacted by climate change, both in
1814 volume and timing. However, it will likely not impact water supply deliveries for the Columbia
1815 Basin Project because existing water users have senior water rights when compared to most
1816 other uses at Lake Roosevelt, and the flow and timing changes will not impact those deliveries.

1817 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

1818 MO3 includes measures to breach dams on the lower Snake River, where water is diverted for
1819 irrigation in Washington. These measures are *Breach Snake Embankments*, *Lower Snake*
1820 *Infrastructure Drawdown*, and *Drawdown Operating Procedures*. Currently and in the No Action
1821 Alternative, water is provided out of the reservoirs of these facilities and groundwater that
1822 results from the reservoirs. The pumps that supply this water would no longer be operational
1823 once the dams are breached and the nearby groundwater elevations could be substantially
1824 lowered by MO3. As a result, approximately 48,000 acres would no longer be irrigated from the
1825 reservoirs behind the lower Snake River dams, affecting approximately 9,000 acre-feet of M&I

1826 delivery. In addition, approximately 63 wells may be impacted by dropping water levels due to
1827 breaching of lower snake dams.

1828 In terms of cumulative effects, it is largely uncertain as to where population growth and
1829 additional water withdrawals for municipal, agricultural, and industrial uses would occur in the
1830 CIAA in the future. If these activities were to occur in Region C (in the vicinity of Dworshak,
1831 Lower Granite, Little Goose, Lower Monumental and Ice Harbor), such as in the Tri-Cities of
1832 Pasco, Richland, and Kennewick, Washington, additive adverse effects would likely result from
1833 increased demands and heightened competition for limited water supplies (water supply
1834 shortages, particularly for M&I). Since 2000, the population of the Tri-Cities metropolitan area
1835 increased approximately 50 percent, adding just over 90,000 people. The area's projected 10-
1836 year growth rate is 12 percent (Washington Office of Financial Management 2019). Future
1837 potential water shortages could stress this growing area's ability to deliver water to residents
1838 and industry.

1839 It is possible under MO3 that existing water supply intakes in the McNary and John Day
1840 reservoirs impacted during periods of breach could be cumulatively impacted by the increase in
1841 frequency of wildland fire due to climate change (which could increase sedimentation in the
1842 river). The same exacerbation of sediment loads could also be cause by mining upstream of
1843 dams and population growth, urban, and rural development. Depending on the nature of land
1844 use management practices, sediment loads could either add cumulatively to increased
1845 sedimentation or reduce sediment to offset other effects. Lastly, Clean Water Act-related
1846 actions could also offset increased sediments due to efforts to reduce sediment in the river. It is
1847 also possible that mitigation may be applied under MO3 to minimize and perhaps eliminate
1848 these potential sedimentation-related effects (see Chapter 5).

1849 Additive cumulative effects from climate change are not expected to differ from the No Action
1850 Alternative.

1851 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

1852 MO4 does not have any measures that would affect the ability to deliver water to meet current
1853 water supply. Effects are similar to the No Action Alternative.

1854 **6.3.1.13 Visual Resources**

1855 RFFAs with the potential to impact visual are primarily those that result in changes to visual
1856 resources in the CIAA and are listed in Table 6-36, along with a description of the effects of
1857 these actions.

1858 **Table 6-36. Reasonably Foreseeable Future Actions Relevant to Visual Resources**

RFFA ID	RFFA Description	Cumulative Impact Description
RFFA1	Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development	There could be potential additive visual effects due to change in the viewshed from human population growth, which brings potential permanent modifications from residential, commercial, industrial, agricultural, recreational, and transportation development.
RFFA3	New and Alternative Energy Development	There could be potential additive visual effects due to the permanent change in the viewshed from construction or deconstruction of energy infrastructure.
RFFA12	Fish Hatcheries	There would be possible adverse effects due to construction and operations of fish hatcheries near the dams effecting the viewer's experience. The construction and operations of fish hatcheries would adversely affect sensitive viewers.
RFFA25	Columbia Pulp Plant	This would be additive visual effects due to the permanent change in the viewshed from the installation of the pulp plant, which is located in Lyons Ferry downstream of Little Goose Dam and upstream of Lower Monumental Dam.

1859 Anticipated future effects to visual resources under the No Action Alternative are anticipated to
 1860 be consistent with current conditions. Direct and indirect effects of the MOs are listed below in
 1861 Table 6-37.

1862 **Table 6-37. Summary of Direct and Indirect Effects to Visual Resources**

Region	MO1	MO2	MO3	MO4
A (Libby, Hungry Horse, Albeni Falls)	No change from No Action Alternative.	No change from No Action Alternative.	No change from No Action Alternative.	Moderate effects on sensitive viewers from operational measures that result in reservoir drawdowns. Minor effects from structural measures. Sensitive viewers may be affected.
B (Grand Coulee, Chief Joseph)	No change from No Action Alternative.	No change from No Action Alternative.	No change from No Action Alternative.	Moderate-to-major effects from operational measures that result in reservoir drawdowns. Minor effects from structural measures. Sensitive viewers may be affected.

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Region	MO1	MO2	MO3	MO4
C (Dworshak, Four Lower Snake River Projects)	Minor overall effect from changes in the seasonal timing and duration of effects from operational measures. Minor-to-moderate effects from structural measures. Sensitive viewers may be affected.	Minor overall effect from changes in the seasonal timing and duration of effects from operational measures. Minor-to-moderate effects from structural measures. Sensitive viewers may be affected.	Breaching the lower Snake River dams would result in a major visual quality effect. Depending on the viewer's perspective, this change could be beneficial or adverse. Sensitive viewers may be affected.	Minimal change from No Action Alternative.
D (Four Lower Columbia River Projects)	Minor overall effect from changes in the seasonal timing and duration of effects from operational measures. Minor-to-moderate effects from structural measures. Sensitive viewers may be affected.	Minor overall effect from changes in the seasonal timing and duration of effects from operational measures. Minor-to-moderate effects from structural measures. Sensitive viewers may be affected.	Minor effect from structural measures. Sensitive viewers may be affected.	Minimal change from No Action Alternative.

1863 Visual impairments associated with construction or modification of facilities are anticipated
 1864 under various MOs. Overall, the effects from the alternatives in combination with past, present,
 1865 and reasonably foreseeable future actions are expected to result in minor cumulative effects to
 1866 visual resources, except for effects associated with MO3 and MO4.

1867 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

1868 MO1 does not contain measures that would substantially affect the viewshed, and therefore
 1869 any cumulative impact from the RFFAs listed above would be negligible. Overall, the
 1870 operational and structural measures under MO1 would have a similar effect as under the No
 1871 Action Alternative. There would be a moderate effect to visual quality from new fish-passage
 1872 structures and minor effect from modifications of existing structures in Region D and the lower
 1873 Snake River projects in Region C, but overall, the effects from MO1 would be minor.

1874 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

1875 MO2 would have a similar effect on visual quality to sensitive viewers as under the No Action
 1876 Alternative. In addition, no substantial reasonably foreseeable cumulative effects are expected
 1877 in the CIAA over the analysis period. Therefore, no cumulative effects are anticipated under this
 1878 alternative.

1879 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

1880 The most substantial effects were identified in Region C from breaching the lower Snake River
 1881 projects. In particular, local residents and visitors would experience viewshed changes due to
 1882 losses of lake-like characteristics and a return to free-flowing river characteristics under MO3 in

1883 the vicinity of the existing reservoirs in the lower Snake River. For the structural measures,
1884 there would be major alterations to the viewshed associated with the dam breaching in Region
1885 C. Viewers would see the loss of earthen embankments and some associated project
1886 infrastructure. There would be a loss of lake-like characteristics in the lower Snake River with
1887 the addition of a free-flowing river. Overall, the visual effect of dam breaching would be
1888 moderate to major. Depending on the viewer’s perspective, this change could be beneficial or
1889 adverse.

1890 These effects would occur in relatively isolated areas without residences immediately nearby.
1891 Ongoing land-based activities would continue under all of the alternatives, but it is unclear how
1892 much new development would be expected after the breach of the four lower Snake River
1893 dams in MO3, for instance.

1894 The Columbia Pulp Plant could potentially increase adverse effects due to visual changes
1895 associated with the newly constructed pulp plant, which is located in Lyons Ferry downstream
1896 of Little Goose Dam and upstream of Lower Monumental Dam in Region C.

1897 Taken together, the impact to visual quality from dam breaching under MO3 in Region C, when
1898 added to other past, present, and reasonably foreseeable future actions affecting the viewshed
1899 such as the Columbia Pulp Plant and other land-based development trends, could result in
1900 cumulative effects on visual quality.

1901 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

1902 The McNary flow target measure drafts the storage projects in Region A and B for fish flows in
1903 the lower basin. These drawdowns would result in a substantial effect to visual quality on a
1904 seasonal basis. At Lake Kocanusa and Hungry Horse Reservoir, these effects would occur in
1905 relatively isolated areas without residences immediately nearby, therefore the likelihood of
1906 adding to the cumulative effects to visual quality is negligible. There is the potential for new
1907 residential and commercial development near both Lake Pend Oreille and Lake Roosevelt. The
1908 drawdowns would add to the cumulative effects to visual resources at these two locations, but
1909 it is unclear how much new development would occur.

1910 **6.3.1.14 Noise**

1911 RFFAs with the potential to impact noise in the CIAA and are listed in Table 6-38, along with a
1912 description of the effects of these actions.

1913 **Table 6-38. Reasonably Foreseeable Future Actions Relevant to Noise**

RFFA ID	RFFA Description	Cumulative Impact Description
RFFA1	Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development	There would be adverse effects from increased volumes of noise as human population growth brings potential increases in background noise from residential, commercial, industrial, agricultural, recreational, and transportation development and activities.
RFFA3	New and Alternative Energy Development	There would be possible adverse effects due to construction or deconstruction of new and old energy infrastructure.

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RFFA ID	RFFA Description	Cumulative Impact Description
RFFA4	Increasing Use of Renewable Energy Sources, Industrial and Vehicle Emissions Reductions, and Decarbonization	There would be possible adverse effects due to construction and operations of renewable energy sources (i.e., wind turbines).
RFFA25	Columbia Pulp Plant	This could increase potential adverse effects due to noise associated with operating the pulp plant, which is located in Lyons Ferry downstream of Little Goose Dam and upstream of Lower Monumental Dam.
RFFA26	Middle Columbia Dam Operations	There would be possible adverse effects due to ongoing noise from operations and maintenance activities.

1914 Anticipated future effects to noise under the No Action Alternative are anticipated to be
 1915 consistent with current conditions. Direct and indirect effects of the MOs are listed below in
 1916 Table 6-39.

1917 **Table 6-39. Summary of Direct and Indirect Effects to Noise**

Region	MO1	MO2	MO3	MO4
A (Libby, Hungry Horse, Albeni Falls)	Negligible and minor effect, similar to the No Action Alternative.	Negligible and minor effect.	Negligible and minor effect, similar to the No Action Alternative.	No change from No Action Alternative.
B (Grand Coulee, Chief Joseph)	Negligible and minor effect, similar to the No Action Alternative.	Negligible and minor effect.	Negligible and minor effect, similar to the No Action Alternative.	No change from No Action Alternative.
C (Dworshak, Four Lower Snake River Projects)	Negligible and minor effect, similar to the No Action Alternative.	Negligible and minor effect.	Short-term effects resulting from breaching the four lower Snake River dams will result from construction activities during the two years following the signing of the ROD. This noise could temporarily exceed state noise standard levels at nearby residences. Overall, construction noise would result in moderate noise effects for nearby residents. Once beaching work is complete, local noise levels would be lower than under the No Action Alternative because operations and maintenance would cease at those project sites. Increased rail and vehicle traffic would likely result in a minor change to noise levels long-term.	No change from No Action Alternative.
D (Four Lower Columbia River Projects)	Negligible and minor effect, similar to the No Action Alternative.	Negligible and minor effect.	Negligible and minor effect, similar to the No Action Alternative.	No change from No Action Alternative.

1918 Noise associated with construction or modification of facilities are mostly short-term in
1919 duration. Ongoing activities, such as operation of motor vehicles and farming would continue
1920 under all of the alternatives. No effects to noise are anticipated from climate change (see
1921 Section 4.2). Overall, the effects from the alternatives in combination with past, present, and
1922 reasonably foreseeable future actions would result in little to no cumulative effects to noise,
1923 except for those associated with MO3.

1924 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

1925 There would be negligible to minor effects to noise levels from operational measures. The
1926 effect of the proposed MO1 structural measures on ambient sound levels at the lower Snake
1927 River projects in Region C and Lower Columbia River projects in Region D would be similar to
1928 the No Action Alternative and would be a minor effect. In addition, no substantial reasonably
1929 foreseeable cumulative effects are expected in the CIAA over the analysis period. Therefore, no
1930 cumulative effects are anticipated under this alternative.

1931 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

1932 There would be a negligible to minor effect to noise levels from structural and operational
1933 measures under MO2. In addition, no substantial reasonably foreseeable cumulative effects are
1934 expected in the CIAA over the analysis period. In addition, no substantial reasonably
1935 foreseeable cumulative effects are expected in the CIAA over the analysis period. Therefore, no
1936 cumulative effects are anticipated under this alternative.

1937 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

1938 The primary noise effects in this EIS would occur under MO3 and would be related to
1939 substantial structural changes to the four lower Snake River projects. These effects would occur
1940 in relatively isolated areas without residences immediately nearby. Short-term effects resulting
1941 from breaching the four lower Snake River dams will result mainly from the construction
1942 activities during the two years following the signing of the ROD. This noise could temporarily
1943 exceed state noise standard levels at nearby residences, but construction noise related to dam
1944 breaching would result in moderate noise effects, particularly for nearby residents. Once
1945 beaching work is completed, the local noise levels would be lower than under the No Action
1946 Alternative because operations and maintenance would cease at those project sites. In the long
1947 term, increased rail and vehicle traffic would likely result in a minor change to noise levels.

1948 There could potentially be adverse effects from increased volumes of noise as human
1949 population growth brings potential increases in background noise from residential, commercial,
1950 industrial, agricultural, recreational, and transportation development and activities in Region C.
1951 However, it is unclear how much new development would be expected after the breach of the
1952 four lower Snake River dams in MO3.

1953 The Columbia Pulp Plant could potentially increase adverse effects due to noise associated with
1954 operating the pulp plant, which is located in Lyons Ferry downstream of Little Goose Dam and

1955 upstream of Lower Monumental Dam in Region C, however, any cumulative effects would be
1956 short-term, as they would only occur during dam breach.

1957 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

1958 There would be a negligible to minor effects to noise levels from structural and operational
1959 measures under MO4. In addition, no substantial reasonably foreseeable cumulative effects are
1960 expected in the CIAA over the analysis period. Therefore, no cumulative effects are anticipated
1961 under this alternative.

1962 **6.3.1.15 Fisheries and Passive Use**

1963 RFFAs with the potential to impact fisheries resources in the CIAA are listed in Table 6-40, along
1964 with a description of the effects of these actions.

1965 **Table 6-40. Reasonably Foreseeable Future Actions Relevant to Fisheries**

RFFA ID	RFFA Description	Impact Description
RFFA 1	Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development	Adverse effects would occur from loss of riparian habitat and fragmentation through new development projects.
RFFA 2	Water Withdrawals for Municipal, Agricultural, Industrial Uses	Overall there would be an adverse effect from reduced availability of water from increased demand.
RFFA 5	Federal and State Wildlife Lands Management	Land management practices are anticipated to continue to include watershed improvement projects that can benefit fish.
RFFA 7	Fishery Management Plans	The goal of Pacific Salmon Management plans is to better manage catch of salmon in ocean waters offshore. This could lead to a trend of beneficial effects to salmon numbers by reducing commercial catch for these species. The U.S. v Oregon Fishery Management Agreement has the overall goal of rebuilding weak runs to full productivity through habitat protection authorities, enhancement efforts, artificial production techniques and harvest management. Implementation of this agreement could lead to a trend of beneficial effects to target species.
RFFA 8	Bycatch and Incidental Take	Bycatch of ESA-listed species and incidental take would continue to have an adverse effect.
RFFA 9	Bull Trout Passage at Albeni Falls	The proposed action is to construct an upstream “trap and haul” fish passage facility at AFD; downstream passage will occur through the spillway and powerhouse.
RFFA 10	Ongoing and Future Habitat Improvement Actions for Bull Trout	A common goal among these projects is the improvement of aquatic habitat and water quality to benefit native salmonids, especially bull trout.

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RFFA ID	RFFA Description	Impact Description
RFFA 11	Resident Fisheries Management	The state and tribal fish and game agencies manage, for recreational, ceremonial, and subsistence, fisheries in the Columbia River Basin and regulate private and public hatchery releases. The agencies modify and publish recreational fishing regulations on an annual basis. Currently, recreational anglers may not target bull trout in most areas, but may incidentally catch and release bull trout. Other resident fisheries include Kokanee and Burbot in the upper basin.
RFFA 12	Fish Hatcheries	Hatcheries would continue to benefit anadromous populations that are increased through stocking.
RFFA 13	Tribal, State, and Local Fish and Wildlife Improvement	New Tribal, State, and Local fish and wildlife improvement projects are projected to restore, maintain, create, or enhance fish and wildlife habitat. Many of these projects are focused on benefiting anadromous species.
RFFA 17	Invasive Species	There would be a continuing trend towards increases in Northern Pike and other species that prey on salmonids. Non-native fishes such as walleye, smallmouth bass, and channel catfish are present in the slower moving areas throughout the CRS as well.
RFFA18	Marine Energy and Coastal Development Projects	There would be adverse effects to anadromous fish, due to collisions with marine mammals (e.g., orcas), and obstruction of migration routes for salmonids and marine mammals.
RFFA 19	Climate Change	Potential effects of climate change, such as warmer air temperatures and changes to hydrology, could have adverse effects on the ecosystem. Warming air temperatures coupled with changing rainfall amounts and rainfall timing could affect soil conditions, plant communities, insects, and fish.

1966 Based on the results of the anadromous and resident fish analyses it is assumed that under the
 1967 No Action Alternative commercial and subsistence catch would be consistent with current
 1968 conditions. Direct and indirect effects of the other alternatives are listed in the below Table
 1969 6-41

1970 Under all of the alternatives, the extent to which changes in the abundance of various fish
 1971 populations result in changes in fisheries is driven by fishery management decisions that
 1972 determine how much, when, and by whom fish can be caught. Due to the complexity of fishery
 1973 management, it is not possible to predict changes in fishery management that may result from
 1974 changes in fish abundance. The direct effects to fish species are presented in sections 3.5.
 1975 Direct effects to fisheries are presented in section 3.15. As noted in Table 6-19 and Table 6-21,
 1976 there are numerous cumulative actions that could both beneficially and adversely affect species
 1977 important to commercial fishing and subsistence and ceremonial purposes. Climate changes,
 1978 including warming air temperatures coupled with changing rainfall amounts and rainfall timing,
 1979 could affect soil conditions, plant communities, insects, and fish. Based on the potential effects
 1980 of the alternatives and cumulative actions, the potential for beneficial cumulative effects to
 1981 commercial fishing, subsistence fishing, and ceremonial use would be most likely under MO3
 1982 and MO4. The potential for adverse cumulative effects would be highest under MO2. MO1 and
 1983 the No Action Alternative would likely have similar effects (Table 6-41).

1984 **Table 6-41. Direct and Indirect Impact Summary for Fisheries**

Impact Type	MO1	MO2	MO3	MO4
Social Welfare Effects	There would be negligible changes in commercial salmon fisheries. There would be minor to moderate adverse effects due to warmer summer water temperatures, reduced flows, increased entrainment, and increased TDG, which could have effects to resident fish and related ceremonial and subsistence fishing.	MO2 may result in adverse effects to Upper Columbia Spring Chinook, Snake River Spring and Summer Chinook, Upper Columbia Steelhead, Mid-Columbia Steelhead, Columbia River Sockeye, Snake River steelhead, Snake River sockeye, and Snake River coho.	MO3 may benefit Upper Columbia Spring Chinook, Snake River Spring and Summer Chinook, Upper Columbia Steelhead, Mid-Columbia Steelhead, Columbia River Sockeye, Snake River steelhead, Snake River sockeye, and Snake River coho.	MO4 may benefit Upper Columbia Spring Chinook and Snake River Spring and Summer Chinook. The overall effect to Snake River steelhead, sockeye, and coho is expected to be beneficial.
Regional Economic Effects	There would be negligible changes in commercial salmon fisheries.	MO2 may result in some adverse regional economic effects.	MO3 may benefit the regional economy through increases in commercially important fish populations.	MO4 may benefit the regional economy through increases in commercially important fish populations.
Other Social Effects	There would be negligible other social effects.	MO2 may adversely affect some commercially important and ceremonial and subsistence fish populations.	MO3 may beneficially affect some commercially important and ceremonial and subsistence fish populations.	MO4 may beneficially affect some commercially important and ceremonial and subsistence fish populations.

1985 **6.3.1.16 Cultural Resources**

1986 RFFAS with the potential to impact cultural resources are primarily those that would result in an
1987 increase in ground disturbance or reservoir level fluctuations in the study area and are listed in
1988 Table 6-42, along with a description of the effects of these actions.

1989 **Table 6-42. Reasonably Foreseeable Future Actions Relevant to Cultural Resources**

RFFA ID	RFFA Description	Cumulative Impact Description
RFFA1	Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development	Population growth could result in ground disturbance and an increase in human presence on the landscape, which could increase the chances of exposure, erosion, and looting of archaeological sites.
RFFA2	Water Withdrawals for Municipal, Agricultural, and Industrial Uses	Increasing water withdrawals could increase the chances of exposure and erosion of archaeological sites through reservoir level fluctuations.

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RFFA ID	RFFA Description	Cumulative Impact Description
RFFA 3	New and Alternative Energy Development	Increasing ground disturbance and/or reservoir level fluctuations and flow modifications could increase the chances of exposure, erosion, and looting of archaeological sites.
RFFA4	Increasing Use of Renewable Energy Sources, Industrial and Vehicle Emissions Reductions, and Decarbonization	Increasing ground disturbance and/or reservoir level fluctuations and flow modifications could increase the chances of exposure, erosion, and looting of archaeological sites.
RFFA5	Federal and State Wildlife and Lands Management	Public land management practices can influence ground disturbance, and therefore could increase or decrease the chances of exposure, erosion, and looting of archaeological sites, depending on the nature of the management action. Bank stabilization and stormwater runoff management projects, for example, are intended to decrease erosion, which could benefit the preservation of archaeological sites.
RFFA6	Increase in Demand for Water Storage Projects	Any new water storage projects could increase ground disturbance or reservoir level fluctuations, and therefore could increase or decrease the chances of exposure, erosion, and looting of archaeological sites.
RFFA9	Bull Trout Passage at Albeni Falls	Ground disturbance from construction of a fish passage facility at Albeni Falls could increase the chances of exposure, erosion, and damage of archaeological sites. Any modifications to historic structures could fall under Section 106 compliance, thus affecting cultural resources.
RFFA10	Ongoing and Future Habitat Improvement Actions for Bull Trout	Any ground disturbance from habitat modifications from restoration efforts could increase or decrease the chances of exposure, erosion, and looting of archaeological sites, depending on the nature of the management action. Bank stabilization projects are intended to decrease erosion, which could benefit the preservation of archaeological sites. Modifications to historic structures as a result of constructing a fish passage facility at Box Canyon Dam could fall under Section 106 compliance, thus affecting cultural resources.
RFFA12	Fish Hatcheries	Any ground disturbance from new hatchery development or maintenance of existing hatchery facilities could increase the chances of exposure, erosion, and damage of archaeological sites
RFFA13	Tribal, State, and Local Fish and Wildlife Improvement	Non-federal actions to improve habitat and regulate stormwater discharges could increase or decrease the chances of exposure, erosion, and looting of archaeological sites.
RFFA15	Snake River Sediment Management Plan	Removal of accumulated sediment in the navigation channel, depositing it in upland locations, and changing reservoir levels to accommodate dredging could increase the chances of exposure, erosion, loss, looting and damage of archaeological sites.
RFFA17	Invasive Species Management	Weed management efforts, invasive species prevention and eradication, and vegetation treatments could increase or decrease the chances of exposure, erosion, and looting of archaeological sites, depending on the nature of the management action.

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RFFA ID	RFFA Description	Cumulative Impact Description
RFFA19	Climate Change	Changes in flow could affect lake levels as a result of climate change. These changes could substantially exacerbate the probability of exposure, erosion, and loss of archaeological sites due to fluctuating runoff timing, intensity, and duration. This would apply to both high and low flows, and operational responses to changing conditions. Refer to section 4.2.15 for more information.
RFFA24	Hanford Site	Any ground disturbance from clean-up efforts could increase the chances of exposure, erosion, and looting of archaeological sites.
RFFA25	Columbia Pulp Plant	Any ground disturbance from construction of the facility could increase the chances of exposure, erosion, and looting of archaeological sites.

1990 Anticipated future cultural resource concerns under the No Action Alternative are anticipated
 1991 to be consistent with current conditions. Direct and indirect effects of the MOs are listed below
 1992 in Table 6-43.

1993 **Table 6-43. Summary of Direct and Indirect Effects to Cultural Resources**

Region	MO1	MO2	MO3	MO4
A (Libby, Hungry Horse, Albeni Falls)	Increased exposure of archaeological resources at Hungry Horse, leading to increased erosion, recreational effects, and possible looting.	Increased exposure of archaeological resources at Hungry Horse and Libby.	There is potential for a small increase in exposure of archaeological resources by reservoir fluctuation and increased flows.	There is potential for a small increase in exposure of archaeological resources.
B (Grand Coulee)	Increased archaeological exposure by 10%, leading to increased erosion, recreational effects, and possible looting. Reservoir elevation changes increase in frequency by 32%, increasing the rate at which erosion occurs.	Increased archaeological exposure by 13%. Reservoir elevation changes increase in frequency by 26%.	High draft rate events increase from an average of 5.8 times a year to above 6.3 times a year, leading to increased potential for slumping and other kinds of mass wasting.	Increased archaeological exposure by 47%. Reservoir elevation changes increase in frequency by 24%. High draft rate events increase the same as MO3.
B (Chief Joseph)	No change from No Action Alternative.	No change from No Action Alternative.	No change from No Action Alternative.	No change from No Action Alternative.

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Region	MO1	MO2	MO3	MO4
C (Dworshak)	High draft rate events increase from an average of 2 times a year to above 4 times a year.	Increased archaeological exposure by 13%. Amplitude of reservoir elevation changes (from max to min) increase by 28%, leading to increased erosion.	No change from No Action Alternative.	No change from No Action Alternative.
C (Four Lower Snake River Projects)	No change from No Action Alternative.	No change from No Action Alternative.	<p>A drawdown rate of 2 feet per day leads to slumping and mass wasting of post-reservoir sediments on archaeological sites.</p> <p>Invasive weeds could take over exposed soils leading to the development of a post-reservoir plant community that does not resemble pre-reservoir conditions. This would diminish the integrity of exposed TCPs.</p> <p>Existing plants may fail to propagate over areas exposed by removal of reservoir due to lack of water. Lack of plant cover would lead to accelerated erosion of archaeological resources.</p> <p>Exposure of archaeological sites due to removal of reservoir waters could lead to increased looting.</p> <p>Exposure of sandy areas along rivers leads to increase vehicle traffic on the former bed of the reservoir, which leads to rutting and damage to exposed sites.</p> <p>Breaching leads to the dismantling of (eligible) historic structures.</p>	No change from No Action Alternative.

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Region	MO1	MO2	MO3	MO4
D (Four Lower Columbia River Projects)	Negligible change from No Action Alternative.	Negligible change from No Action Alternative.	Release of accumulated sediment from Lower Snake River dam breaching overwhelms some wetlands, affecting distribution of plant communities that are critical to some TCPs (such as tule).	Increased archaeological exposure by 23% in John Day Reservoir.

1994 For the No Action and all other alternatives, the following RFFAs are expected to affect fish
 1995 species or increase the chances of damage and/or loss of archaeological sites due to exposure,
 1996 erosion, and/or looting:

- 1997 • Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development
- 1998 • Water Withdrawals for Municipal, Agricultural, and Industrial Uses
- 1999 • New and Alternative Energy Development
- 2000 • Increasing Use of Renewable Energy Sources, Industrial and Vehicle Emissions Reductions,
 2001 and Decarbonization
- 2002 • Federal and State Wildlife and Lands Management
- 2003 • Increase in Demand for Water Storage Projects
- 2004 • Fishery Management
- 2005 • Bull Trout Passage at Albeni Falls
- 2006 • Ongoing and Future Habitat Improvement Actions for Bull Trout
- 2007 • Fish Hatcheries
- 2008 • Tribal, State, and Local Fish and Wildlife Improvement
- 2009 • Lower Columbia River Dredged Material Management Plan
- 2010 • Snake River Sediment Management Plan
- 2011 • Invasive Species Management
- 2012 • Climate Change
- 2013 • Clean Water Act-Related Actions
- 2014 • Mining in Reaches Upstream of CRS Dams
- 2015 • Hanford Site

2016 • Columbia Pulp Plant

2017 • Middle Columbia Dam Operations

2018 • SKQ Dam Operations

2019 In essence, any RFFA that may cause water level fluctuations, changes in flows, has effects to
2020 fish, causes additional ground disturbance, erosion, or exposure of reservoir or riverbanks in
2021 the same space and time as CRSO EIS alternatives could be expected to cause additive adverse
2022 effects to cultural resources, including damage and loss.

2023 Under all alternatives, climate change could contribute cumulatively to the exacerbation of
2024 direct and indirect effects of the CRSO EIS, by increasing the probability of exposure, erosion,
2025 and loss of archaeological sites due fluctuating runoff, scouring sediments, and reservoir level
2026 fluctuations. Climate Change could result in longer periods of low summer flows, resulting in
2027 increased periods of exposure, which can also lead to potential looting and erosion of
2028 archaeological sites. In addition, Climate Change could result in more frequent events of spring
2029 flows with higher average runoff volumes, resulting in increased intensity and duration of
2030 erosion of archaeological sites.

2031 Two sacred sites were identified in the study area: Bear Paw Rock and Kettle Falls. CRSO EIS
2032 alternatives have the potential to affect sacred sites as a result of changes in reservoir
2033 elevations or construction activities. Bear Paw Rock showed no change in effects from the No
2034 Action Alternative for all of the action alternatives. Kettle Falls showed no change from the No
2035 Action Alternative for MO3 and minimal changes for MO1, MO2, and MO4. Overall, the effects
2036 from the alternatives in combination with past, present, and reasonably foreseeable future
2037 actions would result in minor cumulative effects to sacred sites affected by CRS operations.

2038 The use of BMPs or mitigation measures to exposure, erosion, and looting of archaeological
2039 sites could minimize the direct and indirect effects of these activities, thus reducing the
2040 potential cumulative effects.

2041 **NO ACTION ALTERNATIVE**

2042 Under the No Action Alternative, effects to cultural resources from ongoing Columbia River
2043 System operations in addition to the cumulative effects discussed above for all alternatives
2044 would continue. See Section 3.16.3.1 for more information. In general, past cumulative effects
2045 to cultural resources are expected to persist into the future under the No Action Alternative
2046 and for many of the action alternatives. The use of BMPs or mitigation measures to exposure,
2047 erosion, and looting of archaeological sites could minimize the direct and indirect effects of
2048 these activities, thus reducing the potential cumulative effects.

2049 Incorporating mitigation (as identified in Chapter 5) to lessen effects could change the
2050 estimated cumulative to cultural resources. In addition, effects to cultural resources would
2051 continue to be mitigated through the ongoing Federal Columbia River Power System Cultural
2052 Resource Program.

2053 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

2054 Under this MO, a wide array of measures would affect water levels and flows. Adverse effects
2055 related to cultural resources are expected to occur under MO1. The effects of MO1 on cultural
2056 resources are described above in Table 6-43 by region.

2057 MO1 is expected to adversely affect archaeological resources, especially during wet years.
2058 Increased exposure of archaeological resources under MO1, leading to increased erosion,
2059 recreational effects, and possible looting could potentially be exacerbated by climate change, as
2060 increased precipitation in the form of rain is expected alongside more extreme weather events.
2061 For example, if an archaeological site were exposed for a longer length of time because of
2062 measures in MO1 (which is predicted for this MO), there is potential for more rain to fall on
2063 that site during the time period of exposure, thus increasing the rate, frequency, or intensity of
2064 erosion.

2065 Future higher winter and spring volumes due to climate change could also cumulatively
2066 increase the direct and indirect effects of erosion because of the increased scouring caused by
2067 higher flows for longer periods. This results in moderate to major cumulative effects to cultural
2068 resources under MO1 due to additive exposure. Some mitigation actions are intended to
2069 address these effects, as identified in Chapter 5, which could further offset adverse cumulative
2070 effects. In addition, effects to cultural resources would be mitigated through the ongoing
2071 Federal Columbia River Power System Cultural Resource Program.

2072 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

2073 Under alternative MO2, cumulative effects to cultural resources are expected to be similar to
2074 those described under MO1. Mitigation (as identified in Chapter 5) to lessen effects could
2075 change the estimated cumulative to cultural resources. In addition, effects to cultural resources
2076 would continue to be mitigated through the ongoing Federal Columbia River Power System
2077 Cultural Resource Program.

2078 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

2079 Under alternative MO3, cumulative effects to cultural resources are expected to be largely
2080 similar to that as described under MO1. That said, some direct and indirect effects under this
2081 alternative related to dam breach would expose archaeological resources and TCPs in the area
2082 of the reservoir drawdown. Under MO3, these areas could be inundated with more exposure
2083 due to weed infestations, driving, other trampling in sandy areas (where vehicles could go), and
2084 increased looting. Similar to MO1, erosion, recreational effects, and possible looting could
2085 potentially be exacerbated by climate change, as increased precipitation in the form of rain is
2086 expected alongside more extreme weather events. For example, if an archaeological site were
2087 exposed for a longer length of time because of measures in MO3 (which is predicted for this
2088 alternative), there is potential for more rain to fall on that site during the time period of
2089 exposure, thus increasing the rate, frequency, and/or intensity of erosion. That said, the use of
2090 BMPs or mitigation measures to exposure, erosion, and looting of archaeological sites could

2091 minimize the direct and indirect effects of these activities, thus reducing the potential
 2092 cumulative effects. In addition, incorporating mitigation (as identified in Chapter 5) to lessen
 2093 effects could change the estimated cumulative to cultural resources. In addition, effects to
 2094 cultural resources would continue to be mitigated through the ongoing Federal Columbia River
 2095 Power System Cultural Resource Program.

2096 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

2097 For alternative MO4, cumulative effects to cultural resources are expected to be similar to
 2098 those described under MO1. Mitigation (as identified in Chapter 5) to lessen effects could
 2099 change the estimated cumulative to cultural resources. In addition, effects to cultural resources
 2100 would continue to be mitigated through the ongoing Federal Columbia River Power System
 2101 Cultural Resource Program.

2102 **6.3.1.17 Indian Trust Assets, Tribal Perspectives, and Tribal Interests**

2103 Section 3.17 discusses the affected environment and environmental consequences for Indian
 2104 Trust Assets (ITAs), tribal perspectives, and tribal interests. Certain tribes provided their holistic
 2105 perspectives on how the CRS affects tribal interests, and these perspectives can be found in
 2106 Appendix P, *Tribal Perspectives*.

2107 The effects from all the alternatives on ITAs, Tribal Perspectives, and Tribal Interests vary. No
 2108 direct or indirect effects to ITAs were identified for any alternative. Trust lands identified during
 2109 the geospatial database query and tribal outreach are located outside of any direct or indirect
 2110 effects identified from the alternatives. These include lands from the Confederated Tribes of
 2111 Warm Springs Reservation, the Yakama Nation, and the Kootenai Tribe of Idaho, as well as
 2112 these Indian reservations: The Confederated Tribes of the Colville Indian Reservation; Spokane
 2113 Tribe of Indians; Kootenai Tribe of Idaho; Nez Perce Tribe; and The Confederated Salish &
 2114 Kootenai Tribes of the Flathead Reservation. Ongoing activities on Indian Trust lands, for
 2115 example, would be expected to continue under all of the alternatives. Since the CRSO EIS
 2116 alternatives are not expected to have direct or indirect effects on Indian Trust Assets, there
 2117 would likely be no change in effects to these assets, and thus there would be no likely
 2118 cumulative effects to Indian Trust Assets.

2119 RFFAs with the potential to impact tribal interests in the CIAA are listed in Table 6-44 along with
 2120 a description of the effects of these actions.

2121 **Table 6-44. Reasonably Foreseeable Future Actions Relevant to Tribal Interests**

RFFA ID	RFFA Description	Cumulative Impact Description
RFFA1	Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development	Population growth and urban, rural, commercial, industrial, and agricultural development could exacerbate the issues tribes are experiencing related to: loss of anadromous and resident fish important to these communities. increasing costs of power for their communities

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RFFA ID	RFFA Description	Cumulative Impact Description
RFFA2	Water Withdrawals for Municipal, Agricultural, and Industrial Uses	Water withdrawals could exacerbate the issues tribes are experiencing related to loss of water supply, or loss of habitat for anadromous and resident fish important to their communities due to tributary water withdrawals.
RFFA3	New and Alternative Energy Development	Increasing ground disturbance and/or reservoir level fluctuations and flow modifications could increase the chances of exposure, erosion, and looting of archaeological sites important to the tribes.
RFFA4	Increasing Use of Renewable Energy Sources, Industrial and Vehicle Emissions Reductions, and Decarbonization	The planned retirement of coal plants in the region and other decarbonization actions that increase the need for clean power may lead to increases in the price of electricity for tribal communities. However, a beneficial impact would likely be seen from the likelihood of reduced GHG emissions and air pollutant emissions. However, generation could be replaced by gas or renewable sources. If it is replaced by gas, then there could be increased emissions.
RFFA5	Federal and State Wildlife and Lands Management	Land management practices are anticipated to continue to include watershed improvement projects that can benefit fish. Public land management practices can influence ground disturbance, and therefore could increase or decrease the chances of exposure, erosion, and looting of archaeological sites, depending on the nature of the management action. Bank stabilization and stormwater runoff management projects, for example, are intended to decrease erosion, which could benefit the preservation of archaeological sites important to tribes.
RFFA6	Increase in Demand for Water Storage Projects	Any new water storage projects could increase ground disturbance or reservoir level fluctuations, and therefore could increase or decrease the chances of exposure, erosion, and looting of archaeological sites important to tribes.
RFFA7	Fishery Management	The goal of Pacific Salmon Management plans is to better manage catch of salmon in ocean waters offshore. This could lead to a trend of beneficial effects to salmon numbers by reducing commercial catch for these species. The U.S. v Oregon Fishery Management Agreement has the overall goal of rebuilding weak runs to full productivity through habitat protection authorities, enhancement efforts, artificial production techniques, and harvest management. Implementation of this agreement could lead to a trend of beneficial effects to species that are important to tribes.
RFFA9	Bull Trout Passage at Albeni Falls	The proposed action is to construct an upstream “trap and haul” fish passage facility at Albeni Falls; downstream passage will occur through the spillway and powerhouse. Ground disturbance from construction of a fish passage facility at Albeni Falls could increase the chances of exposure, erosion, and damage of archaeological sites, thus potentially affecting cultural resources important to tribes.

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RFFA ID	RFFA Description	Cumulative Impact Description
RFFA10	Ongoing and Future Habitat Improvement Actions for Bull Trout	A common goal among these projects is the improvement of aquatic habitat and water quality to benefit native salmonids, especially bull trout. Any ground disturbance from habitat modifications from restoration efforts could increase or decrease the chances of exposure, erosion, and looting of archaeological sites, depending on the nature of the management action. Bank stabilization projects are intended to decrease erosion, which could benefit the preservation of archaeological sites. These actions potentially affect cultural resources important to tribes.
RFFA11	Resident Fisheries Management	There may be adverse effects to tribes from recreational anglers' catching fish over the catch limits thereby reducing fish availability.
RFFA12	Fish Hatcheries	Hatcheries would continue to benefit anadromous populations that are increased through stocking. Any ground disturbance from new hatchery development or maintenance of existing hatchery facilities could increase the chances of exposure, erosion, and damage of archaeological sites important to tribes.
RFFA13	Tribal, State, and Local Fish and Wildlife Improvement	Tribal, State, and local fish and wildlife improvement projects and activities could have a beneficial additive effect to anadromous and resident fish important to tribes.
RFFA14	Lower Columbia River Dredged Material Management Plan	Removal of accumulated sediment in the navigation channel and depositing it in upland locations could increase the chances of exposure, erosion, loss and damage of archaeological sites important to tribes.
RFFA15	Snake River Sediment Management Plan	Removal of accumulated sediment in the navigation channel, depositing it in upland locations, and changing reservoir levels to accommodate dredging could increase the chances of exposure, erosion, loss, looting and damage of archaeological sites important to tribes.
RFFA16	SKQ Dam Operations	Reservoir level fluctuations and flow modifications could increase the chances of exposure, erosion, and looting of archaeological sites important to tribes.
RFFA17	Invasive Species	Weed management efforts, invasive species prevention and eradication, and vegetation treatments could increase or decrease ground disturbance activities exposing or protecting archaeological sites important to tribes.
RFFA18	Marine Energy and Coastal Development Projects	Coastal development has the potential effects that include non-point source pollution (e.g., stormwater runoff) that would affect tribes that depend on vegetation, wetlands, wildlife and floodplains. There would be adverse effects to anadromous fish, due to collisions with marine mammals (e.g., orcas), and obstruction of migration routes for salmonids and marine mammals would affect tribes that depend on these resources.

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RFFA ID	RFFA Description	Cumulative Impact Description
RFFA19	Climate Change	Effects from climate change have the potential to result in cumulative effects to multiple resources that are important to tribes. Climate change effects could exacerbate the issues tribes are experiencing related to: <ul style="list-style-type: none"> loss of anadromous and resident fish important to their communities increasing costs of power for their communities
RFFA20	Clean Water Act-Related Actions	Any ground disturbance from habitat modifications from restoration efforts could increase or decrease the chances of exposure, erosion, and looting of archaeological sites important to tribes. Depending on the nature of the management action, cumulative effects could be beneficial or adverse.
RFFA21	Idaho Power Hells Canyon Complex Mercury Contamination Issues/Remediation	This could result in remediation and cleanup actions as well as lead to a reduction or elimination of fish consumption advisories for mercury in fish tissue, but it is unclear what the timing and extent of remediation would be.
RFFA22	Idaho Power Hells Canyon Complex Temperature Issues	There is potential for temperature effects during summer migration, which may impact fish species important to the tribes.
RFFA23	Mining in Reaches Upstream of CRS Dams	Future or on-going remediation activities, such as those related to mining on the Spokane Arm of Lake Roosevelt, could increase the chances of exposure, erosion, and looting of archaeological sites important to tribes.
RFFA24	Hanford Site	Any ground disturbance from clean-up efforts could increase the chances of exposure, erosion, and looting of archaeological sites important to tribes.
RFFA25	Columbia Pulp Plant	Any ground disturbance from construction of the facility could increase the chances of exposure, erosion, and looting of archaeological sites important to tribes.
RFFA26	Middle Columbia Dam Operations	Reservoir level fluctuations and flow modifications could increase the chances of exposure, erosion, and looting of archaeological sites important to tribes.

2122 The area potentially affected by the alternatives has served as a homeland since time
2123 immemorial for multiple tribes. The rivers and the resources that they have historically
2124 supported are critical elements of many tribes’ sense of place and identity. As a result, any
2125 evaluation of CRS operations should consider how changes to river conditions affect tribal
2126 interests. This section accordingly considers those effects, which have also been considered
2127 throughout this analysis for resources of particular importance to tribes.

2128 Effects to tribal interests from the alternatives would be negligible for most resources (e.g.
2129 Vegetation, Wetlands, Wildlife, and Floodplains, Air Quality and Greenhouse Gases, Power and
2130 Transmission, Flood Risk Management, Navigation and Transportation, and Recreation). There
2131 is a range of expected effects for all alternatives, including minor beneficial effects such as
2132 those from the refined operations in Region A, and potentially minor adverse effects to resident
2133 fish in Lake Roosevelt due to deeper drawdowns in high water years. However, mitigation
2134 incorporated into the alternatives (as appropriate) includes spawning habitat augmentation to
2135 offset these effects. The expected range of effects to fish is described in more detail in the

2136 anadromous fish, resident fish, water quality, and fisheries sections. Additionally, ongoing Fish
2137 and Wildlife programs would continue under alternatives and extending the boat ramp at the
2138 Inchelium-Gifford ferry would mitigate some of the operational effects at Grand Coulee,
2139 including accessibility.

2140 RFFAs 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, and 26
2141 would likely affect a variety of tribal interests, including: Anadromous Fish; Resident Fish; Water
2142 Quality; Vegetation, Wetlands, Wildlife, and Floodplains; Air Quality and Greenhouse Gases;
2143 Power and Transmission, Flood Risk Management; Navigation and Transportation, and
2144 Recreation. The descriptions of impacts from these RFFAs for these respective resources are
2145 described in depth previously in this Chapter.

2146 **6.3.1.18 Environmental Justice**

2147 RFFAs with the potential to impact environmental justice communities in the CIAA are listed in
2148 Table 6-45 along with a description of the effects of these actions.

2149 **Table 6-45. Reasonably Foreseeable Future Actions Relevant to Environmental Justice**

RFFA ID	RFFA Description	Cumulative Impact Description
RFFA1	Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development	Population growth and urban, rural, commercial, industrial, and agricultural development could exacerbate the issues tribes and low-income communities are experiencing related to: loss of anadromous and resident fish important to these communities. increasing costs of power for these communities
RFFA2	Water Withdrawals for Municipal, Agricultural, and Industrial Uses	Water withdrawals could exacerbate the issues tribes and low-income communities are experiencing related to loss of water supply, or loss of habitat for anadromous and resident fish important to these communities due to tributary water withdrawals.
RFFA3	New and Alternative Energy Development	Increasing ground disturbance and/or reservoir level fluctuations and flow modifications could increase the chances of exposure, erosion, and looting of archaeological sites important to these communities.
RFFA4	Increasing Use of Renewable Energy Sources, Industrial and Vehicle Emissions Reductions, and Decarbonization	The planned retirement of coal plants in the region and other decarbonization actions that increase the need for clean power may lead to increases in the price of electricity.
RFFA5	Federal and State Wildlife and Lands Management	Public land management practices can influence ground disturbance, and therefore could increase or decrease the chances of exposure, erosion, and looting of archaeological sites, depending on the nature of the management action. Bank stabilization and stormwater runoff management projects, for example, are intended to decrease erosion, which could benefit the preservation of archaeological sites important to these communities.
RFFA6	Increase in Demand for Water Storage Projects	Any new water storage projects could increase ground disturbance or reservoir level fluctuations, and therefore could increase or decrease the chances of exposure, erosion, and looting of archaeological sites important to these communities.

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RFFA ID	RFFA Description	Cumulative Impact Description
RFFA7	Fishery Management	The goal of Pacific Salmon Management plans is to better manage catch of salmon in ocean waters offshore. This could lead to a trend of beneficial effects to salmon numbers by reducing commercial catch for these species. The U.S. v Oregon Fishery Management Agreement has the overall goal of rebuilding weak runs to full productivity through habitat protection authorities, enhancement efforts, artificial production techniques, and harvest management. Implementation of this agreement could lead to a trend of beneficial effects to species that are important to environmental justice communities.
RFFA9	Bull Trout Passage at Albeni Falls	Ground disturbance from construction of a fish passage facility at Albeni Falls could increase the chances of exposure, erosion, and damage of archaeological sites, thus potentially affecting cultural resources important to environmental justice communities.
RFFA10	Ongoing and Future Habitat Improvement Actions for Bull Trout	Any ground disturbance from habitat modifications from restoration efforts could increase or decrease the chances of exposure, erosion, and looting of archaeological sites, depending on the nature of the management action. Bank stabilization projects are intended to decrease erosion, which could benefit the preservation of archaeological sites. These actions potentially affect cultural resources important to environmental justice communities.
RFFA11	Resident Fisheries Management	There may be adverse effects to environmental justice communities from recreational angler's catching fish over the catch limits thereby reducing fish availability for environmental justice communities.
RFFA12	Fish Hatcheries	Hatcheries would continue to benefit anadromous populations that are increased through stocking. Any ground disturbance from new hatchery development or maintenance of existing hatchery facilities could increase the chances of exposure, erosion, and damage of archaeological sites important to environmental justice communities.
RFFA13	Tribal, State, and Local Fish and Wildlife Improvement	Tribal, State, and local fish and wildlife improvement projects and activities could have a beneficial additive effect to anadromous and resident fish important to tribes and low-income communities.
RFFA14	Lower Columbia River Dredged Material Management Plan	Removal of accumulated sediment in the navigation channel and depositing it in upland locations could increase the chances of exposure, erosion, loss and damage of archaeological sites important to environmental justice communities.
RFFA15	Snake River Sediment Management Plan	Removal of accumulated sediment in the navigation channel, depositing it in upland locations, and changing reservoir levels to accommodate dredging could increase the chances of exposure, erosion, loss, looting and damage of archaeological sites important to environmental justice communities.
RFFA16	SKQ Dam Operations	Reservoir level fluctuations and flow modifications could increase the chances of exposure, erosion, and looting of archaeological sites important to environmental justice communities.
RFFA17	Invasive Species	Weed management efforts, invasive species prevention and eradication, and vegetation treatments could increase or decrease ground disturbance activities exposing or protecting archaeological sites important to environmental justice communities.

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RFFA ID	RFFA Description	Cumulative Impact Description
RFFA18	Marine Energy and Coastal Development Projects	Coastal development has the potential effects that include non-point source pollution (e.g., stormwater runoff) that would affect environmental justice communities that depend on vegetation, wetlands, wildlife and floodplains. There would be adverse effects to anadromous fish, due to collisions with marine mammals (e.g., orcas), and obstruction of migration routes for salmonids and marine mammals would affect environmental justice communities that depend on these resources.
RFFA19	Climate Change	Effects from climate change have the potential to result in cumulative effects multiple resources that are important to environmental justice populations. Refer to section 4.2.16 for more information. Climate change effects could exacerbate the issues tribes and low-income communities are experiencing related to: <ul style="list-style-type: none"> loss of anadromous and resident fish important to these communities increasing costs of power for these communities
RFFA20	Clean Water Act-Related Actions	Any ground disturbance from habitat modifications from restoration efforts could increase or decrease the chances of exposure, erosion, and looting of archaeological sites important to environmental justice communities. Depending on the nature of the management action, cumulative effects could be beneficial or adverse.
RFFA21	Idaho Power Hells Canyon Complex Mercury Contamination Issues/Remediation	This could result in remediation and cleanup actions as well as lead to a reduction or elimination of fish consumption advisories for mercury in fish tissue, but it is unclear what the timing and extent of remediation would be.
RFFA23	Mining in Reaches Upstream of CRS Dams	Future or on-going remediation activities, such as those related to mining on the Spokane Arm of Lake Roosevelt, could increase the chances of exposure, erosion, and looting of archaeological sites important to environmental justice communities.
RFFA24	Hanford Site	Any ground disturbance from clean-up efforts could increase the chances of exposure, erosion, and looting of archaeological sites important to environmental justice communities.
RFFA25	Columbia Pulp Plant	Any ground disturbance from construction of the facility could increase the chances of exposure, erosion, and looting of archaeological sites important to environmental justice communities.
RFFA26	Middle Columbia Dam Operations	Reservoir level fluctuations and flow modifications could increase the chances of exposure, erosion, and looting of archaeological sites important to environmental justice communities.

2150 Anticipated future environmental justice concerns under the No Action Alternative are
2151 anticipated to be consistent with current conditions. Direct and indirect effects of the Action
2152 Alternatives are listed below in Table 6-46.

2153 **Table 6-46. Summary of Direct and Indirect Effects to Environmental Justice**

Region	MO1	MO2	MO3	MO4
A (Libby, Hungry Horse, Albeni Falls)	Adverse effects on resident fish (bull trout and Kootenai River white sturgeon) could adversely impact ceremonial and subsistence fishing opportunities. An increase in electricity rates could impact low-income households, but these effects would occur across the region, and therefore would not result in an EJ effect (disproportionate effect).	Resident fish species may be adversely impacted downstream of Libby and in Hungry Horse Reservoirs. There could be reduced sturgeon habitat in the Kootenai River. These effects have the potential to adversely affect ceremonial and subsistence fishing opportunities.	Similar to MO1, MO3 would have adverse effects to bull trout and Kootenai River white sturgeon, adversely impacting ceremonial and subsistence fishing opportunities. An increase in electricity rates of up to \$53 per year could impact low-income households at a regional level, but these effects would be felt across the region and therefore would not result in an EJ effect (disproportionate effect).	Bull trout, westslope cutthroat trout, and Kootenai River white sturgeon would have increased entrainment risk and some reduced habitat and food availability. An increase in electricity rates of up to \$113 per year could impact low-income households, but these effects would occur across the region and therefore would not result in an EJ effect (disproportionate effect).
B (Grand Coulee, Chief Joseph)	Adverse effects on fish could adversely impact ceremonial and subsistence fishing opportunities. An increase in electricity rates could impact low-income households, but these effects would occur across the region. The Inchelium-Gifford ferry is expected to have 9 fewer operational days during wet years.	Increased entrainment risk for some resident species (bull trout, kokanee, rainbow trout, and burbot) could adversely affect the recreational fishery at Lake Roosevelt. Adverse effects on fish (Upper Columbia River salmon and steelhead) could adversely impact ceremonial and subsistence fishing opportunities. An increase or decrease in electricity rates could impact low-income households, but these effects would occur across the region, and therefore would not result in an EJ effect (disproportionate effect).	Small increases in the abundance of key anadromous recreational fishing species are anticipated, particularly Columbia River runs of Chinook and steelhead, increasing fishing opportunities for these species over the long term below Chief Joseph Dam. Reduced entrainment risk for some resident species (bull trout, kokanee, rainbow trout, and burbot) could benefit the fishery at Lake Roosevelt. An increase in electricity rates of up to \$54 per year could impact low-income households, but these effects would occur across the region, and therefore would not result in an EJ effect (disproportionate effect).	MO4 has the potential to adversely affect ceremonial and subsistence fishing opportunities for low-income populations, minority populations, and Indian tribes. The effects to the Inchelium-Gifford ferry are similar to MO1. An increase in electricity rates of up to \$85 per year could impact low-income households, but these effects would occur across the region, and therefore would not result in an EJ effect (disproportionate effect).

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Region	MO1	MO2	MO3	MO4
C (Dworshak, Four Lower Snake River Projects)	Adverse effects on fish could adversely impact ceremonial and subsistence fishing opportunities. An increase in electricity rates could impact low-income households, but these effects would occur across the region, and therefore would not result in an EJ effect (disproportionate effect).	Decreased abundance of Snake River Spring Chinook and Snake River steelhead could contribute to adverse effects on ceremonial and subsistence, and tribal commercial fishing opportunities. Adverse effects to kokanee at Dworshak Reservoir are also anticipated. These losses could represent an adverse impact to Indian tribes in the region for whom salmon and steelhead are a predominant element of cultural traditions, traditional diet, as well as sources of revenue.	People would be able to access landscapes and locations that have been inaccessible since the dams were completed, allowing practitioners of traditional lifeways and religions to physically access the landforms and Traditional Cultural Properties (TCPs) to practice their traditional lifeways. Archaeological resources could also be damaged through increasing exposure and erosion associated with increased reservoir level fluctuations associated with dam breach. An increase in electricity rates of up to \$47 per year could impact low-income households, but these effects would occur across the region, and therefore would not result in an EJ effect (disproportionate effect).	Adverse effects to bull trout and other resident fish have the potential to impact ceremonial and subsistence fishing opportunities in Region C. An increase in electricity rates of up to \$98 per year could impact low-income households, but these effects would occur across the region, and therefore would not result in an EJ effect (disproportionate effect).

*Columbia River System Operations Environmental Impact Statement
Chapter 6, Cumulative Effects*

Region	MO1	MO2	MO3	MO4
D (Four Lower Columbia River Projects)	Adverse effects on fish could adversely impact ceremonial and subsistence fishing opportunities. An increase in electricity rates could impact low-income households, but these effects would occur across the region, and therefore would not result in an EJ effect (disproportionate effect).	Decreased abundance of Snake River Spring Chinook and Snake River steelhead, Upper Columbia River Spring Chinook, and decreased in-river survival rates of Upper Columbia River steelhead could contribute to adverse effects on ceremonial and subsistence, and tribal commercial fishing opportunities. These losses could represent an adverse impact to Indian tribes in the region for whom salmon and steelhead are a predominant element of cultural traditions, traditional diet, as well as sources of revenue.	Short-term increased sedimentation above McNary Dam would adversely affect fishing conditions. Long-term increases in the abundance of key anadromous recreational fishing species, including Chinook salmon and other salmonids as well as white sturgeon, are anticipated to occur. An increase in electricity rates of up to \$80 per year could impact low-income households, but these effects would occur across the region, and therefore would not result in an EJ effect (disproportionate effect).	Adverse effects on resident fish have the potential to adversely impact ceremonial and subsistence fishing opportunities in Region D. An increase in electricity rates of up to \$109 per year could impact low-income households, but these effects would occur across the region, and therefore would not result in an EJ effect (disproportionate effect).

2154

2155 **NO ACTION ALTERNATIVE**

2156 Under the No Action Alternative, effects from ongoing Columbia River System operations on
2157 minority populations, low-income populations, and Indian tribes would continue. As described
2158 in the Environmental Justice section (Section 3.18), “the construction of the dams and the
2159 current system operations have ongoing effects on tribal culture, lifeways (e.g., customs and
2160 practices), and traditions. The loss of foundational aspects of tribal culture resulting from the
2161 inundation of important fishing sites and the reduction in wild salmon populations has
2162 adversely affected tribal communities.” These ongoing effects include adverse outcomes
2163 related to ceremonial, subsistence and other tribal fishing practices; energy affordability; water
2164 supply needs; and cultural resources important to Environmental Justice communities. This past
2165 cumulative effect is expected to persist into the future under the No Action Alternative and
2166 many of the action alternatives.

2167 Natural and cultural resources associated with the Columbia River System are of critical
2168 importance to tribes in the region for subsistence, commerce, preservation of cultural
2169 traditions and history, religious practice, and self-determination as sovereign nations. As
2170 discussed in the Cultural Resources section, ongoing effects of ground disturbance, inundation,
2171 variable flows, and reservoir fluctuation would continue to have substantial adverse effects on
2172 traditional cultural properties and archaeological resources under the No Action and all MOs.
2173 The discussion under the cumulative effects section for cultural resources 6.3.1.15 below
2174 describes how RFFAs would cumulatively impact cultural resources through increasing exposure
2175 and erosion, resulting in effects associated with public access, including looting, vandalism,
2176 creation of trails, and unauthorized activities. In addition, Table 6-42 details numerous RFFAs
2177 that could have additive effects to cultural resources that could be important to environmental
2178 justice communities, and what those effects could be. Any RFFA that has an additive effect to
2179 ground disturbance, water levels and flows, access to certain areas, and/or abundance and
2180 distribution of fish in the CIAA would be considered a cumulative effect under the No Action
2181 and Action Alternatives

2182 In addition, commercial, ceremonial, and subsistence fishing activity occurs in various locations
2183 on the mainstem Columbia and Snake Rivers and in tributaries throughout the study area. The
2184 MOs have the potential to affect the availability of fish for harvest for low-income populations,
2185 minority populations, and Indian tribes participating in these activities. Insofar as indirect and
2186 direct effects combine with RFFAs to cumulatively impact fish, as described in Section 6.3.1.4
2187 for Anadromous fish and Section 6.3.1.5 for Resident fish, environmental justice communities
2188 would also be affected if they relied on those fish for subsistence, ceremonial, or commercial
2189 fishing. Please refer to these sections for discussions on the cumulative effects for fish species
2190 throughout the Columbia River Basin. That said, tribal, State, and local fish and wildlife
2191 improvement projects and activities could have a beneficial additive effect when it comes to
2192 effects to loss of anadromous and resident fish important to environmental justice
2193 communities.

2194 Low-income communities, minority communities, and Indian Tribes, and particularly low-
2195 income households in these communities, already experience potentially unaffordable
2196 electricity costs under the No Action Alternative. Any increase in electricity rates in this region
2197 would be acutely felt by low-income households, for whom electricity costs are a larger percent
2198 of their income than for other households. In some cases, these low-income households are
2199 also minority, tribal, or both. However, these effects would be felt across the region and
2200 therefore would not result in an EJ effect (disproportionate effect).

2201 **MULTIPLE OBJECTIVE ALTERNATIVE 1**

2202 Under this alternative, a wide array of measures would affect water levels and flows, as well as
2203 the abundance and distribution of fish. Adverse effects related to the following resources and
2204 therefore cumulative effects to the same resources may occur under MO1: power generation
2205 and transmission, rates for power customers, navigation and transportation, and cultural
2206 resources. The effects of MO1 on environmental justice populations resulting from changes in
2207 these resources are described above in Table 6-46 by region. See Section 6.3.1.16 for discussion
2208 of cumulative effects to cultural resources under MO1.

2209 Low-income households typically spend a larger portion of their income on home electricity
2210 costs than other households spend and would likely have a more difficult time adapting to a
2211 higher cost of living if annual electricity bills increase. Annual potential power rate increases for
2212 residential customers could be as high as \$29 in Region A, \$24 in Region B, \$25 in Region C, and
2213 \$44 in Region D as compared to the No Action Alternative. Any increase in electricity cost could
2214 be acutely felt by low-income or minority households (or both), for whom electricity costs are a
2215 larger percent of their income. In some cases, these low-income households are also minority,
2216 tribal, or both. RFFAs such as population growth could exacerbate this issue by creating a larger
2217 demand for energy, or by driving up other costs to low income or minority households (or both)
2218 that tend to increase alongside population growth, such as housing costs. However, these
2219 effects would be felt across the region and therefore would not result in an EJ effect
2220 (disproportionate effect).

2221 In terms of navigation, Inchelium-Gifford ferry is operated by the Confederated Tribes of the
2222 Colville Reservation and primarily serves the tribal population as the primary and most practical
2223 means of transportation across Lake Roosevelt. However, the ferry becomes inoperable when
2224 the lake falls below a certain elevation. There are other longer or more costly modes of
2225 transportation that could be used in case of emergency if the ferry was out of service. MO1 is
2226 expected to adversely affect the Inchelium-Gifford Ferry on Lake Roosevelt because it is
2227 expected to have nine fewer operational days during wet years. Effects would primarily fall on
2228 the Confederated Tribes of the Colville Reservation. Future spring volumes due to climate
2229 change could cumulatively increase the direct and indirect effects of the alternatives on the
2230 Inchelium-Gifford Ferry operations because of higher winter and spring volumes, but mitigation
2231 actions are intended to address this impact, as identified in Chapter 5, which could further
2232 offset adverse cumulative effects. In addition, effects to cultural resources would be mitigated
2233 through the ongoing Federal Columbia River Power System Cultural Resource Program.

2234 Effects related to effects on water supply on low-income, minority, and Indian tribes are
2235 anticipated to be negligible under MO1.

2236 Incorporating mitigation to lessen effects could change the estimated cumulative effects to
2237 environmental justice, and effects to cultural resources would be mitigated through the
2238 ongoing Federal Columbia River Power System Cultural Resource Program. Therefore, through
2239 analysis considering effects detailed in Chapter 3 Affected Environment and Environmental
2240 Consequences; Chapter 4 Climate; Chapter 5 Mitigation; and this chapter (Cumulative Effects),
2241 there would not likely be a disproportionately high and adverse effect on environmental justice
2242 populations for MO1.

2243 **MULTIPLE OBJECTIVE ALTERNATIVE 2**

2244 Adverse effects related to the following resources may occur under MO2: fish; navigation and
2245 transportation; and cultural resources. The effects of MO2 on environmental justice
2246 populations resulting from changes in these resources are described in Table 6-46 above by
2247 region.

2248 Ferry operations on Lake Roosevelt are expected to be affected under MO2 similar to the
2249 effects described under MO1, so cumulative effects are expected to be similar as well. Similarly,
2250 mitigation actions identified in Chapter 5 to address these effects could minimize cumulative
2251 effects. In addition, effects to cultural resources would be mitigated through the ongoing
2252 Federal Columbia River Power System Cultural Resource Program.

2253 Under MO2, decreased abundance of Snake River spring Chinook and Snake River steelhead
2254 would contribute to adverse effects on ceremonial and subsistence, and tribal commercial
2255 fishing opportunities in Region C under MO2. Adverse effects to kokanee at Dworshak Reservoir
2256 are also anticipated. These losses could represent an adverse impact to Indian tribes in the
2257 region for whom salmon and steelhead are a predominant element of cultural traditions and
2258 traditional diet, as well as sources of revenue. Cumulative effects to these species are described
2259 in detail in Sections 6.3.1.4 and 6.3.1.5. RFFAs such as population growth could exacerbate the
2260 loss of revenue by driving up other economic costs to low income or minority households (or
2261 both) that tend to increase alongside population growth, such as housing costs. There is
2262 potential for Tribal, State, and local fish and wildlife improvement projects and activities to
2263 offset some of the loss of anadromous and resident fish important to environmental justice
2264 communities.

2265 In addition to the resources identified under section 3.15.3.1, effects related to effects of water
2266 supply on low-income, minority, and Indian tribes are anticipated to be negligible under MO2.
2267 Therefore, through analysis considering effects detailed in Chapter 3 Affected Environment and
2268 Environmental Consequences; Chapter 4 Climate; Chapter 5 Mitigation; and this chapter
2269 (Cumulative Effects) there would not likely be a disproportionately high and adverse effect on
2270 environmental justice populations for MO2.

2271 Incorporating mitigation (as identified in Chapter 5) to lessen effects could change the
2272 estimated cumulative effects to environmental justice, and effects to cultural resources would
2273 be mitigated through the ongoing Federal Columbia River Power System Cultural Resource
2274 Program.

2275 **MULTIPLE OBJECTIVE ALTERNATIVE 3**

2276 MO3 involves the breaching of the four Lower Snake projects, which would reduce hydropower
2277 generation, increase regional emissions and air pollutants, affect navigation along the Snake
2278 River, adversely affect resident non-native fish populations, and could potentially benefit
2279 anadromous fish populations, as well as white sturgeon and bull trout.

2280 Any increase in electricity cost could impact low-income and/or minority households, for whom
2281 electricity costs are a larger percent of their income than for other households. In some cases,
2282 these low-income households are also minority, tribal, or both. RFFAs such as population
2283 growth could exacerbate this issue by creating a larger demand for energy, or by driving up
2284 other costs to low income or minority households (or both) that tend to increase alongside
2285 population growth, such as housing costs. However, these effects would be felt across the
2286 region and therefore would not result in an EJ effect (disproportionate effect).

2287 Incorporating mitigation to lessen effects could change the estimated cumulative effects to
2288 environmental justice, and effects to cultural resources would be mitigated through the
2289 ongoing Federal Columbia River Power System Cultural Resource Program. Therefore, through
2290 analysis considering effects detailed in Chapter 3 Affected Environment and Environmental
2291 Consequences; Chapter 4 Climate; Chapter 5 Mitigation; and this chapter (Cumulative Effects)
2292 there would not likely be a disproportionately high and adverse effect on environmental justice
2293 populations for MO3.

2294 **MULTIPLE OBJECTIVE ALTERNATIVE 4**

2295 The MO4 alternative includes substantial operational changes to Libby, Hungry Horse, and
2296 Grand Coulee Dams, and operational changes at the Lower Columbia and Snake River projects.
2297 The effects of MO4 on environmental justice populations resulting from changes in these
2298 resources are described in Table 6-46 above by region. Adverse effects related to the following
2299 resources are expected under MO4: fish; power generation and transmission; navigation and
2300 transportation; water supply; and cultural resources.

2301 In addition, commercial, ceremonial, and subsistence fishing activity occurs in various locations
2302 Please refer to Section 6.3.1.4 for Anadromous Fish and Section 6.3.1.5 for Resident fish for
2303 discussions of the cumulative effects for fish species throughout the Columbia River Basin. That
2304 said, tribal, State, and local fish and wildlife improvement projects and activities could have a
2305 beneficial additive effect when it comes to effects to loss of anadromous and resident fish
2306 important to environmental justice communities.

2307 Annual potential power rate increases for residential customers could be as high as \$113 in
2308 Region A, \$85 in Region B, \$98 in Region C, and \$109 in Region D as compared to the No Action
2309 Alternative. Any increase in electricity costs could be acutely felt by low-income or minority
2310 households (or both), for whom electricity costs are a larger percent of their income than for
2311 other households. In some cases, these low-income households are also minority, tribal, or
2312 both. RFFAs such as population growth could exacerbate this issue by creating a larger demand
2313 for energy, or by driving up other costs to low income or minority households (or both) that
2314 tend to increase alongside population growth, such as housing costs. However, these effects
2315 would be felt across the region and therefore would not result in an EJ effect (disproportionate
2316 effect).

2317 In terms of navigation, cumulative effects to the Inchelium-Gifford ferry are the same as those
2318 described under MO1.

2319 Please see the discussion under the cumulative effects section for cultural resources in Section
2320 6.3.1.16, which describes how RFFAs would cumulatively impact cultural resources
2321 through increasing exposure and erosion.

2322 Incorporating mitigation to lessen effects could change the estimated cumulative effects to
2323 environmental justice, and effects to cultural resources would be mitigated through the
2324 ongoing Federal Columbia River Power System Cultural Resource Program.

2325 Under MO4, certain pumps may need to be extended to allow for continued provision of water
2326 supply. If these pumps provide drinking water or agricultural water sources for minority
2327 populations, low-income populations, or Indian tribes, this could affect the costs of living in an
2328 area as well as the availability of employment opportunities.

2329 Through analysis considering effects detailed in Chapter 3 Affected Environment and
2330 Environmental Consequences; Chapter 4 Climate; Chapter 5 Mitigation; and this chapter
2331 (Cumulative Effects) there would not likely be a disproportionately high and adverse effect on
2332 environmental justice populations for MO2.

CHAPTER 7 - PREFERRED ALTERNATIVE

7.1 INTRODUCTION

This chapter describes the alternatives introduced in Chapter 2 and analyzed in Chapters 3, 4, 5, and 6. Alternatives were evaluated based on their ability to meet the Purpose and Need, degree to which they met the objectives, as well as consideration of environmental, economic, and social effects. Major and moderate environmental, economic, and social effects to affected resources from the No Action Alternative, Multiple Objective Alternatives (MOs) and the Preferred Alternative are summarized in Table 7-1. This chapter focuses on how the Preferred Alternative was developed, including the operational, structural, and mitigation actions as well as preliminary measures to be included in the Endangered Species Act (ESA) consultations associated with this environmental impact statement (EIS). It includes the effects analysis related to the direct, indirect, climate, and cumulative effects analyses.

The Preferred Alternative includes a combination of measures that meet the Purpose and Need and objectives of the Columbia River System Operations (CRSO) EIS, while balancing the authorized purposes of the 14 Federal dam and reservoir projects that make up the Columbia River System (CRS). The Preferred Alternative is a combination of measures included in the five alternatives described in Chapter 2 and information that was evaluated in Chapter 3. In some instances, measures were modified to improve their ability to meet the Purpose and Need or objectives, as well as to avoid, reduce, or minimize environmental, economic, and social impacts. It is expected that the Preferred Alternative would allow the co-lead agencies to meet the congressionally authorized purposes of the system and the Purpose and Need and objectives of the EIS, including those to benefit ESA-listed species. The Preferred Alternative balances the multiple purposes of the Federal projects while complying with relevant laws and regulations.

While developing the Preferred Alternative, the co-lead agencies also considered the benefits, environmental consequences, tradeoffs, and costs of alternatives within and outside of current authorities as reflected in Chapters 3 to 6. This included evaluating the effects of each alternative as described in Chapter 3; projected changes to future regional climatic and hydrologic conditions as described in Chapter 4; possible mitigation measures to avoid, minimize, and reduce impacts to the human environment as described in Chapter 5; and cumulative effects as described in Chapter 6. Collectively, this information was used to help identify suites of measures from the alternatives described in Chapter 2 for inclusion in the Preferred Alternative.

As part of the development process for the Preferred Alternative, the co-lead agencies met with and considered input from cooperating agencies, members of the congressional delegation, state governors and other officials, tribes, National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), and other groups with a vested interest in system operations that included utility customers, irrigators, environmental organizations, and representatives from the navigation sector.

40 Many tribal representatives were vocal about past impacts to tribal resources and ways of life
41 that resulted from the construction of the CRS. For thousands of years, salmon have been an
42 important food source to tribes within the Pacific Northwest and are an important part their
43 cultural identity, spirituality, and ways of life. Impacts from the CRS, such as the loss of
44 important fishing sites at Celilo and Kettle Falls, among an uncountable number of other
45 locations, have adversely impacted tribal resources and ways of life. In addition, the lack of fish
46 passage at some dams, including Chief Joseph and Grand Coulee Dams, within the region has
47 restricted the range of salmonids from some locations where they were historically present.
48 Impacts such as these have adversely affected how tribal communities define themselves,
49 interact with each other, and live full spiritual lives. Many of the tribes have not only lost access
50 to traditional places on the river due to construction of dams, but they have also lost access to
51 shared resources that bound them together: salmon and steelhead. For many of the tribes, any
52 discussion pertaining to the CRS must include actions to return salmon and steelhead to
53 historical numbers and to improve access to historical fish habitat. In addition to evaluating
54 significant analytical input from regional tribes throughout this process, agency decision-makers
55 also considered the “Tribal Perspectives” narratives from those tribes who elected to submit
56 one (see Chapter 3.17 and Appendix P) in the process of identifying measures to be included as
57 part of the Preferred Alternative.

58 The co-lead agencies met with the irrigation stakeholders, who expressed concerns that any
59 measures that allowed reservoir levels to be lowered behind Ice Harbor Dam or McNary Dam
60 will result in operation concerns and increased costs to irrigators. They were concerned about
61 elevation changes, increased lift to stranding of some pump stations, and major sediment loads
62 moving through the system resulting from potential dam breach.

63 Navigation interests and local stakeholders expressed concerns that include the potential for
64 rail and truck rates to increase substantially if shallow draft barges no longer operate, reduce
65 grain growers’ cost competitiveness, having adequate capacity for transportation by rail and
66 road, and the high cost of adding capacity to these other transportation modes. Cruise line
67 industries expressed concern about no longer being able to come to port and the loss of
68 tourism.

69 The scope of this EIS focuses on the operation, maintenance, and configuration of the 14
70 Federal projects. The Preferred Alternative also includes measures to benefit ESA-listed juvenile
71 adult salmon and steelhead and resident fish, as well as to improve conditions for Pacific
72 lamprey within the CRS. As with salmon and steelhead, Pacific lamprey is a species that is
73 important to many tribes.

74 The Preferred Alternative includes structural modifications to infrastructure at certain projects
75 to benefit passage of adult salmon, steelhead, and Pacific lamprey (e.g., *Modify the Bonneville*
76 *Ladder Serpentine Weir, Lamprey Passage Ladder Modifications*). Additionally, proposed
77 operational changes in the upper basin would avoid adverse impacts to resident fish, including
78 ESA-listed bull trout and Kootenai River white sturgeon. As discussed in Chapter 2 under the No
79 Action Alternative, ongoing actions to benefit resident and anadromous fish would be

80 continued into the future. The *Juvenile Fish Passage Spill Operations* measure in the Preferred
81 Alternative builds off the range of spill analyzed in the alternatives, as well as the core
82 principles, objectives, and model of successful regional collaboration underlying the *2019-2021*
83 *Spill Operation Agreement* and includes an updated approach to adaptively implement spill.
84 Over time, the proposed spill operation would allow for more scientific certainty regarding
85 latent mortality (as discussed in Chapter 3.5), and it would address uncertainty in outputs from
86 fish models related to potential benefits of increased spill to ESA-listed salmon and steelhead in
87 the lower Columbia and Snake Rivers.

88 Unless otherwise noted, all other actions that were planned or part of ongoing CRS operations
89 and maintenance in 2016 when the EIS was initiated are included as part of the Preferred
90 Alternative. For example, the co-lead agencies are proposing to include measures to benefit
91 ESA-listed fish, and are planning to continue certain ongoing fish and wildlife mitigation actions
92 for non-listed species in the Preferred Alternative (see Chapter 7.5). A more detailed discussion
93 of the Preferred Alternative is presented later in this chapter.

94 **7.2 ABILITY TO MEET THE PURPOSE AND NEED**

95 As part of evaluating the effectiveness of the alternatives, the co-lead agencies used the
96 Purpose and Need Statement to determine if the alternatives met the co-lead agencies'
97 purposes. The co-lead agencies' assessment of this included an evaluation of the ability of the
98 U.S. Army Corps of Engineers (Corps) and U.S. Bureau of Reclamation (Reclamation) to operate
99 and maintain the 14 CRS projects to meet all congressionally authorized purposes, and
100 Bonneville's congressionally mandated ability to market power from the projects. This
101 assessment also evaluated the co-lead agencies' ability to mitigate for the ongoing operations
102 of the CRS, and to incorporate new information and adjust system operations to respond to
103 changing environmental conditions.

104 The co-lead agencies' assessment also addressed the need to respond to the Opinion and Order
105 issued by the U.S. District Court for the District of Oregon¹ to evaluate how the system can be
106 operated in compliance with Section 7(a)(2) of the ESA. The co-lead agencies are also
107 responding to observations the Court made regarding the reasonable range of alternatives that
108 could be considered, and comments received during public scoping, to consider breaching the
109 four lower Snake River dams as part of a reasonable range of alternatives. The co-lead agencies
110 considered the ability of each alternative to comply with all applicable Federal laws and
111 regulations, as well as to uphold the unique trust relationship between federally recognized
112 tribes and the United States, including upholding tribal rights that legally accrue to a tribe or
113 tribes by virtue of inherent sovereign authority, unextinguished aboriginal title, treaty, statute,
114 judicial decision, Executive Order, or agreement. Under this section of the ESA, the co-lead
115 agencies are responsible for ensuring that their actions are not likely to jeopardize the
116 continued existence of endangered or threatened species or result in the destruction or

¹ *National Wildlife Federation, et al. v. National Marine Fisheries Service (NMFS), et al.*, 184 F. Supp. 3d 861 (D Or. 2016).

117 adverse modification of designated critical habitat. While federal agencies must ensure their
118 actions do not “...reduce appreciably the likelihood of both the survival and recovery of a listed
119 species...”², the co-lead agencies are not, however, obliged under Section 7(a)(2) to contribute
120 affirmatively toward recovery achievement. Recovery is an important, but distinct, public policy
121 objective that is furthered through a separate planning process governed by ESA Section 4(f) to
122 guide societal actions by both federal and non-federal actors.

123 The co-lead agencies determined that the No Action Alternative, MO1, MO2, and MO4
124 (described in Chapter 2), allow for the operation of the projects in furtherance of all of the
125 congressionally authorized purposes to varying degrees (the rationale for these differences is
126 described in Section 7.2 and 7.3). This includes flood risk management, navigation, irrigation,
127 hydropower generation, fish and wildlife conservation, and recreation. See Part 1 in Table 7-1
128 for additional detail. Alternative MO3 would not meet the congressionally authorized purposes
129 of operating and maintaining the four lower Snake River dams for navigation, hydropower,
130 envisioned recreational benefits, and providing irrigation. New congressional authority through
131 the passage of new laws and associated funding would be required to implement the dam
132 breaching measures in MO3. However, the dam breaching measures in MO3 were carried
133 forward in the analysis to align with the District Court's Opinion and Order, and in response to
134 comments received during public scoping that requested this alternative be evaluated.
135 Breaching of the four lower Snake River dams also received substantial interest by several
136 tribes who believe that this alternative is the best option to offset some of the substantial
137 adverse impacts of the CRS.

138 **7.3 EVALUATION OF THE NO ACTION ALTERNATIVE AND MULTIPLE OBJECTIVE**
139 **ALTERNATIVES**

140 The co-lead agencies evaluated the alternatives to determine how effectively they meet the
141 objectives as described in Chapter 2, including objectives related to several key tribal resources
142 and treaty reserved rights—an important consideration for decision-makers. The specific
143 objectives are as follows:

- 144 1) Improve ESA-listed anadromous salmonid juvenile fish rearing, passage, and survival within
145 the CRS project area through actions including but not limited to project configuration, flow
146 management, spill operations, and water quality management.
- 147 2) Improve ESA-listed anadromous salmonid adult fish migration within the CRS project area
148 through actions including but not limited to project configuration, flow management, spill
149 operations, and water quality management.
- 150 3) Improve ESA-listed resident fish survival and spawning success at CRS projects through
151 actions including but not limited to project configuration, flow management, improving
152 connectivity, project operations, and water quality management.

² 50 C.F.R. § 402.02.

- 153 4) Provide an adequate, efficient, economical, and reliable power supply that supports the
154 integrated Columbia River Power System.
- 155 5) Minimize greenhouse gas emissions from power production in the Northwest by generating
156 carbon-free power through a combination of hydropower and integration of other
157 renewable energy sources.
- 158 6) Maximize operating flexibility by implementing updated, adaptable water management
159 strategies to be responsive to changing conditions, including hydrology, climate, and the
160 environment.
- 161 7) Meet existing contractual water supply obligations and provide for authorized additional
162 regional water supply.
- 163 8) Improve conditions for lamprey within the CRS projects through actions potentially
164 including but not limited to project configurations, flow management, spill operations, and
165 water quality management.

166 The alternatives met the authorized purposes and objectives to varying degrees, as detailed in
167 Part 2 of Table 7-1. The co-lead agencies developed a reasonable range of alternatives to be
168 able to select a long-term operating strategy for the CRS. The effects analysis showed the
169 impacts, benefits and tradeoffs to affected resources, which informed which measures would
170 be identified in the Preferred Alternative. Some measures that provide the ability to meet one
171 objective sometimes conflict with the ability to meet other objectives. For example, drafting
172 reservoirs deeper in the upper Columbia River Basin storage projects to benefit downstream
173 ESA-listed fish species results in adverse effects on upper basin resident fish species.

174 **7.3.1 No Action Alternative**

175 The No Action Alternative includes all operations, maintenance, fish and wildlife programs, and
176 mitigation in effect when the EIS was initiated in September 2016. Juvenile fish passage spill
177 operations at the four lower Columbia River and four lower Snake River dams would follow the
178 2016 Fish Operations Plan developed by the Corps. This plan used performance standard spill
179 developed under previous ESA biological opinions. The co-lead agencies would also implement
180 structural measures that were already budgeted and scheduled as of September 2016 that
181 affected CRS operations. The majority of these structural measures are dam modifications to
182 improve conditions for fish listed as threatened and endangered under the ESA. For example,
183 installation of improved fish passage turbines planned for Ice Harbor and McNary Dams would
184 occur. Other ongoing habitat and mitigation programs would continue, as was planned for at
185 the time the EIS process started. A detailed description of measures included in the No Action
186 Alternative is included in Section 2.4.2.

187 The No Action Alternative met the Purpose and Need of the EIS, but it did not meet all of the
188 objectives developed for the EIS. The No Action Alternative generally satisfied the objective for
189 hydropower generation as it resulted in no additional upward power rate pressure or potential
190 regional reliability issues. However, it only partially met the objectives for water supply and
191 adaptable water management because it does not provide the additional authorized regional

192 water supply. Further, it does not include effects of the changes to CRS operations from
193 important maintenance activities at Grand Coulee needed in the near term.

194 The No Action Alternative did not provide adequate improvements to meet the juvenile
195 salmon, adult salmon, resident fish, and lamprey objectives. As outlined in this alternative,
196 improvements to fish survival and abundance would be achieved through construction of
197 additional fish passage structural measures at the lower Columbia River and lower Snake River
198 projects. Additional measures could be adopted to improve fish survival to meet these
199 objectives.

200 It is not expected that there would be any new moderate or major impacts to environmental,
201 economic, or social effects as a result of continuing the No Action Alternative. The co-lead
202 agencies used the analysis to develop a Preferred Alternative that balances managing the
203 system for all authorized purposes while providing additional benefits to fish.

204 **7.3.2 Multiple Objective Alternative 1**

205 MO1 was developed with the goal to benefit or avoid adverse effects to congressionally
206 authorized purposes while also benefiting ESA-listed fish species relative to the No Action
207 Alternative. MO1 differs from the other alternatives by carrying out a juvenile fish passage spill
208 operation referred to as a block spill design. The block spill design alternates between two
209 operations: a base operation that releases surface flow, where juvenile fish are most present,
210 over the spillways using different flows at each project based on historical survival tests; and a
211 fixed higher spill target at all projects. For the block that uses the same target at all projects, the
212 operators would release flow through the spillways up to a target of no more than 120 percent
213 total dissolved gas (TDG) in the tailrace of projects and 115 percent TDG in the forebay of those
214 projects. The intent of these two spill operations is to demonstrate the benefit of different spill
215 levels to fish passage. In addition, MO1 sets the duration of juvenile fish passage spill to end
216 based on a fish count trigger, rather than a predetermined date. MO1 proposes to initiate
217 transport operations for juvenile fish approximately 2 weeks earlier than under the No Action
218 Alternative.

219 MO1 also incorporated measures to increase hydropower generation flexibility in the lower
220 basin projects and alters the use of stored water at Dworshak for downstream water
221 temperature control in the summer. MO1 includes measures similar to the other action
222 alternatives, which include increased water management flexibility and water supply, and using
223 local forecasts in whole-basin planning. MO1 includes measures to disrupt predators of ESA-
224 listed fish. A detailed description of the measures that are included in MO1 are described in
225 Chapter 2.4.3 of the EIS.

226 Following the detailed evaluation in Chapter 3, 4, 5, and 6, MO1 would provide minor benefits
227 to most ESA-listed anadromous salmonid fish species, both juvenile and adult. The expected
228 degree of these benefits varied depending on specific species, location, and the outputs from
229 two separate models (Fish Passage Center's Comparative Survival Study [CSS] and NMFS's Life
230 Cycle Model [LCM]). The CSS model generally predicted minor improvements for the species

231 modeled while the LCM generally predicted negligible decreases to minor improvements to
232 anadromous species that were modeled. This alternative would also result in localized
233 moderate adverse effects to ESA-listed resident fish species in the upper Columbia River basin.
234 With regard to cultural resources, there would be additional major effects at Hungry Horse,
235 Lake Roosevelt, and Dworshak reservoirs. There would also be the potential to impact the
236 Kettle Falls sacred site if changes in reservoir elevations were to result in increased potential for
237 looting. MO1 marginally meets the objective to provide an adequate, efficient, economical, and
238 reliable power supply. In particular, the *Implement modified timing of Lower Snake Basin*
239 *reservoir draft for additional cooler water* measure did not provide the intended water
240 temperature benefits and largely contributed to lower power generation in the summer. In
241 addition, this alternative would not meet the objective to minimize greenhouse gas emissions if
242 reductions in hydropower generation were replaced by carbon-producing sources for power
243 generation. MO1 met the objectives for implementing adaptable water management
244 strategies, water supply, ESA-listed anadromous fish and resident fish. MO1 also includes
245 structural modifications to infrastructure at the dams (e.g., *Modify the Bonneville Ladder*
246 *Serpentine Weir, Lamprey Passage Ladder Modifications*) to benefit passage of adult salmon,
247 steelhead, and Pacific lamprey that are expected to meet the objectives to benefit ESA-listed
248 salmon and steelhead and Pacific lamprey. Overall, the expected degree of improvements to
249 ESA-listed salmonids was less than was desired by the co-lead agencies.

250 Under MO1, there would likely be moderate adverse effects to water quality in the lower Snake
251 River from the *Implement modified timing of Lower Snake Basin reservoir draft for additional*
252 *cooler water* measure. There would also likely be moderate adverse effects to resident fish in
253 the upper Columbia River basin due to changes in reservoir operations and elevations that
254 would require mitigation. There would likely be no major or moderate economic effects, but
255 there are major social effects, including adverse impacts to cultural resources at Hungry Horse,
256 Lake Roosevelt and Dworshak reservoirs. The co-lead agencies used this analysis to inform the
257 development of the Preferred Alternative that balances managing the system for all authorized
258 purposes while providing additional benefits to fish.

259 **7.3.3 Multiple Objective Alternative 2**

260 MO2 was developed with the goal to increase hydropower production and reduce regional
261 greenhouse gas emissions while avoiding or minimizing adverse impacts to other authorized
262 project purposes. MO2 would slightly relax the No Action Alternative's restrictions on operating
263 ranges and ramping rates to evaluate the potential to increase hydropower production
264 efficiency, and increase operators' flexibility to respond to changes in power demand and
265 changes in generation of other renewable resources. The measures within MO2 would increase
266 the ability to meet power demand with hydropower production during the most valuable
267 periods (e.g., winter, summer, and daily peak demands). The upper basin storage projects
268 would be allowed to draft slightly deeper, allowing more hydropower generation in the winter
269 and less during the spring. MO2 also differs from the other alternatives by excluding the water
270 supply measures and evaluating an expanded juvenile fish transportation operation season.
271 This alternative proposes to transport all collected ESA-listed juvenile fish for release

272 downstream of the Bonneville project, by barge or truck, and reduce juvenile fish passage spill
273 operations to a target of up to 110 percent TDG. Inclusion of the target up to 110 percent TDG
274 spill operation provides the lowest end of the range of juvenile fish passage spill operations
275 evaluated in this EIS.

276 Structural measures of MO2 are aimed at benefits for ESA-listed fish and lamprey. These
277 measures are similar to other alternatives and include making improvements to adult fish
278 ladders, upgrading spillway weirs, adding powerhouse surface passage, and turbine upgrades at
279 John Day. A detailed description of measures that are included in MO2 are described in Chapter
280 2.4.4 of the EIS.

281 Following the detailed evaluation in Chapter 3, 4, 5, and 6, MO2 resulted in the greatest
282 benefits to providing an adequate, efficient, economical and reliable power supply and to
283 minimizing greenhouse gas emissions from power production. It was not as effective at meeting
284 objectives for ESA-listed salmonids in certain instances. This varied depending on the specific
285 species, location, and by the outputs from the two distinct models (CSS and LCM) used in this
286 analysis. The CSS model generally predicted moderate to major adverse effects for the species
287 modeled while the LCM generally predicted negligible to moderately adverse effects to
288 anadromous species that were modeled. There were also major adverse effects predicted to
289 upper Columbia River basin resident fish due to changes in reservoir operations and elevations
290 that would require mitigation. There would also be additional major effects to cultural
291 resources at Dworshak and Lake Roosevelt reservoirs. There would also be the potential for
292 major effects to the sacred site, Kettle Falls, if changes in reservoir elevations result in increased
293 looting.

294 MO2 also includes structural modifications to infrastructure at the dams (e.g., *Improved Fish*
295 *Passage Turbines at John Day, Lamprey Passage Ladder Modifications*) to benefit passage of
296 adult salmon, steelhead, and Pacific lamprey. MO2 did meet the existing contractual water
297 supply obligations, but did not provide for authorized additional regional water supply.

298 There is the potential for minor beneficial to major adverse effects for anadromous fish that
299 vary by species, location, and models. There would be major beneficial economic effects to
300 hydropower if the *McNary Powerhouse Surface Passage* structural measure is excluded; no
301 other major economic effects are expected. Additionally, there would be ongoing major social
302 effects, including impacts to cultural resources and tribal interests at Lake Roosevelt and
303 Dworshak. There would also be the potential for major effects to the sacred site, Kettle Falls, if
304 changes in reservoir elevations result in increased looting. The co-lead agencies used this
305 analysis to inform the development of the Preferred Alternative that balances managing the
306 system for all authorized purposes while providing additional benefits to fish.

307 **7.3.4 Multiple Objective Alternative 3**

308 MO3 was developed to integrate actions for water management flexibility, hydropower
309 generation at the remaining CRS projects, and water supply with measures that would breach
310 the four lower Snake River dams (Lower Granite, Little Goose, Lower Monumental, and Ice

311 Harbor). In addition to breaching these four projects, MO3 differs from the other alternatives
312 by carrying out a juvenile fish passage spill operation that sets flow through the spillways up to
313 a target of no more than 120 percent TDG in the tailrace of the four lower Columbia River
314 projects (McNary, John Day, The Dalles, and Bonneville). This alternative also proposes an
315 earlier end to summer juvenile fish passage spill operations than the No Action Alternative.
316 Instead, flows would transition to increased hydropower generation when low numbers of
317 juvenile fish are anticipated.

318 Structural measures in this alternative include breaching the four lower Snake River dams by
319 removing the earthen embankment at each dam location, resulting in a controlled drawdown.

320 A detailed description of measures that are included in MO3 is described in Chapter 2 of the
321 EIS.

322 MO3 was developed with the goal to meet objectives to benefit ESA-listed fish while integrating
323 actions for water management flexibility for flood risk management, provide hydropower
324 generation flexibility at the remaining CRS projects, and additional water supply. This
325 alternative would eliminate hydropower generation and navigation on the lower Snake River
326 which affects the ability of this alternative to meet the Purpose and Need.

327 The measure to breach the four lower Snake River dams in MO3 (a main component of this
328 alternative) has been the topic of a large amount of public discourse for decades. Many
329 environmental organizations and some tribes have been strong proponents of breaching the
330 dams. They assert breaching the dams will result in large improvements to certain salmonid
331 populations, and this in turn would have beneficial impacts to the overall function of the
332 Northwest ecosystem and for tribal ways of life. At the same time, many stakeholders within
333 the navigation industry, and agricultural producers within the region that depend on the
334 navigation industry to export grains to overseas markets, have expressed high concern with the
335 potential regional socioeconomic impacts from breaching the dams. There would also be an
336 adverse effect to irrigation and power from this MO.

337 As described in Chapter 3, model estimates for MO3 showed the highest predicted potential
338 smolt-to-adult returns (SARs) for Snake River salmon and steelhead amongst the alternatives.
339 The two models used to evaluate effects to certain salmon and steelhead (see section 3.5 for
340 specific species) predict a wide range of improved SARs for this alternative, indicating higher
341 uncertainty pertaining to the level of benefits compared to the other alternatives. For example,
342 MO3 is predicted to result in improvements to SARs for Snake River Spring/Summer Chinook
343 that range from 14 percent (LCM) to 140 percent (CSS) relative to the No Action Alternative.
344 Additionally, under MO3 there is a slight increase predicted in upper Columbia spring Chinook
345 salmon in-river survival due to increased spill levels in the lower Columbia River. The
346 quantitative model results vary in the magnitude of their predictions due to how they factor in
347 latent mortality and density dependence. Model predictions also vary by Evolutionarily
348 Significant Unit (ESU). MO3 is also expected to provide a long-term benefit to species that
349 spawn or rear in the mainstem Snake River habitats, such as fall Chinook. By breaching the four
350 lower Snake River dams, there would be short-term adverse impacts to fish in the Snake River

351 associated with initially breaching the dams and drawing down the reservoirs, but these effects
352 are expected to diminish over time.

353 In the upper basin, there were also major and moderate adverse effects to resident fish due to
354 changes in operations at Libby and Hungry Horse dams respectively that would require
355 mitigation. MO3 also includes structural modifications to infrastructure at the lower Columbia
356 River dams (e.g., *Improved Fish Passage Turbines at John Day, Lamprey Passage Ladder*
357 *Modifications*) to benefit passage of adult salmon, steelhead, and Pacific lamprey that are
358 expected to meet the objectives to benefit ESA-listed salmon and steelhead and Pacific
359 lamprey.

360 MO3 would only partially meet the objective for an adequate, efficient, economical, and
361 reliable power supply due to the loss of hydropower generation, system flexibility and peaking
362 capabilities at the four lower Snake River projects. As discussed in more detail below, without
363 adequate and timely resource replacement, including battery storage (at utility level scales),
364 MO3 would not meet the objective for hydropower due to the loss of 1,100 average megawatts
365 (aMW) of hydropower generation, more than 2,000 megawatts (MW) of sustained peaking
366 capabilities during the winter, and a quarter of Bonneville's current reserves holding capability
367 provided by the four lower Snake River projects. The detailed evaluation in Section 3.7.3.5
368 describes different portfolios that were designed to replace these capabilities.

369 The analysis of power impacts started with the question of what resources would be needed to
370 maintain the current No Action Alternative Loss of Load Probability (LOLP) of 6.6 percent (also
371 see Section 3.7.2.2).³ Two potential resource replacement portfolios were developed for this
372 approach. The first was the conventional-least cost portfolio, where the region would need to
373 purchase or build 1,120 MW of combined cycle natural gas generation. The second was a zero-
374 carbon portfolio.

375 Several states in the western United States have passed, or are likely to pass, legislation
376 directed at decarbonizing the electric grid. California began implementing an economy-wide
377 cap-and-trade program in 2013. In 2018, the California legislature passed a law seeking to
378 achieve 100 percent carbon-free electricity by 2045 (Senate Bill 100). Washington enacted the
379 Clean Energy Transformation Act (CETA) in 2019, requiring that Washington utilities eliminate
380 coal costs from their retail rates by 2025. CETA also directs Washington retail utilities to serve
381 loads with 100 percent carbon-neutral power by 2030, and 100 percent carbon-free power by
382 2045 (RCW 19.405). Oregon has been considering a cap-and-trade program similar to
383 California's program. Additionally, Nevada (Senate Bill 358, 2019) and New Mexico (Senate Bill
384 489, 2019) both adopted 100 percent carbon-free goals for the electricity sector. The province
385 of British Columbia has had a carbon tax in place since 2008.

³ As discussed in Section 3.7.2.2, the LOLP is a measure of system reliability. The Northwest Power and Conservation Council targets an LOLP of 5.0 percent, and higher numbers represent less reliability and higher risk of power shortages and blackouts.

386 In light of this legislative and policy trend, the co-lead agencies assume that no new gas-fired
387 generation would be built to replace the lost generation from the lower Snake River dams, only
388 zero-carbon resources may be selected. At the utility-scale, the current best options are solar
389 and wind resources, some batteries, and demand response programs. For MO3, the EIS analysis
390 identified a potential zero-carbon replacement portfolio consisting of 2,550 MW of solar
391 resources, , and 600 MW of demand response to restore LOLP. Tis portfolio relies on using the
392 existing regional system to help make up for some of the lost capabilities of the lower Snake
393 River projects - primarily by operating thermal plants more frequently to meet regional load.
394 However, in light of regional policy initiatives to curtail or cease the operation of thermal
395 plants, a zero-carbon resource replacement portfolio with insufficient dispatchable sustained
396 capacity may not be feasible. If the replacement does not include firm generating capacity with
397 only 600 MW of dispatchable capability, it is likely not a realistic assumption for MO3 where a
398 substantial amount of generation capacity is lost.

399 In order to partially reflect the permanent loss of sustained dispatchable hydropower peaking
400 capacity, reserve capability and flexibility at the lower Snake River projects an additional 1,275
401 MW of battery storage was added to the zero-carbon portfolio for the base case analysis. While
402 this portfolio with batteries continues to rely on regional thermal resources to make up for lost
403 energy, capacity and reserves, it lessens that reliance. This portfolio is captured in the Base
404 Case section of the rate analysis described in in Section 3.7.3.5.

405 The zero-carbon replacement portfolio for MO3 discussed above does not replace the full
406 capability of the hydropower that would be lost in MO3. To estimate what would be needed to
407 replace the lower Snake River projects' full operational capabilities, including integrating
408 replacement resources, another zero-carbon replacement portfolio was developed, called the
409 Lower Snake River Replacement portfolio. In this portfolio, 3,306 MW of wind, 1,144 MW of
410 solar and 2,515 MW of batteries were considered. This portfolio assumes that the larger
411 quantity of batteries would come closer to replacing the reserve capability of the lower Snake
412 River projects than the portfolios described above. More analysis would need to be done to test
413 if the Lower Snake River Replacement portfolio is capable of a full replacement of the lost
414 generation (i.e., heavy load hour and light load hour energy, ramping capacity and ability to
415 provide operating reserves at similar levels currently provided by the lower Snake River
416 projects). To provide a sense of scale for this portfolio, currently, the largest lithium ion battery
417 system in the world is 100 MW in South Australia, so battery storage of the proposed scale in
418 the replacement portfolio has not been developed and tested. While grid scale battery storage
419 technology is undoubtedly improving, existing studies focus on storage in the hundreds of MW,
420 not the thousands that would be required under the full replacement portfolio. Siting wind and
421 solar projects along with the routing of new transmission power lines required to bring the
422 renewable energy to load would also need to undergo environmental review and permitting.
423 This would need to be completed prior to absorbing the loss of hydropower generation
424 identified in MO3, if the LOLP is to remain within a reasonable range. This portfolio is captured
425 in the Rate Sensitivity section of the rate analysis.

426 Other resource possibilities that were contemplated included pumped storage and small
427 modular nuclear reactors. More details on these resources can be found in Section 3.7.3.5. As
428 also discussed in Chapter 3, if Bonneville were to pursue a major resource acquisition under
429 current law, then Bonneville would need to conduct a formal Section 6(c) process under the
430 Northwest Power Act in which further analysis and public involvement would need to occur.
431 These processes would consider a full range of resource options and prioritization in
432 accordance with the Northwest Power Act.

433 MO3 would meet the objective for water supply, but there are adverse impacts to irrigation in
434 the lower Snake River.

435 MO3 does not meet the objective to minimize greenhouse gas emissions because of the loss of
436 hydropower and the loss of navigation on the Snake River. The power analysis considered a
437 range of scenarios for replacing the hydropower to maintain system reliability. Greenhouse gas
438 emissions increase the most if the hydropower is replaced with natural gas (an 8.9 percent or
439 3.3 MMT of CO₂ increase in power-related emissions across the Pacific Northwest). However,
440 even assuming that new replacement resources are renewable (i.e., solar and additional
441 storage), some increase in fossil fuel based generation would occur in order to maintain system
442 reliability. This zero-carbon replacement scenario therefore increases power-related emissions
443 by 2.7 percent or 1.0 MMT of CO₂ across the region. In addition, MO3 results in a shift of
444 shipping activities from barge to road and rail transport. As barge transportation is a relatively
445 low source of emissions per ton-mile of freight, MO3 would also increase transportation-
446 related emissions for wheat that is currently transported along the lower Snake River by up to
447 53 percent (0.056 MMT of CO₂).

448 Additionally, Snake River barge navigation would be eliminated. The lower Snake River shallow
449 draft navigation channel would no longer be available and commercial navigation would be
450 eliminated. As a result, the cost to transport goods to market would increase (the cost to
451 transport wheat to market is estimated to increase by \$0.07-\$0.24/bushel. Farmers would
452 experience increased production costs associated with higher transportation costs (i.e.,
453 fertilizer, crops). There would be additional demands on existing road and rail infrastructure as
454 well as at barging facilities near the Tri-Cities area in Washington. Additional capacity and
455 infrastructure improvements would likely be required. Some port facilities within Lake Wallula
456 would require additional dredging to maintain access to the navigation channel. Commercial
457 cruise lines that operate on the lower Columbia and lower Snake River would be adversely
458 affected from reduced numbers and distance of trips, with adverse effects to tourism revenues
459 and associated jobs and income. These communities, such as Clarkston, Lewiston and Asotin,
460 would lose their 'river port' community identity. There would be potential for increased
461 accident rates with increased truck traffic. Section 3.10 discusses navigation in more detail.

462 Based on the analyses in Chapters 3, 4, 5, and 6, there would likely be major adverse short-term
463 effects to environmental resources along the lower Snake River due to the impacts associated
464 with the initial breaching of the dams and drawing down the existing reservoirs, but there
465 would be major long-term beneficial effects to vegetation, wildlife, wetlands, floodplains, fish,

466 in the lower Snake River. Overall, long-term water quality would improve in the lower Snake
467 River under MO3, with improved water temperatures during the fall and increased nighttime
468 cooling in the summer. In addition, riverine processes would be restored, eliminating some of
469 the pH, and harmful algal bloom problems that currently exist. Elevated TDG would also be
470 eliminated. Additionally, there would be major increases in Snake River fall Chinook spawning
471 habitat and associated potential beneficial effects for recreational, tribal, and commercial
472 fishing.

473 There are expected to be major adverse impacts at Libby reservoir and moderate adverse
474 impacts at Hungry Horse reservoir for resident fish from reservoir operation changes, which
475 would be mitigated.

476 In terms of economic effects, there would also be major long-term adverse effects to lower
477 Snake River barge navigation and reservoir-based recreation in the lower Snake River, including
478 impacts to recreation facilities. There could also be a major adverse social effect to the port
479 communities along the lower Snake River (e.g., economics, potential shift in employment, etc.).
480 Transitional effects from the loss of Snake River barging would decrease over time as the
481 transportation industry expanded to one that would be entirely dependent on trucks and rail to
482 move goods. There would be major adverse effects to reservoir-based recreation because these
483 reservoirs, and boat ramp access, would cease to exist, but there would likely be major long-
484 term beneficial effects to river-based recreation. Other major long-term impacts to community
485 identity from loss of lower Snake River ports (e.g., Clarkston, Lewiston, Asotin) could also occur.
486 Long-term beneficial effects to recreational, tribal and commercial fishing may be realized.

487 In the lower Snake River, MO3 would result in the potential for additional major adverse effects to
488 cultural resources due to potential exposure of 14,000 acres that are currently inundated. The exposure
489 of Traditional Cultural Properties, however, could allow for some traditional uses that have not been
490 possible since the dams were built. There is also the potential for additional major adverse effects to
491 cultural resources at Hungry Horse Reservoir from changes to reservoir elevations and operations.

492 The co-lead agencies used the MO3 analysis to inform the development of the Preferred
493 Alternative that balances managing the system while meeting the purpose and need and
494 project objectives, and minimizes adverse effects. Based on the overall major and moderate
495 long term adverse effects to environmental, social, and economic resources in the region, and
496 the inability to mitigate the scale of these effects, this alternative was not identified as the
497 Preferred Alternative.

498 **7.3.5 Multiple Objective Alternative 4**

499 MO4 was developed to examine an additional combination of measures to benefit ESA-listed
500 fish, integrated with measures for water management flexibility, hydropower production in
501 certain areas of the basin, and additional water supply. This alternative includes the highest fish
502 passage spill level considered in this EIS, dry-year augmentation of spring flow with water
503 stored in upper basin reservoirs, and annually drawing down the lower Snake River and
504 Columbia River reservoirs to their minimum operating pools. This alternative also includes

505 spillway weir notch inserts, changes to the juvenile fish transportation operations, and
506 increased powerhouse surface passage for kelt and overshoots. In MO4, the juvenile fish
507 transport program would operate only in the spring and fall, while juvenile fish passage spill is
508 set to no more than 125 percent TDG during the spring and summer spill season. The
509 alternative also contains a measure for restricting winter flows from the Libby project to
510 protect newly established downstream riparian vegetation to improve conditions for ESA-listed
511 resident fish, bull trout, and Kootenai River White Sturgeon in the upper Columbia River Basin.

512 The structural measures in this alternative are primarily focused on improving passage
513 conditions for ESA-listed salmonids and Pacific lamprey. The inclusion of spillway weir notch
514 inserts is the only structural measure unique from the other action alternatives. A detailed
515 description of measures that are included in MO4 is described in Chapter 2.4.6 of the EIS.

516 Following a detailed evaluation of this alternative in Chapter 3, 4, 5 and 6, it was determined
517 that MO4 does not meet the objective for hydropower generation because the impacts to cost
518 and reliability would not allow Bonneville to provide an adequate, efficient, economical, and
519 reliable power supply. It is expected that there would be an approximate one in three
520 probability of blackouts in a given year. It would not meet the objective to minimize
521 greenhouse gas emissions if reductions in hydropower generation were replaced by carbon-
522 producing sources for power generation or if zero-carbon resources were built to restore
523 reliability because the existing thermal resources (gas and potentially coal) would be operated
524 more often to meet demand for power.

525 This alternative would meet the objectives for implementing adaptable water management
526 strategies and water supply; however, it would have moderate effects to irrigation in the John
527 Day reservoir from impacts due to the *McNary Flow Target*.

528 This alternative could meet the objectives related to ESA-listed anadromous salmonids
529 providing major beneficial impacts, but could also have potential adverse effects to some stocks
530 depending largely on the degree to which higher spill reduces latent mortality. This high range
531 of potential results from MO4 is evident in the differing estimates of SARs produced by the two
532 models. The CSS model predicts major increases in Snake River Spring Chinook salmon and
533 steelhead returns, to both the Columbia and Snake Rivers. For example, the CSS model
534 estimates an increase of 75 percent in the SARs for Snake River Spring/Summer Chinook. These
535 predictions are primarily driven by increased spill levels that would increase the number of fish
536 passing via the spillways and avoiding powerhouses, which the CSS model predict would reduce
537 latent mortality associated with CRS passage. In contrast, the NMFS LCM predicts minor
538 increases in benefits to Upper Columbia spring Chinook and steelhead, but potential
539 detrimental effects for Snake River stocks. For example, the LCM estimates a 12 percent
540 reduction in SARs for Snake River Spring/Summer Chinook relative to the No Action Alternative.
541 This potential decrease in overall adult returns is driven by reductions in transportation rates
542 due to high spill, a relationship that could be similar for Snake River steelhead. However, the
543 NMFS LCM estimates that if changes in passage through the CRS can increase ocean survival by
544 at least 10 percent (i.e., latent mortality effects are decreased by 10 percent), the net impact to

545 Snake River Chinook salmon could switch from adverse to beneficial. The objective for resident
546 fish would not be met in the upper basin due to the deep drafts to the upper basin storage
547 projects. MO4 also includes structural modifications to infrastructure at the dams (e.g.,
548 *Improved Fish Passage Turbines at John Day, Lamprey Passage Ladder Modifications*) to benefit
549 passage of adult salmon, steelhead, and Pacific lamprey.

550 This alternative would potentially have moderate to major adverse environmental effects,
551 depending on the affected resources. For ESA-listed salmonids, there are potential benefits
552 ranging from major beneficial to moderate adverse effects. Results varied depending on the
553 specific species, location, and by the outputs from the two separate models (CSS and LCM). It
554 would result in major adverse effects to vegetation, wildlife, wetlands, floodplains, and resident
555 fish in the upper basin that would require mitigation.

556 Overall, there would also be major adverse economic effects under MO4. For irrigation on the
557 lower Columbia, the reservoirs levels may be lowered to the point where pumping could no
558 longer be possible. Additionally, in low water years, major adverse effects to water-based
559 recreational access at Lake Pend Oreille could occur.

560 Finally, there could be major social effects, including impacts to cultural resources at Lake
561 Roosevelt, John Day, and Hungry Horse reservoirs due to impacts from the *McNary Flow Target*
562 measure. There would be additional moderate effects to cultural resources at the remaining
563 lower Columbia River projects due to additional drawdown. There is the potential for major
564 effects to Kettle Falls (sacred site) if changes in reservoir elevations lead to increased looting.
565 Changes in reservoir elevation at Albeni Falls may result in reduced access to Bear Paw Rock
566 (sacred site), which may result in less tribal visitation. As with the other alternatives, the co-lead
567 agencies used this analysis to inform and improve the Preferred Alternative that balances
568 managing the system for all authorized purposes while providing additional benefits to fish.

569 **7.4 SUMMARY**

570 The alternatives met the authorized purposes and objectives to varying degrees and with
571 varying levels of beneficial and adverse effects. Because of this, the co-lead agencies used the
572 information from the evaluation of the alternatives in Chapters 3, 4, 5, and 6 to develop the
573 Preferred Alternative that better met the Purpose and Need and objectives while avoiding,
574 reducing, or minimizing adverse effects to environmental, economic, and social resources. To
575 do this, measures included in the Preferred Alternative were combined and modified from the
576 existing alternatives described in Chapter 2. In addition, the co-lead agencies modified the
577 juvenile fish passage spill operation for the Preferred Alternative using the analysis from the
578 range of spill levels evaluated in the No Action Alternative and MOs. The Preferred Alternative
579 was also informed by actual operations in 2019 and considers the adaptive implementation
580 framework that uses the planned 2020 spill operation, as described in the December 2018
581 “2019-2021 Spill Operation Agreement,” as a starting point for implementation. Details of the
582 development and evaluation of the Preferred Alternative are included in the remaining sections
583 of this chapter.

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585 **Table 7-1. Evaluation of alternatives. Part 1 indicates whether each alternative met the Purpose and Need of the EIS. Part 2 indicates whether each alternative met the objectives of the EIS. Part 3 summarizes major**
586 **and moderate effects for each of the alternatives.**

Evaluation Criteria	No Action Alternative	MO1	MO2	MO3	MO4	Preferred Alternative
Part 1: Purpose and Need						
Can the System Be Operated for the Following Authorized Purposes of the Projects?	–	–	–	–	–	–
Flood Risk Management	Yes	Yes	Yes	Yes	Yes	Yes
Navigation	Yes	Yes	Yes	Partially. This alternative eliminates navigation in the lower Snake River.	Yes	Yes
Hydropower	Yes	Yes	Yes	Partially. This eliminates hydropower generation on the lower Snake River.	Partially, due to increased costs and reliability impacts.	Yes
Irrigation	Yes	Yes	Yes	Partially. Dam breaching has major adverse effects on irrigation in the lower Snake River region.	Partially. Has major effects to irrigation in the John Day Reservoir.	Yes
Fish and Wildlife Conservation	Yes	Yes	Yes	Yes	Yes	Yes
Recreation	Yes	Yes	Yes	Yes	Yes	Yes
Does the Alternative Comply with Legal and Institutional Purposes?	Yes	Yes	Yes	No. Due to the impacts to the integrated Columbia River Power System.	Yes ^{1/}	Yes
Part 2: Study Objectives						
Improve ESA-Listed Anadromous Salmonid Juvenile Fish Rearing, Passage, And Survival	No change from 2016 actions	Yes. Minor benefits to in-river survival and PITPH that vary by species, location, and model. PITPH is decreased with potential benefits ranging from minor to moderate compared to No Action Alternative. Minor to moderate increased TDG exposure	Mixed negligible to major adverse effects vary by species, location, and model. Decreased in-river survival, increased PITPH, increased proportion of transport and associated effects compared to the No Action Alternative. Decreased exposure to TDG.	Yes. In the long term, beneficial effects for all stocks, short term adverse impacts to Snake River stocks, Effects vary by species, location, and model. In-river survival generally moderately higher than No Action Alternative. PITPH shows a major decrease compared to No Action Alternative. Similar TDG exposure with minor effects for upper Columbia species and Snake River species. Major increase in Snake River fall Chinook spawning habitat.	Mixed major beneficial to moderate adverse effects vary by species, location, and model. Increased in-river survival, major decrease in PITPH, decreased proportion of transport and associated effects compared to the No Action Alternative. Increased exposure to TDG	Yes. Minor benefit to in-river survival. PITPH is decreased with potential benefits ranging from minor to moderate compared to No Action Alternative. Moderate increase in TDG exposure.
Improve ESA-Listed Anadromous Salmonid Adult Fish Migration	No change	Yes. SARs vary depending on model used, but generally show minor increases compared to the No Action Alternative.	Mixed beneficial and adverse effects based on model. SARs vary depending on model used, showing minor increases to moderate decreases compared to the No Action Alternative.	Yes. Long-term benefits in lower Snake and Columbia Rivers, but short-term adverse effects for Snake River stocks. SARs vary depending on model used, showing minor to major increases compared to the No Action Alternative.	Yes. SARs vary widely depending on model used, showing moderate decreases to major increases compared to the No Action Alternative. Increased exposure to TDG and increased fallback and passage delay.	Yes. Estimated SARs expected to vary depending on model used, likely showing minor increases to major increases compared to the No Action Alternative. TDG exposure is expected to increase.

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Evaluation Criteria	No Action Alternative	MO1	MO2	MO3	MO4	Preferred Alternative
Improve ESA-Listed Resident Fish Survival and Spawning Success	No change	Yes. Similar to No Action Alternative in most regions. Localized moderate adverse effects in upper Columbia River basin compared to No Action Alternative.	No. Major adverse effects to upper Columbia River basin ESA-listed resident fish compared to No Action Alternative.	Mixed effects. Upper basin and lower Columbia River similar to No Action Alternative with the exception of adverse impacts at Libby (major) and Hungry Horse (moderate). In the lower Snake River, long-term benefits, but short-term adverse effects compared to No Action Alternative.	No. In upper Columbia basin there are major adverse effects to ESA-listed resident fish and critical habitat compared to No Action Alternative. In lower basin, minor adverse effects from higher TDG spill and exposure duration compared to the No Action Alternative.	Yes. It is expected to be similar to No Action Alternative in most regions. Localized minor beneficial effects in upper Columbia basin, minor adverse effects in Lake Roosevelt, as well as minor mixed effects in the Lower basins compared to No Action Alternative.
Improve Conditions for Lamprey Within the Project Area	No change	Yes	Yes	Yes	Yes	Yes
Maximize Operating Flexibility by Implementing Updated Adaptable Water Management Strategies	No change	Yes	Yes	Yes. There is no adaptable water management on the lower Snake River.	Yes	Yes
Meet Existing Contractual Water Supply Obligations and Provide for Authorized Additional Water Supply	Partially. Does not provide authorized additional water supply.	Yes	Partially. Does not provide authorized additional water supply.	Yes ^{2/}	Yes ^{2/}	Yes
Provide an Adequate, Efficient, Economical, And Reliable Power Supply That Supports the Integrated Columbia River Power System	No change	No. Due to upward rate pressure and nearly twice the risk to regional reliability relative to the No Action Alternative.	Yes. Increases hydropower production and allows for flexibility for wind and solar integration relative to the No Action Alternative.	No. Due to loss of hydropower generation on Lower Snake Projects, which adversely affects the adequacy, economics and reliability of the system, and leads to significant upward pressure on power rates relative to the No Action Alternative.	No. Due to loss of hydropower generation in spring and summer on the Lower Columbia and Lower Snake River Projects. There would be a one in three probability of blackouts in a given year. Adversely affects the adequacy, economics and reliability of the system, and leads to high upward pressure on power rates relative to the No Action Alternative.	Yes. Power reliability is met and upward rate pressure is expected to be minor relative to the No Action Alternative.
Minimize Greenhouse Gas Emissions from Power Production in The Northwest By Generating Carbon Free Power Through A Combination Of Hydropower And Integration Of Other Renewables	No change	No. Hydropower generation would decrease resulting in increased generation from existing gas and coal plants resulting in increased GHG.	Yes. Increases hydropower production thereby decreasing natural gas and coal power production and allows flexibility for integration of wind and solar.	No. Breaching the lower Snake River dams would require replacement of lost power generation and flexible capacity. Lost power generation could be replaced by gas or renewable sources. Loss of navigation would result in an increase in truck and/or train transport.	No. The forgone hydropower generation could be replaced by gas or large amounts of renewable sources combined with large amounts of storage capacity. Even if only renewable sources were used as replacements, greenhouse gas emissions would still increase because existing coal and gas fired generation could increase leading to elevated emissions.	No. Hydropower generation would decrease resulting in increased generation from existing gas and coal plants resulting in increased greenhouse gas emissions.

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Evaluation Criteria	No Action Alternative	MO1	MO2	MO3	MO4	Preferred Alternative
Part 3: Summary of Major Effects						
Environmental	No change	No major adverse effects to wetlands, floodplains, water quality, vegetation, wildlife, air quality and fish. There are localized moderate adverse effects to water quality in the lower Snake River and fish in the upper Columbia River basin, which would be mitigated to reduce the effects.	No major adverse effects to wetlands, floodplains, water quality, vegetation, wildlife, and air quality. Minor beneficial effects to major adverse effects for anadromous fish that vary by species, location, and models. Major adverse effects to upper Columbia River basin resident fish compared to No Action Alternative. Effects to fish would be mitigated to reduce effects.	Major short-term adverse effects to wetlands, floodplains, water quality, fish, wildlife and vegetation due to breaching of lower Snake River dams. Major long-term beneficial effects to wetlands, floodplains, fish, wildlife, and vegetation in the lower Snake River. For water quality, there would be warmer water temperatures in the summer (during the day) that may exceed water quality standards, but spring and fall water temperature improvements are anticipated. Major increase in Snake River fall Chinook spawning habitat. Mixed effects to upper basin and lower Columbia River fish similar to No Action Alternative with the exception of adverse impacts at Libby (major) and Hungry Horse (moderate), which will be mitigated. Long-term adverse effects from increased regional greenhouse gas emissions if lost power generation is replaced by gas or renewable sources.	Major adverse effects in the upper basin to wetlands, floodplains, vegetation, wildlife, and resident fish, which would be mitigated to reduce effects. Mixed major beneficial to moderate adverse effects vary by species, location, and models for anadromous fish, which would be mitigated to reduce effects. Long-term adverse effects from increased regional greenhouse gas emissions if lost power generation is replaced by gas or renewable sources.	No major adverse effects to wetlands, floodplains, water quality, vegetation, wildlife, and air quality. For waterfowl in the Columbia River estuary, there would be a moderate beneficial effect to reproductive success associated with improved abundance and condition of juvenile salmon and steelhead. For water quality, there would be moderate increases in TDG associated with juvenile fish passage spill up to 125% TDG. For anadromous salmon and steelhead in Regions C and D, effects may range from moderate adverse (if adult returns are reduced) to major beneficial (if adult returns increase). For resident fish, there would be moderate beneficial effects to the food web in Lake Koochanusa (increased macroinvertebrates) and minor to moderate adverse effects in Lake Roosevelt from potential dewatering of kokanee, burbot, and redband trout eggs.
Economic	No change	No major effects to economics.	Major beneficial impact to hydropower when McNary powerhouse surface passage structural measure is excluded. No other major effects to economics are expected.	Major long-term adverse effects to hydropower, irrigation, lower Snake River barge navigation and reservoir-based recreation in the lower Snake River. Impact to recreation facilities would be partially mitigated. Major long-term effect to community identify from loss of lower Snake River ports (e.g., Clarkston, Lewiston, Asotin). Potential for major beneficial effects to river-based recreation, and beneficial effects to recreational, tribal and commercial fishing.	Major adverse effects to hydropower generation and localized moderate adverse effects to irrigation operations in the lower Columbia River. Potential beneficial effects to recreational, tribal and commercial fishing. Under low water years major adverse effects to water based recreational access at Lake Pend Oreille. These impacts would be partially mitigated.	Major beneficial to moderate adverse effects to recreational, tribal and commercial fishing in Regions C and D dependent upon increase or decrease in adult returns of salmon and steelhead. No other major economic effects are expected.

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Evaluation Criteria	No Action Alternative	MO1	MO2	MO3	MO4	Preferred Alternative
Social	No change	<p>Ongoing major effects to cultural resources and tribal interests. Additional major effects to cultural resources at Hungry Horse, Lake Roosevelt and Dworshak reservoirs. There is the potential for major effects to the sacred site, Kettle Falls, if changes in reservoir elevations result in increased looting.</p> <p>Major effects to Inchelium-Gifford Ferry at Lake Roosevelt which would be mitigated. No major effects to Environmental Justice populations are anticipated.</p>	<p>Ongoing major effects to cultural resources and tribal interests. Additional major effects to cultural resources at Dworshak and Lake Roosevelt. There is the potential for major effects to the sacred site, Kettle Falls, if changes in reservoir elevations result in increased looting.</p> <p>Major adverse effects to important tribal resources, specifically resident and anadromous fish.</p> <p>Major effects to Inchelium-Gifford Ferry at Lake Roosevelt which would be mitigated. No major effects to Environmental Justice populations are anticipated.</p>	<p>Ongoing major effects to cultural resources and tribal interests. Potential for additional major adverse effects to cultural resources compared to No Action Alternative in the lower Snake River due to potential exposure of 14,000 acres currently inundated. The exposure of the TCPs would allow for some traditional uses that have not been possible since the dams were built. There is also the potential for additional major adverse effects to cultural resources at Hungry Horse Reservoir.</p> <p>Major effects to Inchelium-Gifford Ferry at Lake Roosevelt which would be mitigated. No major effects to Environmental Justice populations are anticipated.</p>	<p>Ongoing major effects to cultural resources and tribal interests. Additional major effects to cultural resources at Lake Roosevelt, John Day, and Hungry Horse. Additional moderate effects at the remaining Lower Columbia River projects due to additional drawdown. There is the potential for major effects to Kettle Falls (sacred sites) if changes in reservoir elevations cause increased looting. Changes in reservoir elevation at Albeni Falls may result in a decrease of access to Bear Paw Rock, which may result in less tribal visitation or access to the site.</p> <p>Major adverse effects to numerous tribal interests and resources in upper basin.</p> <p>Major effects to Inchelium-Gifford Ferry at Lake Roosevelt which would be mitigated. No major effects to Environmental Justice populations are anticipated.</p>	<p>Ongoing major effects to cultural resources and tribal interests. Additional minor to moderate effects to the built environment at Grand Coulee from potential increased erosion.</p> <p>Major beneficial effects to archaeological resources at Libby due to reduced frequency of high draft rate events.</p> <p>No major effects to Environmental Justice populations are anticipated.</p>

587 1/ The Washington Water Quality Standard for TDG is pending approval by EPA.

588 2/ The objective does not include irrigation and municipal and industrial that was impacted under MO3 and MO4 in Regions C and D as opposed to new or existing contractual water supply.

589

590 **7.5 DEVELOPMENT OF THE PREFERRED ALTERNATIVE**

591 Based on the information above, insights that resulted from the evaluation of the alternatives
592 in Chapters 3, 4, 5, and 6, and information presented in Sections 7.1 through 7.2, the co-lead
593 agencies developed the Preferred Alternative. The co-lead agencies worked together, with
594 input from cooperating agencies, to identify a suite of measures to form an alternative that
595 allowed for the agencies to continue to operate the system in accordance with congressionally
596 authorized purposes, while best meeting the objectives of the EIS in a balanced manner.
597 Following the evaluation of the No Action and MO alternatives, the co-lead agencies selected a
598 combination of measures for the Preferred Alternative based on how well the measures met
599 the Purpose and Need and study objectives, with consideration of environmental, economic,
600 and social effects. Development of the Preferred Alternative allowed the co-lead agencies to
601 refine several measures based on information learned during the modeling and evaluation
602 process of the alternatives detailed in Chapter 3. In addition, new information on juvenile fish
603 passage from the 2018 and 2019 operations for spring juvenile fish spill that benefit
604 downstream migration of juvenile anadromous fish became available after the alternatives
605 were developed. Using this information, the co-lead agencies modified the juvenile fish spill
606 operation for the Preferred Alternative using the analysis from the range of spill levels
607 evaluated in the MOs to attempt to provide a high potential benefit to salmon and steelhead
608 through increased spill while avoiding many of the adverse impacts to power generation and
609 reliability associated with MO4. The primary method to accomplish this was a flexible spill
610 operation that spills more for fish passage when power is less valuable and spills less when
611 power is more valuable. The Preferred Alternative also acknowledges the range of potential
612 outcomes predicted by the models used to estimate impacts to anadromous fish, including a
613 study to evaluate the potential benefits and unintended consequences of a flexible spill
614 operation.

615 All actions included in the Preferred Alternative are either: 1) carried forward from the No
616 Action Alternative; 2) original measures or refined measures that were evaluated in MO1 to
617 MO4; 3) added measures for lamprey passage (e.g., Closeable Floating Orifice Gates); or 4)
618 measures identified as part of the associated CRS ESA consultation processes. This led to a
619 Preferred Alternative that is a balanced approach that enables the co-lead agencies to meet the
620 multiple congressionally authorized purposes of the system and requirements for fish and
621 wildlife, including ESA-listed species. Following the initial development of the Preferred
622 Alternative, it was shared with NMFS, USFWS, tribes, and cooperating agencies to solicit
623 feedback.

624 **7.6 DESCRIPTION OF THE PREFERRED ALTERNATIVE**

625 The Preferred Alternative includes a description of measures that would be implemented, in
626 addition to components of the No Action Alternative, to operate the CRS to better meet the
627 Purpose and Need and objectives developed for the EIS. Operations, maintenance and
628 programs that were ongoing or planned as of 2016 are carried forward into the Preferred

629 Alternative unless described otherwise. Ongoing operations and maintenance measures are
630 described in more detail in Chapter 2.4.2.1.

631 As discussed in Chapter 2, the CRS is operated for a number of purposes: to reduce flood risk,
632 generate hydropower, provide water for irrigation and water supply, to provide navigation,
633 provide recreation, and to conserve fish and wildlife. These operations would continue unless
634 modified by the Preferred Alternative below or under emergency operations described in
635 Chapter 2. An operational emergency may be related to hydropower generation, transmission
636 loss or interruption, fish emergencies related to equipment failure or other interruption of fish
637 protection measures, and other unexpected circumstances such as fires, human health and
638 safety concerns, or threats to dam infrastructure.

639 Consistent with Chapter 2, there are also research studies that may require special operations
640 that differ from the routine operations otherwise described in the current Fish Passage Plan.
641 Variations in normal operations for research actions are coordinated with the Technical
642 Management Team (TMT). Additionally, the co-lead agencies conduct monitoring activities. For
643 example, under the Preferred Alternative, Bonneville is funding USFWS to conduct monitoring
644 and surveys of plant and waterbird communities, including aquatic invasive species, and public
645 outreach efforts during the implementation of the *Predator Disruption Operations* measure.
646 This effort would evaluate whether there are impacts to critical plant and waterbird
647 communities and habitat along the reservoir and Umatilla National Wildlife Refuge.

648 Moreover, the Corps, Reclamation and Bonneville will continue to implement a maintenance
649 program at each CRS project, consisting of routine inspection and maintenance of both power
650 and non-power assets. The co-lead agencies conduct annual routine maintenance at all
651 projects. Preventive and corrective maintenance coordinated and planned to occur at regular
652 intervals is referred to as scheduled, or routine, maintenance. This type of routine maintenance
653 would continue to be performed on all fish facilities, spillway components, navigation locks,
654 generating units, and supporting systems to ensure project safety and reliability and to comply
655 with North American Electric Reliability Corporation (NERC)/Western Electricity Coordinating
656 Council (WECC) regulatory requirements (16 U.S.C. 824o[c]). Unplanned maintenance would
657 also continue under the Preferred Alternative. It is unscheduled and may occur any time a
658 problem, unforeseen maintenance issue, or emergency requires a project feature (e.g., a
659 generating unit), be taken offline in order to resolve the problem.

660 Additionally, ongoing actions are being carried forward from the No Action Alternative in

661 Chapter 2, which includes measures committed to in the past to benefit ESA-listed fish species.
662 These include actions under Bonneville's Fish and Wildlife (F&W) Program, Corps' Columbia
663 River Fish Mitigation Program and Reclamation's Tributary Habitat Program.

664 The Preferred Alternative includes actions to benefit ESA-listed fish, and these actions also
665 benefit tribal interests and treaty resources. These actions include measures such as
666 management of invasive species, improvements to fish and wildlife habitat, fish hatchery
667 production, and management of avian and pinniped predators of ESA-listed salmonids. Most of

668 the structural measures and some of the operational measures are intended to improve
669 survival of anadromous salmon and steelhead, lamprey and resident fish. These fish are
670 important to tribes and the exercise of treaty-reserved rights, and traditional cultural practices
671 including fishing, hunting, and gathering. In some locations, the Corps and Reclamation also
672 operate the dams to support tribal interests, primarily to benefit fish and wildlife and tribal
673 fishing. Operations that support specific tribal interests are described in Chapter 2.4.2.1.

674 The rest of this section provides additional detail on the structural, operational, and mitigation
675 measures included in the Preferred Alternative. They have been grouped into the following
676 categories:

- 677 1) Structural and operational measures carried forward, modified, or added to the Preferred
678 Alternative from those described in the MOs in Chapter 2;
- 679 2) Mitigation measures to avoid, minimize, or offset adverse effects from the current suite of
680 measures being proposed; and
- 681 3) Other measures to comply with Section 7(a)(2) of the ESA.

682 **7.6.1 Measures Carried Forward, Modified, or Added from Alternatives in Chapter 2**

683 This section describes a complete list of structural and operational measures that are being
684 carried forward, modified, or added to the Preferred Alternative from those described as part
685 of the MO alternatives in Chapter 2. These measures are listed in Table 7-2.

686 **Table 7-2. List of Measures that were Carried Forward, Modified, or Added to the Preferred**
687 **Alternative from Alternatives in Chapter 2**

Description
Structural Measures
Hungry Horse Project Power Plant Modernization ^{1/}
Third Powerplant Overhaul Project
John W. Keys III Pump-Generating Plant Modernization Project
Grand Coulee G1 through G18 Plant Modernization Project
Lower Granite Trap Modifications
Lower Granite Juvenile Facility Bypass Improvements ^{1/}
Lower Granite Spillway Passive Integrated Transponder (PIT) Monitoring System ^{1/}
Little Goose Adjustable Spillway Weir Closure ^{1/}
Little Goose Adult Ladder Temperature Improvements ^{1/}
Little Goose Boat Barrier ^{1/}
Little Goose Trash Shear Boom Repair ^{1/}
Ice Harbor Turbines 1–3 Replacement and Generator Rewind ^{1/}
McNary Turbine Replacement ^{1/}
John Day Adult Passive Integrated Transponder Tag (PIT) Monitoring System ^{1/}
John Day Improved Fish Passage Turbines

Description
Bonneville Gatewell Orifice Modifications ^{1/}
Bonneville Ladder Serpentine Weir Modifications
Closeable Floating Orifice Gates for Lamprey
Bypass Screen Modifications for Lamprey
Lamprey Passage Ladder Modifications
Turbine Strainer Lamprey Exclusion
Fewer Fish Screens
Operational Measures
Sliding Scale at Libby and Hungry Horse
Modified Draft at Libby
Planned Draft Rate at Grand Coulee
Grand Coulee Maintenance Operations
Update System FRM Calculation at Grand Coulee
Lake Roosevelt Incremental Storage Release Project
Lake Roosevelt Additional Water Supply
Fall Operational Flexibility for Hydropower (Grand Coulee)
Slightly Deeper Draft for Hydropower (Dworshak)
Juvenile Fish Passage Spill Operations
Contingency Reserves within Juvenile Fish Passage Spill
Above 1% Turbine Operations
Increased Forebay Range Flexibility
Early Start Transport
Zero Generation Operations
Predator Disruption Operations
John Day Full Pool

688 1/ Carried forward from No Action Alternative.

689 **7.6.2 Preferred Alternative Structural Measures**

690 The following structural measures are included in the Preferred Alternative.

691 **7.6.2.1 Hungry Horse Project Power Plant Modernization**

692 This structural measure was carried forward from the No Action Alternative description in
 693 Chapter 2 with no changes. The power plant at Hungry Horse Project began an extensive
 694 modernization effort in Fiscal Year (FY) 2018 to bring the facilities to current industry standards.
 695 It will include the full overhaul or replacement of governors, exciters, fixed-wheel gates, and
 696 turbines; a generator rewind; overhaul of the selective withdrawal system; and recoating the
 697 penstocks. This power plant overhaul will occur over 1 year and will limit the powerplant
 698 availability to two units during the overhaul period. In addition, cranes that service the power

699 plant will be refurbished or replaced, and the power plant will be brought up to modern fire
700 protection standards. The full effort is expected to take 10 years to complete.

701 **7.6.2.2 Third Powerplant Overhaul Project**

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

705 **7.6.2.3 John W. Keys III Pump-Generating Plant Modernization Project**

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

708 **7.6.2.4 Grand Coulee G1 through G18 Modernization and Overhaul Project**

709 Reclamation is implementing this project to modernize and overhaul the power-generating
710 units G1 through G18 in the left and right powerhouses at Grand Coulee Dam, by refurbishing
711 or replacing key components. Reclamation would maintain current operations for FRM to
712 protect communities and generate hydropower while the project is being implemented. Under
713 the G1 through G18 Modernization and Overhaul Project, current hydrologic operations would
714 be maintained and, therefore, the project is not expected to have any impacts on water or
715 fisheries resources in the Columbia River or Lake Roosevelt.

716 **7.6.2.5 Lower Granite Trap Modifications**

717 This measure was included in MO1 and MO4, but was refined to reduce the scope to
718 improvements to the trap gate. The existing trap gate would be replaced with a gate operated
719 by a dedicated hoist and would reduce cost while retaining anticipated benefits to fish. The trap
720 would be designed and implemented to reduce delay and stress for adult salmonids and other
721 species such as Pacific lamprey. The new gate would be designed to more efficiently shed
722 debris and would include a gap in the bottom to allow upstream passage of lamprey. This
723 measure is intended to increase adult salmon and steelhead survival by reducing upstream
724 travel times.

725 **7.6.2.6 Lower Granite Project Juvenile Facility Bypass Improvements**

726 This structural measure was carried forward from the No Action Alternative in Chapter 2 with
727 no changes. This action modified the existing bypass system to construct an open channel with
728 increased orifice size, intended to move fish from the collection channel to the existing juvenile
729 fish collection facility. The work was intended to reduce the time fish spend in the system,
730 moving them more quickly and reducing stress and delays. The project included an enlarged
731 collection channel, flow reduction through the transport channel, improved water supply to the
732 location downstream of the collection channel, and a relocation of the primary outfall to reduce
733 predation. Construction was complete and the system became fully operational in FY 2019.

734 **7.6.2.7 Lower Granite Project Spillway Passive Integrated Transponder Monitoring System**

735 This structural measure was carried forward from the No Action Alternative description in
736 Chapter 2 with no changes. A passive integrated transponder (PIT)-tag monitoring system was
737 installed over spillbay 1, the location of the removable spillway weir. The system includes a set
738 of antennas mounted in the surface of the spillway and connected to an electrical transceiver
739 located on the tailrace deck. These antennas support collection of data so numbers of juvenile
740 fish migrating over the spillway can be compared with using the bypass system or other routes.
741 This system is scheduled to become functional in FY 2020.

742 **7.6.2.8 Little Goose Project Adjustable Spillway Weir Closure**

743 This structural measure was carried forward from the No Action Alternative description in
744 Chapter 2 with no changes. An adjustable spillway weir (ASW) was fabricated and installed in
745 spillbay 1 at Little Goose Dam. The project included a mechanical system to adjust the crest
746 elevation of the spillway to allow juvenile salmon and steelhead to pass the dam near the water
747 surface. This allows operators to adjust quickly to changing conditions, thus increasing the
748 likelihood of juvenile salmon and steelhead survival.

749 **7.6.2.9 Little Goose Project Adult Ladder Temperature Improvements**

750 This structural measure was carried forward from the No Action Alternative description in
751 Chapter 2 with no changes. This structural measure includes a 90-foot-deep chimney attached
752 to the face of the dam to pull cool water from lower reservoir elevations and release it into the
753 fish ladder. In the ladder, the cold water mixes with warmer surface water from the forebay to
754 lower water temperatures. The cold water is also sprayed onto the surface water in the forebay
755 to cool water at the ladder exit. This project is intended to keep ladder water temperatures
756 within an acceptable range, and prevent delays in fish passage during periods of high water and
757 air temperatures. Construction was completed in FY 2018.

758 **7.6.2.10 Little Goose Project Boat Barrier**

759 This structural measure was carried forward from the No Action Alternative description in
760 Chapter 2 with no changes. This structure is comprised of a set of anchors and lines holding a
761 string of booms and cables in the forebay of the Little Goose Project. It is a safety measure
762 intended to keep boats from approaching the spillway. The cables have bird spikes to keep
763 piscivorous birds off the structure in an attempt to reduce predation in the forebay.
764 Construction was completed in FY 2018.

765 **7.6.2.11 Little Goose Project Trash Shear Boom Repair**

766 This structural measure was carried forward from the No Action Alternative description in
767 Chapter 2 with no changes. This is a repair of an existing boom. The action included
768 replacement of longitudinal cable to reconnect 20 concrete floats. The floats are 40 feet long

769 and 8 inches wide. This boom is intended to direct debris away from the powerhouse to protect
770 powerhouse infrastructure.

771 ***7.6.2.12 Ice Harbor Project Turbines 1 to 3 Replacement and Generator Rewind***

772 This structural measure was carried forward from the No Action Alternative description in
773 Chapter 2 with no changes. The Ice Harbor turbine replacement and rewind will replace existing
774 turbine runner blades on units 1, 2, and 3, with state-of-the-art improved fish passage runners.
775 The project will also rewind the electrical components and replace the distributors. Collectively,
776 these changes will improve hydraulic conditions for fish and increase hydropower generating
777 efficiency. Units 1 and 3 will be replaced with adjustable blades for increased operating
778 flexibility to adjust to changing river conditions. Unit 2 will remain a fixed-blade unit. The
779 turbine replacement is scheduled to be completed in FY 2021, with some turbines being
780 installed sooner than FY 2021.

781 ***7.6.2.13 McNary Project Turbine Replacement***

782 This structural measure was carried forward from the No Action Alternative description in
783 Chapter 2 with no changes. This action includes full replacement of all 14 turbines at McNary
784 with new turbines. This includes replacement of runners, discharge rings, windings, wicket
785 gates, and potential draft tube modifications, pending final design. The replacement will
786 increase reliability, increase generating efficiency, increase hydraulic capacity, and improve
787 hydraulic conditions for fish. Construction began in 2018 and is expected to continue through
788 FY 2033.

789 ***7.6.2.14 Adult Passive Integrated Transponder Tag (PIT) Monitoring System at John Day
790 Project***

791 This structural measure was carried forward from the No Action Alternative description in
792 Chapter 2 with no changes. PIT antennas were installed in both the north and south adult fish
793 ladders during the 2016/2017 winter maintenance period. A PIT detection system at John Day
794 Project will allow biologists to track and monitor adult upstream migration and assist in
795 development of more accurate estimates of adult salmon survival through the CRS.

796 ***7.6.2.15 Improved Fish Passage Turbines at John Day Dam***

797 The co-lead agencies would install Improved Fish Passage (IFP) turbines at John Day Dam
798 starting in FY 2025 to improve hydraulic conditions for fish passing through the turbines. The
799 IFP turbines would be designed to improve hydropower turbine efficiency and hydraulic
800 conditions for fish, similar to the IFP turbines installed at Ice Harbor. Under current plans, the
801 existing turbines (up to 16) would be replaced two at a time over a period of approximately 8 to
802 12 years, beginning around the time turbine improvements at McNary and Ice Harbor have
803 been completed. Installation of the IFP turbines has the potential to improve fish passage
804 conditions, improve hydropower efficiency and capacity, minimize greenhouse gas emissions,
805 and indirectly improve water quality by reducing total dissolved gas (TDG).

806 **7.6.2.16 Bonneville Project Gatewell Orifice Modifications**

807 This structural measure was carried forward from the No Action Alternative description in
808 Chapter 2 with no changes. Biological testing in 2008, 2009, and 2013 showed elevated
809 mortality for juvenile salmon in the gatewells when the units are operating at the upper end of
810 the peak efficiency range (greater than 15 thousand cubic feet per second [kcfs]). This project is
811 designed to improve juvenile salmon survival in the gatewells at the Bonneville Project's second
812 powerhouse.

813 **7.6.2.17 Bonneville Ladder Serpentine Weir Modifications**

814 This measure was included in MO1 and MO3, but was refined to reduce the scope to limit
815 modifications to improvements to the trap gate. The Corps would modify the serpentine-style
816 flow control sections of Bonneville Dam's Washington Shore and Bradford Island fish ladders,
817 converting them to an Ice Harbor-style vertical slot with submerged orifice configurations. This
818 would improve passage conditions for adult lamprey and likely reduce stress and delay for adult
819 salmon, steelhead and bull trout. This action has the potential to increase adult salmon and
820 steelhead survival by reducing upstream passage time at the dam.

821 **7.6.2.18 Closeable Floating Orifice Gates for Lamprey**

822 This measure was developed for inclusion in the Preferred Alternative to meet the lamprey
823 objective to provide a benefit to Pacific lamprey passage at Bonneville Dam. It installs closeable
824 gates on Bonneville Powerhouse 2 floating orifice gates to reduce incidences of lamprey falling
825 out of the Washington Shore Fish Ladder. Closeable gates would allow seasonal closure during
826 the lamprey passage season. This measure is intended to increase adult lamprey upstream
827 passage success. This action was identified after the development of measures and has been
828 added to the Preferred Alternative to provide a benefit to lamprey passage at Bonneville Dam.

829 **7.6.2.19 Bypass Screen Modifications for Lamprey**

830 This measure was included in all MOs to provide a benefit to lamprey passage at Little Goose,
831 Lower Granite and McNary projects. It has been modified to only be implemented at Lower
832 Granite and Little Goose. Turbine intake bypass screens used to divert fish into the collection
833 channel of the juvenile bypass system would be replaced at Little Goose and Lower Granite
834 projects. The Corps would replace the existing extended length bar screens with screens
835 designed to reduce juvenile lamprey entanglement. The reason that it would not be
836 implemented at McNary is because it would conflict with another measure, *Fewer Fish Screens*
837 planned for this location. These upgrades would occur when the existing screens need
838 replacement. This measure has the potential to reduce lamprey mortality from impingement on
839 the fish screens.

840 **7.6.2.20 Lamprey Passage Ladder Modifications**

841 This measure is included in all MOs to provide a benefit to Pacific lamprey passage. Existing fish
842 ladders at the lower Snake River and lower Columbia River projects would be modified as
843 described:

- 844 • **Install ramps to salmon orifices at Bonneville Dam.** Install concrete or aluminum ramps in
845 the Bradford Island Fish Ladder to make salmon orifices elevated above fish ladder floors
846 more accessible to lamprey. Ramps would enable adult lamprey to more easily and directly
847 access the salmon passage openings by removing right angles at the approach.
- 848 • **Install diffuser grating plating at Bonneville (south and Cascade Island ladders), The Dalles**
849 **(north ladder), and Lower Monumental (north and south ladders).** Where feasible, install
850 steel plating over floor diffuser grating immediately adjacent to submerged weir orifices
851 within the existing fish ladders. Floor diffusers add water to the fish ladder to provide
852 attraction flows for fish, but the grating makes it difficult for lamprey to attach as they
853 attempt to pass through submerged weir orifices. Steel plating would provide an
854 attachment surface for lamprey to attach and rest as they swim upstream through the fish
855 ladder.
- 856 • **Install additional refuge boxes at Bonneville Dam.** At Washington Shore and Bradford
857 Island fish ladders, install metal refuge boxes or similar structures on the floors or walls of
858 fish ladders to provide a protected resting environment for lamprey migrating upstream.
- 859 • **Install a wetted wall in the fish ladder at Bonneville Dam.** At the Bonneville Dam
860 Washington Shore Fish Ladder, install a metal wall in the control section of the fishway
861 (similar to the structure already installed in the Bradford Island Fish Ladder). This would
862 provide an alternate upstream passage route for migrating adult lamprey and allow the
863 lamprey to escape the higher water velocities and turbulence in the adjacent control
864 section of the fish ladder.
- 865 • **Install entrance weir caps at McNary, Ice Harbor, Lower Monumental, Little Goose, and**
866 **Lower Granite.** Install rounded entrance caps at fish ladder entrance weirs to eliminate 90-
867 degree corners which hinder lamprey from entering fish ladders on the lower Snake and
868 McNary projects. Rounding the edges would provide lamprey a constant attachment
869 surface to overcome the high-water velocities encountered at fish ladder entrances. This
870 measure is intended to improve adult lamprey passage through the fish ladders.
- 871 • **Lamprey Passage Structures (LPS).** Ramp-like flume structures would be installed or
872 modified in fish ladders at Bonneville, The Dalles, and John Day dams to guide adult lamprey
873 out of fish ladders and into parallel systems for volitional passage or collection for upstream
874 transport or passage studies. The LPSs would use independent water sources (pumps or
875 gravity-flow systems) and may be placed in various locations within fish ladders, such as
876 collection channels, junction pools, or auxiliary water supply channels. New structures
877 would be installed at Bonneville Dam's Bradford Island and Washington Shore fish ladders,
878 The Dalles Dam's east fish ladder, or John Day Dam's south fish ladder. At John Day Dam,

879 the existing LPS on the north fish ladder may be extended from the tailrace deck to the
880 forebay. This measure is intended to increase adult lamprey passage at the dams.

881 **7.6.2.21 Turbine Strainer Lamprey Exclusion**

882 This measure was included in all MOs to provide a benefit to lamprey passage. Structures would
883 be installed to prevent juvenile lamprey, juvenile salmonids, and other fish from being
884 entrained into the intakes of turbine unit cooling water systems. Hood-like structures would be
885 installed over existing intake gratings and would allow sweeping flows to move fish past the
886 opening, reducing entrainment and related risk of fish injury or mortality. This measure may be
887 implemented at all lower Snake River and all lower Columbia River Projects. This measure has
888 the potential to reduce lamprey mortality.

889 **7.6.2.22 Fewer Fish Screens**

890 This measure was included in MO2 and MO3. This measure would potentially cease installation
891 of fish screens to increase the efficiency of new hydropower turbines at Ice Harbor, McNary,
892 and John Day dams once Improved Fish Passage turbines are installed. This measure is intended
893 to consider running the new IFP turbines unscreened if acceptable biologically. The co-lead
894 agencies would collaborate with NMFS and USFWS to develop a Turbine Intake Bypass Screen
895 Management and Future Strategy process to monitor success of the IFP turbines and determine
896 if and when it would best to remove fish screens at these projects.

897 **7.6.3 Preferred Alternative Operational Measures**

898 The following operational measures are included in the Preferred Alternative:

899 **7.6.3.1 Sliding Scale at Libby and Hungry Horse**

900 This operational measure was included in all MOs. To implement this measure, the Corps and
901 Reclamation would determine the summer draft from the Libby and Hungry Horse projects for
902 delivery of flow augmentation for downstream fish based on a local water supply forecast.
903 Additionally, this elevation objective would be incrementally adjusted over a range of water
904 supply conditions. These changes would allow water managers to balance local resident fish
905 priorities in the upper basin with downstream flow augmentation for the Columbia River
906 downstream of Chief Joseph Dam. This operation continues with the No Action Alternative
907 ramping rates and minimum downstream flow requirements.

908 **7.6.3.2 Modified Draft at Libby**

909 This operational measure was included in all four MOs, but was modified to remove the
910 December draft target elevation at Libby to those targets in the No Action Alternative in years
911 when the water supply forecast is expected to be greater than 6.9 million acre-feet (Maf). This
912 measure would modify operations at Libby to provide water managers more flexibility to
913 incorporate local conditions in the upper basin. The measure would change flow management
914 so that local flood durations and start of refill operations are tied to Kootenai Basin runoff. In

915 order to provide flexibility to respond to local conditions, years with an April-August water
916 supply of less than 6.9 Maf at Libby would be drafted lower than No Action after December.
917 Draft targets remain the same as No Action in December and for all months with an April-
918 August water supply forecast greater than 6.9 Maf at Libby. During refill (generally Apr/May-
919 July), this measure would modify the VarQ refill flow calculation so that it: (1) modifies the past
920 release calculation to occur in real time; (2) takes into account planned releases, such as the
921 sturgeon volume release, before it occurs, thereby eliminating “double-accounting;” (3)
922 changes the duration over which VarQ flows are determined so that local flood duration, along
923 with the start of refill, is tied to the Kootenai River Basin for forecasts less than 6.9 Maf; and (4)
924 adjusts the initial VarQ flows to be appropriate to the modified draft levels. This measure would
925 modify refill based on local conditions by setting the start of refill to May 1 for forecasts less
926 than 6.9 Maf and the earlier of May 1 or No Action Alternative methodology in all other years.
927 Implementing this action would improve water management flexibility to respond to local flood
928 risk management conditions in the upper basin. It would also provide greater flexibility to
929 provide suitable temperature and flow conditions to benefit resident fish. As this operation is
930 implemented adjustments to provide more space in the reservoir may be made with input from
931 interested parties if new information emerges about nutrient flushing and temperature impacts
932 that could not be captured with the current modeling tools.

933 **7.6.3.3 Planned Draft Rate at Grand Coulee**

934 This operational measure was included in all four MOs. The Storage Reservation Diagram for
935 Grand Coulee would be modified to include a planned draft rate of 0.8 feet per day; this would
936 not change the draft rate limit of 1.5 feet per day or the deepest flood risk management
937 elevation, typically on April 30. This measure changes the planned timing and rate of the draft
938 to satisfy the flood risk management requirements. Flood risk management space requirements
939 are determined by water supply forecasts and upstream storage reservoir capacity. The
940 reduced draft rate would reduce the risk of erosion along the shoreline and may reduce spill in
941 some years. This action will maintain the same level of flood risk and allow water managers to
942 better manage drafts for Grand Coulee under a wide range of hydrologic conditions.

943 **7.6.3.4 Grand Coulee Maintenance Operations**

944 This operational measure was included in all four MOs. This measure could expedite the
945 maintenance schedule for the power plants and spillways of the Grand Coulee project relative
946 to the No Action Alternative schedule. The maintenance on the power plants could reduce the
947 number of generating units available, requiring additional spill in some situations. The project
948 could keep 27 of the 40 regulating gates and/or 8 drum gates in service and take the others out
949 of service to perform spillway maintenance activities. This action could improve safety,
950 reliability, and the capacity of power plants and spillways at Grand Coulee Dam.

951 **7.6.3.5 Update System FRM Calculation at Grand Coulee**

952 This operational measure was included in all four MOs with slight variation. The Preferred
953 Alternative includes the MO3 version of this measure, which, under a range of water supply,

954 attempts to maintain the elevation of Grand Coulee above 1,222.7 feet for irrigation pump
955 efficiency (NGVD29). This measure modifies the procedure used to determine Grand Coulee
956 flood risk management drafts by changing the current upstream correction method calculation
957 to reflect the relationship between the geographic and hydrologic location of flood risk storage
958 and the project's ability to manage flooding within the basin. This measure is not intended to
959 increase or decrease the current level of CRS flood risk. This measure allows the Grand Coulee
960 project to reciprocally respond to unanticipated trapped storage in an upstream CRS reservoir.
961 Under certain conditions it could result in more draft for flood risk management at Grand
962 Coulee compared to the No Action Alternative.

963 **7.6.3.6 Lake Roosevelt Incremental Storage Release Project**

964 The Lake Roosevelt Incremental Storage Release Project is a component of the Columbia River
965 Water Management Program (CRWMP). It is intended to improve municipal and industrial
966 water supply, provide water to replace some groundwater use in the Odessa Subarea, enhance
967 stream flows in the Columbia River to benefit fish, and provide water to interruptible water
968 right holders in drought years. The Lake Roosevelt Incremental Storage Release Project does
969 not reduce flows during the salmon flow objective period (April through August). This project
970 provides for Lake Roosevelt to be drafted an additional 1.0 foot in non-drought years and up to
971 1.8 feet in drought years by the end of August. One-third of this water will go to instream flows.

972 **7.6.3.7 Lake Roosevelt Additional Water Supply**

973 This operational measure was included in MO1, MO3, and MO4 where an additional 1.15
974 million acre-feet could be pumped from Lake Roosevelt at Grand Coulee above what was
975 provided in the No Action. This measure was updated for the Preferred Alternative to pump up
976 to 45,000 acre-feet of water above the No Action due to the uncertainty over the timing and
977 extent of the development of new water supply projects for the full volume. Additionally, this
978 measure would change the timing of delivery of recently developed water supplies for the
979 Odessa Subarea of the Columbia Basin Project (164,000 acre-feet for irrigation and 15,000 acre-
980 feet for M&I of the current supplies) from September and October to when the water is
981 needed, on demand. The 45,000 acre-feet water supports near-term additional development of
982 authorized project acres. Water pumped from Lake Roosevelt would be delivered as the
983 demand arises during the irrigation season (March to October).

984 **7.6.3.8 Fall Operational Flexibility for Hydropower (Grand Coulee)**

985 This measure modifies the Lake Roosevelt minimum refill elevation of 1,283 feet from the end-
986 of-September to the end-of-October to allow more operational flexibility for power generation
987 while also meeting downstream flow objectives including Priest Rapids minimum flows and
988 lower Columbia River minimum flows for navigation. This measure may result in lower end of
989 September Lake Roosevelt elevations when compared to the No Action Alternative, particularly
990 in low water years. Short-term operations would continue to be coordinated with the tribes.

991 **7.6.3.9 Slightly Deeper Draft for Hydropower (Dworshak)**

992 This measure has been modified from the original measure in MO2. The Corps would define a
993 rule curve through further coordination and study with Bonneville to operate Dworshak. The
994 project would be operated to increase hydropower generation in winter and reduce spill in the
995 spring. The reservoir drafts would be calculated in-season to improve flood risk management
996 operations, reduce spring spill at Dworshak, and increase hydropower generation in the January
997 to March timeframe when market demand is higher. These modifications would result in a
998 reduction of non-fish passage spill in the spring, resulting in reduced TDG exposure to fish in the
999 Clearwater River below Dworshak Dam, and in particular, fish in hatcheries downstream of the
1000 dam. This measure would be implemented in a manner to limit the risk of the reservoir not
1001 refilling later in the year.

1002 **7.6.3.10 Juvenile Fish Passage Spill Operations**

1003 This measure was modified using the analysis from the range of spill levels evaluated in the
1004 MOs to attempt to provide a high potential benefit to salmon and steelhead through increased
1005 spill while avoiding many of the adverse impacts to power generation and reliability associated
1006 with MO4. Juvenile fish passage spill would be implemented to aid juvenile salmonid migration
1007 at the lower Snake River projects and the lower Columbia River projects. The initial spring
1008 component of juvenile fish passage spill is a flexible spill operation over a 24-hour period to
1009 take advantage of peak and off-peak load hours for hydropower, while also providing high
1010 levels of spill intended to test the CRSO EIS modeled estimates of the benefits to downstream
1011 juvenile passage⁴, while also ensuring operational feasibility for the Corps. The implementation
1012 of the juvenile fish passage spill operations is intended to decrease the number of juvenile fish
1013 that bypass the dams through non-spillway routes, improve fish travel through the forebays,
1014 gain scientific information on latent (delayed) mortality, and provide flexibility for hydropower
1015 generation.

1016 The juvenile spill operation would be adaptively implemented over time, but the initial
1017 operation is expected to include the following elements. Over the course of a 24-hour period,
1018 16 hours would be operated to spill up to the 125 percent TDG cap⁵ at most projects with the
1019 intention of benefiting juvenile outmigration. Some projects are limited below 125 percent for
1020 dam safety, countervailing impacts on juveniles or to balance adverse hydropower impacts (or a
1021 combination). For the remaining 8 hours, the projects would spill at a lower level (referred to as
1022 performance standard spill⁶ in the table below). Because performance standard spill levels have
1023 been implemented in the past, the 8 hours of reduced spill each day provide a degree of
1024 protection against unexpected or unintended consequences that may occur due to spilling up
1025 to the 125 percent TDG cap during juvenile fish passage spring operations such as adult

⁴ This measure also will allow the co-lead agencies to gather important scientific information on the relationship between the CRS and latent (delayed) mortality.

⁵ Spill up to 125% TDG is dependent upon ongoing state water quality processes.

⁶ "Performance standard" spill is a NMFS term and refers to spill levels intended to meet NMFS's performance standard testing, as described in the 2008 Biological Opinion and accompanying administrative record.

1026 migration delay, gas bubble trauma, or damage to infrastructure. These spill levels are slightly
 1027 variable, depending on the project, and may be higher or lower, depending on river conditions
 1028 and the opportunity to spill. Expected operations are described in Table 7-3, below. This
 1029 operation would allow increased hydropower generation during times of peak demand, while
 1030 still providing high spill for fish when it is expected to be most important. The co-lead agencies
 1031 would implement these operations in the spring, April 3 to June 20, at the lower Snake River
 1032 projects, and April 10 to June 15 at the lower Columbia River projects. Summer spill would be
 1033 implemented as described in Table 7-4. Spill operations would be managed adaptively, through
 1034 the established Regional Forum processes,⁴ to address unexpected challenges, such as potential
 1035 delays to adult migration, effects to navigation, and other challenges or opportunities that may
 1036 require either a temporary or permanent change.

1037 **Table 7-3. Estimated Juvenile Spring Fish Passage Spill and Performance Standard Spill**
 1038 **Operations by Columbia River System Project**

Location	Juvenile Fish Spill Cap (16 hours)	Performance Standard Spill (8 hours)
Lower Granite (125 flex)	125% TDG	20 kcfs
Little Goose (125 flex)	125% TDG	30%
Lower Monumental (125 flex)	125% TDG	30 kcfs
Ice Harbor (125 flex)	125% TDG	30%
McNary (125 flex)	125% TDG	48%
John Day (120 flex)	120% TDG	32%
The Dalles (Performance Standard)	40%	40%
Bonneville (125 flex with 150 kcfs spill constraint)	125% TDG	100 kcfs

1039 The details of the *Juvenile Fish Passage Spill* operation have been refined and coordinated with
 1040 regional fish managers. Several site-specific conditions apply to the juvenile fish passage spill
 1041 operations. These conditions were developed to address site conditions at specific locations, as
 1042 described:

- 1043 • Spill may be temporarily reduced at any project if necessary to ensure navigation safety or
 1044 transmission reliability.
- 1045 • Spring spill operations would be initiated April 3 at lower Snake River projects and April 10
 1046 at lower Columbia River projects and transition to summer spill operations on June 20 at
 1047 lower Snake River projects and on June 15 at lower Columbia River projects.
- 1048 • The 8 hours of performance standard spill may occur with some flexibility (with the
 1049 exception of Little Goose and Lower Granite operations as specifically described below).
 1050 Other than at The Dalles Dam, performance standard spill would occur in either a single 8
 1051 hour block or in up to two separate blocks per calendar day. No more than 5 hours of
 1052 performance standard spill may occur between sunset and sunrise, as defined in the annual
 1053 Fish Passage Plan (FPP). Performance standard spill shall not be implemented between 10
 1054 pm and 3 am.

- 1055 • Little Goose Exception One: As soon as practicable (and, in any event, no more than 24
1056 hours) after a cumulative total of 25 adult spring Chinook salmon (not including jacks) pass
1057 Lower Monumental Dam, operate Little Goose spill at 30 percent spill for 8 consecutive
1058 morning hours (April 3 to 15 start at 5 am; April 16 to June 20 start at 4 am).
- 1059 • Little Goose Exception Two: During periods of involuntary spill above specified fish passage
1060 spill levels (due to lack of market availability or hydraulic capacity at the dam), the Corps
1061 would spill at 30 percent for 8 hours/day (daylight hours as defined in the Fish Passage Plan)
1062 and store additional inflows that exceed hydraulic capacity in the forebay above minimum
1063 operating pool (MOP) if necessary. When it is necessary to pond water to achieve the lower
1064 spill levels due to high inflows, water stored above MOP should be drafted out over the
1065 remaining hours by increasing spill to pass inflow from 1200 to 1600 hours, then increasing
1066 spill as necessary from 1600 to 0400 to draft the pool back to MOP. If it is forecasted that
1067 the drafting spill would generate TDG levels in the tailrace in excess of 130 percent, use all
1068 16 hours to return the pool to MOP.
- 1069 Lower Granite Exception One: If adult passage delays are observed at Lower Granite during
1070 operations to increase spill up to 125 percent TDG, the Corps would follow the Adaptive
1071 Implementation Framework (Appendix R) and may implement performance standard spill at
1072 Lower Granite Dam for at least 4 hours in the morning (beginning near dawn).
- 1073 • Voluntary Spill at Bonneville Dam is capped at 150 kcfs due to structural integrity risks from
1074 erosion.
- 1075 • Voluntary Spill at The Dalles Dam would be contained between the walls (Bays 1-8) unless
1076 river flows are over 350 kcfs, in which case spill outside the walls is permitted. TDG levels in
1077 The Dalles tailrace may fluctuate up to 125 percent TDG prior to reducing spill at upstream
1078 projects, subject to the 40 percent spill cap.
- 1079 • Attempts should be made to minimize in-season changes to the proposed operations.
1080 However, if serious deleterious effects to fish or infrastructure as a result of these spill
1081 operations are observed, existing adaptive management processes may be employed to
1082 help address such issues.
- 1083 Summer spill operations are described in Table 7-4, below. Cessation of juvenile transportation
1084 would occur June 21 through July 15 with allowance for adaptive management adjustments
1085 through the TMT.

1086 **Table 7-4. Typical Summer Juvenile Fish Passage Spill Operations by Columbia River System**
1087 **Project**

Location	Initial Summer Spill Operation: Volume/Percent of Total Flow routed to Spillway (June 21/16 to August 14)	Late Summer Transition Spill Operation: Volume/Percent of Total Flow Routed to Spillway (August 15 to August 31)
Lower Granite	18 kcfs	RSW or 7 kcfs
Little Goose	30%	ASW or 7 kcfs
Lower Monumental	17 kcfs	RSW or 7 kcfs
Ice Harbor	30%	RSW or 8.5 kcfs
McNary	57%	20 kcfs
John Day	35%	20 kcfs
The Dalles	40%	30%
Bonneville	95 kcfs	55 kcfs – includes 5 kcfs corner collector

1088 Note: RSW = removable spillway weir.

1089 **7.6.3.11 Contingency Reserves Within Juvenile Fish Passage Spill**

1090 This measure was included in all four MOs. This measure would allow operations to change fish
1091 spill for short durations during fish passage spill season at all lower Columbia and Snake River
1092 projects. This measure would provide operating flexibility to allow Bonneville to carry required
1093 reserves on the turbines to ensure grid reliability. The measure would be implemented to meet
1094 energy demands that are caused by unexpected events such as transmission interruption or the
1095 failure of a generator. These events are rare and, when they occur, the co-lead agencies may be
1096 able to cover the contingencies without temporarily reducing spill. The expected impact on spill
1097 reductions is typically once per month for less than an hour. This measure would increase the
1098 available capacity of hydropower generation and reduce the overall cost to consumers of
1099 implementing the Preferred Alternative.

1100 **7.6.3.12 Above 1% Turbine Operations**

1101 This measure was included in MO3 and MO4. Turbines may be operated above 1 percent peak
1102 efficiency for hydropower generation flexibility, with an increased likelihood of this operation
1103 during high flow periods. The operation is expected to occur primarily when there is insufficient
1104 turbine capacity to generate with the available water after providing fish passage spill. This
1105 occurs most frequently in high flow periods, a time when operating above 1 percent would also
1106 help manage for high TDG by reducing spill. This operation may also occur to maintain power
1107 system reliability if contingency reserves are deployed or for limited durations during periods of
1108 high power demand. This operation is expected to occur infrequently as the co-lead agencies
1109 strive to operate turbine units in the most efficient manner possible (i.e., within the 1 percent
1110 efficiency band) because it is typically the best operation for power. However, having this
1111 operation available for power use allows Bonneville to carry contingency reserves in the upper
1112 generation band with a benefit during all hours. Bonneville estimates that it would actually
1113 operate the turbines above 1 percent roughly once per month for deployment of contingency
1114 reserves, averaging about 35 minutes. Operating above 1 percent when there is insufficient

1115 turbine capacity would primarily occur in high-flow periods, which are 20 percent of years at
1116 McNary and 5 to 10 percent of the years at the other projects. There may be other instances
1117 (e.g., unexpected outages) where operating above 1 percent occurs. Recent studies showed
1118 that turbine operations above 1 percent can provide similar turbine survival for juveniles, for
1119 example, at Bonneville Powerhouse 1 (Weiland et al. 2015).

1120 **7.6.3.13 Increased Forebay Range Flexibility**

1121 This measure was included in MO1. As part of this operation, the Corps would implement
1122 operating elevation range restrictions consistent with actual 2019 operations. This operation
1123 was described in the *2019-2021 Spill Operation Agreement* at the lower Snake River projects
1124 and John Day to provide operating flexibility during the fish passage season (April 3 to August
1125 31). The lower Snake River projects would operate within a 1.5-foot MOP range, and John Day
1126 would operate within a 2-foot minimum irrigation pool (MIP) range (262.5 to 264.5 feet),
1127 except from April 10 to June 1 (or as late as June 15) when the John Day forebay operating
1128 range would remain between elevations 264.5 and 266.5 feet for *Predator Disruption*
1129 *Operations*. The operating range restrictions would end when spill is reduced (as described for
1130 summer spill in the *Juvenile Fish Passage Spill* measure) or ends. Safety related restrictions
1131 would continue, including but not limited to maintaining ramp rates to minimize shoreline
1132 erosion and maintain power grid reliability. This measure is intended to increase flexibility for
1133 water management, shape hydropower production to meet energy demand, and maintain
1134 power grid reliability. At John Day, the reservoir would be operated at or above MIP (262.5
1135 feet) throughout the irrigation season (March 15 through November 15), except as needed for
1136 flood risk management.

1137 **7.6.3.14 Early Start Transport**

1138 This measure was modified from the version of the measure in MO1. The transport of juvenile
1139 salmon collected at Lower Granite, Little Goose, and Lower Monumental projects could begin
1140 as early as April 15, approximately 2 weeks earlier than current fish transport operations
1141 described in the No Action Alternative, if warranted based on transportation benefits or to
1142 facilitate transport research. Transport operations would end September 30 at Lower
1143 Monumental and October 31 at Lower Granite and Little Goose. Collected juvenile fish would
1144 be transported to a location below Bonneville Dam via barge or truck on a daily or every-other-
1145 day schedule, depending on the numbers of fish collected at the collector projects. This
1146 measure does not preclude the co-lead agencies from ceasing juvenile transportation June 21
1147 through August 14 with allowances for adaptive management adjustments through the TMT as
1148 was contemplated in the *2019-2021 Spill Operation Agreement*. This action could increase the
1149 number of juvenile fish transported to the estuary.

1150 **7.6.3.15 Zero Generation Operations**

1151 This measure was modified from MO2. This action would expand the ability of the Corps to
1152 temporarily stop flows through the turbines on the lower Snake River projects. These
1153 operations would be undertaken when there is little demand for hydropower, unless limited by

1154 grid stability requirements. This measure would allow operators to save water in low demand
1155 periods to use for hydropower generation during high demand periods. Currently, these
1156 projects are allowed to operate at Zero Generation from early or mid-December through
1157 February 28 (based on an implementation trigger). The updated operation would begin as early
1158 as October 15 and could continue through February 28, when power markets warrant and
1159 when river conditions make it feasible. These operations would be implemented at night only
1160 from October 15 to November 30 and would cease 2 hours before dawn to reestablished flows
1161 for adult salmon migration upstream during the day. Between December 1 and February 28 this
1162 operation could also be implemented for up to 3 hours daily during the daylight hours. These
1163 dates were selected to minimize impacts to anadromous salmon and steelhead.

1164 **7.6.3.16 Predator Disruption Operations**

1165 This measure would allow the Corps to manipulate the John Day reservoir elevation to decrease
1166 avian predation on ESA-listed juvenile salmon and steelhead in the lower Columbia River. The
1167 John Day reservoir normal operating range is up to 266.5 feet (although it is authorized to
1168 operate up to 268 feet). The Corps would operate John Day within a 2-foot MIP range of 262.5
1169 to 264.5 feet, except from April 10 to as late as June 15, when the John Day forebay would
1170 operate from 264.5 to 266.5 feet, except as needed for flood risk management. These
1171 operations would be initiated prior to the start of nesting by Caspian terns, to avoid take.
1172 Unless adaptively managed due to changing run timing, the co-lead agencies intend to return to
1173 reservoir elevations of 262.5 to 264.5 on June 1, which generally captures 95 percent of the
1174 annual juvenile steelhead migration. The results of this action would be monitored and
1175 coordinated with USFWS and NMFS.

1176 **7.6.3.17 John Day Full Pool**

1177 This measure would remove current restrictions on seasonal pool elevations at John Day
1178 project in the winter, allowing more operating flexibility for hourly and daily shaping of
1179 hydropower generation. The measure would allow for operation of the reservoir across the full
1180 range possible, between 262.0 to 266.5 feet elevation outside of fish passage season, except as
1181 needed for flood risk management. Also, there would be a minimum elevation of 262.5 feet
1182 during the irrigation season.

1183 **7.6.4 Mitigation Measures**

1184 In some instances, the measures carried forward, modified, or added from alternatives in
1185 Chapter 2 resulted in undesirable effects. Mitigation measures were incorporated into the
1186 Preferred Alternative to avoid, reduce, or minimize these effects. These include operational,
1187 land management and mitigation actions from ongoing programs, measures developed as part
1188 of the EIS process, and measures developed as part of the CRS ESA consultations.

1189 **7.6.4.1 Ongoing Programs**

1190 **MANAGEMENT OF LANDS FOR FISH AND WILDLIFE**

1191 The Corps is authorized by Congress to manage Corps-owned lands across the Columbia Basin
1192 for fish and wildlife purposes. These lands vary by vegetative cover type and the species
1193 supported, from wetlands that support ducks and aquatic invertebrates to uplands that support
1194 deer and game birds such as quail. Corps management actions include invasive species
1195 management, installation of facilities such as gallinaceous guzzlers as water sources for upland
1196 birds, or planting of native species to provide food and cover for birds, reptiles, and mammals
1197 on Corps-owned lands, as examples.

1198 **FISH AND WILDLIFE ACTIONS**

1199 In addition to routine operations and maintenance of the CRS, the co-lead agencies implement
1200 a number of actions and programs, intended to benefit ESA-listed species in the Columbia River
1201 Basin. These actions range from items like dry year operations to chum salmon spawning flows,
1202 which are adaptively managed by the TMT. These actions are listed in Table 7-5. These actions
1203 are included in greater detail in the Biological Assessment and are expected to be contained in
1204 the Biological Opinions. To make the most of available funds, investments in fish and wildlife
1205 protection, mitigation and enhancements will be prioritized based on biological and cost-
1206 effectiveness and their connection to mitigating for impacts of the CRS.

1207 **BONNEVILLE'S FISH AND WILDLIFE PROGRAM AND LOWER SNAKE RIVER COMPENSATION**
1208 **PLAN**

1209 Bonneville's Fish and Wildlife (F&W) Program funds hundreds of projects each year to mitigate
1210 the impacts of the development and operation of the Federal hydropower system on fish and
1211 wildlife. Bonneville began this program to fulfill mandates established by Congress in the Pacific
1212 Northwest Electric Power Planning and Conservation Act of 1980 (Northwest Power Act), 16
1213 USC § 839b(h)(10)(A), to protect, mitigate, and enhance fish and wildlife affected by the
1214 development and operation of the FCRPS. Each year Bonneville funds projects with many local,
1215 state, tribal, and Federal entities to fulfill its Northwest Power Act fish and wildlife
1216 responsibilities and to implement offsite mitigation actions listed in various Biological Opinions
1217 for ESA-listed species. Offsite protection and mitigation actions typically address impacts to fish
1218 and wildlife not caused directly by the CRS, but they are actions that can improve overall
1219 conditions for fish to help address uncertainty related to any residual adverse effects of the
1220 CRS. For example, F&W Program funding improves habitat in the mainstem as well as
1221 tributaries and the estuary, builds hatcheries and boosts hatchery fish production, evaluates
1222 the success of these efforts, and improves scientific knowledge through research. This work is
1223 implemented through annual contracts, many of which are associated with multi-year
1224 agreements like the Columbia River Basin Fish Accords, the Accord extensions, or wildlife
1225 settlements.

1226 In addition to the hatchery operations that are funded through the F&W Program, Bonneville
1227 directly funds the USFWS' annual operations and maintenance of the Lower Snake River
1228 Compensation Plan (LSRCP). Congress authorized the LSRCP as part of the Water Resources
1229 Development Act of 1976 (90 Stat. 2917) to offset fish and wildlife losses caused by
1230 construction and operation of the four lower Snake River dams. A major component of the
1231 authorized plan was the design and construction of fish hatcheries and satellite facilities. The
1232 LSRCP is administered through the USFWS. The LSRCP hatcheries and satellite facilities produce
1233 and release more than 19 million salmon, steelhead and rainbow trout each year as part of the
1234 program's mitigation responsibility.

1235 **COLUMBIA RIVER FISH MITIGATION PROGRAM**

1236 The Columbia River Fish Mitigation Program is the Corps' construction account for studying,
1237 designing, and constructing new anadromous fish, including lamprey, passage improvements at
1238 CRS dams. Nearly all fish passage improvements required under past Biological Opinions have
1239 been constructed, and few new anadromous fish improvements requiring construction have
1240 been identified. Therefore, it is assumed that for CRS dams, requirements for new construction
1241 will be completed within the next 10 years.

1242 **COLUMBIA RIVER TRIBUTARY HABITAT PROGRAM**

1243 Reclamation has a Columbia-Snake salmon program to help meet its ESA obligations for its two
1244 projects, Grand Coulee and Hungry Horse. The program funds, designs, and implements
1245 tributary habitat improvements for anadromous fish, including lamprey, in specified Columbia
1246 River sub-basins. This program also provides funds avian predation management.

1247 **Table 7-5. Measures Included in the Preferred Alternative to Benefit Endangered Species Act-listed Fish that are Being Carried**
1248 **Forward from Previous Commitments by the Co-Lead Agencies**

	Measure	Description
Habitat Measures	Tributary Habitat Improvements for both Chinook salmon and steelhead	Implementation of specified construction projects, research, monitoring and evaluation (RM&E) actions, and species status and trend data collection on habitat and survival improvement.
	Kootenai White Sturgeon Habitat Restoration	Implementation of habitat projects as included in the CRS Biological Assessment (BA).
	Estuary Habitat Implementation	Implementation of specified construction projects, RM&E actions, and species status and trend data collection on habitat and survival improvement.
	Kootenai River White Sturgeon Nutrient Enhancement	Continued Bonneville 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)	Operate storage projects to deliver additional flow in spring and summer to augment flows for anadromous fish migration. These operations would continue to be communicated through an Annual Water Management Plan and Fish Operations Plan.
	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, as described in the 2006 USFWS Biological Opinion and 2008 update, consistent with the Flow Plan Implementation Protocol; Real-Time Management.
	Kootenai River Operations for Bull Trout	Libby Dam minimum flow to aid bull trout as included in the CRS BA.
	Hungry Horse Bull Trout Operations	Hungry Horse operations for minimum flows, ramping rate restrictions, temperature and TDG management, reservoir elevation management, and avoiding double peak flows in the Flathead River to aid bull trout as included in the CRS BA.
	In-Season Water Management	Communication and potential adjustments to in-season water management will be documented in 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 per CRS BA definition.
	Water Quality Plan for TDG and Water Temperature	Maintain Water Quality Plan for Total Dissolved Gas and Water Temperature in the mainstem Columbia and Snake Rivers to continue to operate in a way to reduce system TDG and temperature.
	Chum Spawning Flow	Coordination of operations via the Technical Management Team (TMT); Real-Time Management.

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	Measure	Description
	Develop Annual Fish Passage Plan	The Fish Passage Plan (FPP) is developed annually by the Corps in coordination with Bonneville and regional Federal, state, and tribal fish agencies. The FPP describes year-round operation and maintenance activities at Corps dams on the Columbia and Snake rivers. Detailed criteria and guidelines for Lower Snake River Project operations are included in annual Water Management Plans (WMP) and the FPPs.
Hatcheries	FCRPS Mitigation Hatcheries – Programmatic	Continued 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 due to 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.
Predation	Northern Pikeminnow Management Program (NPMP)	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 ESI and prevent birds from establishing satellite colonies outside of 1.0 acre colony site.
	Double-Crested Cormorant Management	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.

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Measure	Description
Hatchery and Habitat Program	<p>Lower Snake River Fish & Wildlife Compensation Plan</p> <p>Congress authorized the Lower Snake River Compensation Plan (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 25 LSRCP hatcheries and satellite facilities are operated by Idaho Fish and Game (IDFG), Washington Department of Fish and Wildlife (WDFW), Oregon Department of Fish and Wildlife (ODFW), USFWS, the Nez Perce Tribe (NPT), Confederated Tribes of the Umatilla River (CTUIR), and Shoshone-Bannock Tribes (SBT). The LSRCP hatcheries and satellite facilities produce and release more than 19 million salmon, steelhead and rainbow trout as part of the program's mitigation responsibility. Bonneville directly funds USFWS for the annual operation and maintenance of these LSRCP facilities. 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.</p>

1249

1250 **7.6.4.2 Additional Mitigation Developed As Part of the Columbia River System Operations**
1251 **Environmental Impact Statement**

1252 **PLANT COTTONWOOD TREES (UP TO 100 ACRES) NEAR BONNERS FERRY**

1253 The flow regime at Libby makes natural establishment of riparian vegetation downstream of
1254 the dam challenging. Higher winter flows make it difficult to sustain young stands of
1255 cottonwoods to maturity. The co-lead agencies would plant up to 100 acres of riparian forest
1256 along the Braided and Meander reaches of the Kootenai River near Bonners Ferry, using 1-2
1257 gallon cottonwood trees, with the expectation that the larger size trees would be better suited
1258 to withstand the higher winter flows. This would improve habitat and floodplain connectivity to
1259 benefit ESA-listed Kootenai River White Sturgeon, and complement other actions already being
1260 taken in the region to benefit their habitat. To the extent possible, this work will be completed
1261 through ongoing projects under Bonneville's F&W Program, such as the Kootenai Tribe of
1262 Idaho's Kootenai River White Sturgeon Habitat Restoration Program.

1263 **PLANT NATIVE WETLAND AND RIPARIAN VEGETATION (UP TO 100 ACRES) ON THE KOOTENAI**
1264 **RIVER DOWNSTREAM OF LIBBY**

1265 The co-lead agencies would plant up to 100 acres of native forested and scrub-shrub wetland
1266 vegetation at a lower river elevation in Region A. This would offset effects to existing wetlands
1267 and riparian forests downstream of Libby, which would be caused by the *Modified Draft at*
1268 *Libby*, and result in lower water levels on the Kootenai River.

1269 **TEMPORARY EXTENSION OF PERFORMANCE STANDARD SPILL OPERATIONS**

1270 It is expected that higher spill levels and the resultant TDG associated with the *Juvenile Fish*
1271 *Passage Spill* measure could result in delays to adult passage. Eddies created by a high spill
1272 operation may confound upstream passage by salmonids. If a delay in adult salmon and
1273 steelhead upstream passage is observed, operations would revert to performance standard spill
1274 until the adult fish pass the dam.

1275 **UPDATE AND IMPLEMENT INVASIVE SPECIES MANAGEMENT PLANS**

1276 Deeper drafts at Libby would result in lower lake elevations in spring, exposing previously
1277 submerged lands during the growing season and potentially allowing establishment of invasive
1278 weeds. The Corps would update and implement an invasive species management plan to
1279 combat the establishment and proliferation of invasive species, as required by Executive Order
1280 13751.

1281 **SPAWNING HABITAT AUGMENTATION AT LAKE ROOSEVELT**

1282 Increased flexibility of refilling Lake Roosevelt that may occur through the month of October,
1283 depending on the annual water conditions, may impact the spawning success of kokanee,
1284 burbot and redband rainbow trout. In 2019, Bonneville funded year one of a 3-year study to

1285 determine if modifications in Lake Roosevelt refill would impact resident fish access to
1286 spawning habitat. If the results indicate that resident fish spawning habitat is impacted by the
1287 operation, the co-lead agencies would supplement spawning habitat at locations along
1288 reservoir and tributaries (up to 100 acres).

1289 **EXTENSION OF THE BOAT RAMP FOR THE INCHELIUM-GIFFORD FERRY IN LAKE ROOSEVELT**

1290 Earlier and longer drafts at Grand Coulee would affect water levels, making the Inche-
1291 lium-Gifford Ferry on Lake Roosevelt unavailable approximately 4 days per year more than under the
1292 No Action Alternative. To mitigate this impact, the co-lead agencies would extend the ramp at
1293 the Gifford-Inche-
1294 lium Ferry on Lake Roosevelt so that it would be available at lower water
elevations.

1295 **MONITORING AT LOWER GRANITE, LOWER MONUMENTAL, AND MCNARY TO EVALUATE**
1296 **EFFECTS OF SHOALING FROM INCREASED SPILL, AND IF WARRANTED, INSTALL COFFER CELLS**
1297 **TO DISSIPATE ENERGY**

1298 It is expected that higher spill and variable timing of the spill over the course of a day could
1299 result in changes to the tailraces at Lower Granite, Lower Monumental and McNary projects.
1300 The Corps would monitor the tailrace at each project to track changes that could affect safe
1301 navigation or conditions for ESA-listed fish. If changes to the tailrace warrant action, coffer cells
1302 to dissipate energy would be constructed.

1303 **INCREASED DREDGING AT MCNARY, ICE HARBOR, LOWER MONUMENTAL, AND LOWER**
1304 **GRANITE PROJECTS**

1305 In Regions C and D, the increased spill operations and lower tail water would increase shoaling
1306 in the navigation channel due to increased spill operations in the lower Snake and Columbia
1307 rivers, adversely effecting navigation. In order to maintain the navigation channel and reduce
1308 impacts to negligible, effects would be mitigated by increasing the frequency and total volume
1309 of dredging at McNary, Ice Harbor, Lower Monumental, and Lower Granite at a 4- to 7-year
1310 interval. As discussed above, shoaling would also be monitored to determine if additional
1311 installation of coffer cells at Lower Monumental, Little Goose, and McNary could reduce
1312 dredging needs and further maintain the channel. Coffers would dissipate energy during
1313 high spill operations, which would support movement of sediment in the navigation channel,
1314 thereby maintaining navigational capacity and river transportation. This would increase overall
1315 maintenance costs for the projects, but would reduce the adverse effects to negligible.

1316 **FCRPS CULTURAL RESOURCE PROGRAM AND SYSTEM-WIDE PROGRAMMATIC AGREEMENT**

1317 For new effects to archaeological resources, traditional cultural properties, and the built
1318 environment at storage projects caused by implementation of the Preferred Alternative relative
1319 to the No Action Alternative, the co-lead agencies would use the existing FCRPS Cultural
1320 Resources Program and the System-Wide Programmatic Agreement to implement mitigation
1321 actions, as warranted and appropriate.

1322 **7.6.4.3 Preliminary Measures Agreed to During Endangered Species Act Consultation**

1323 This section describes preliminary measures agreed to by the co-lead agencies during informal
1324 ESA consultation with NMFS and USFWS on the Preferred Alternative. Due to the fact that the
1325 consultation is ongoing, the measures in this list may be modified or expanded prior to the Final
1326 EIS. A list of the preliminary measures is included in Table 7-6 and more detailed descriptions
1327 follow.

1328 **Table 7-6. Preliminary List of Measures Agreed to by the Co-Lead Agencies during Endangered**
1329 **Species Act Consultation on the Preferred Alternative**

Measure
Bull Trout Access to Perched Tributaries in the Kootenai River
Study Off-season Surface Spill for Downstream Passage of Adult Steelhead & Bull Trout
Maintenance Improvements to Little Goose Dam Jetty & Retaining Wall
Enhanced Debris Management at Lower Snake River dams & McNary
Investigate Shad Deterrence at Lower Granite Dam
Reduce Mortality Associated with Dworshak Dam Turbine Maintenance & Testing
Adult Fish Ladder Temperature Differentials
Adjust Refill at Grand Coulee to Offset Reclamation Water Withdrawal Request
Adult Separator at the Lower Granite Dam Juvenile Bypass System (JBS)

1330 **BULL TROUT ACCESS TO PERCHED TRIBUTARIES IN KOOTENAI RIVER**

1331 Based on recent conversations with USFWS, the co-lead agencies are evaluating whether delta
1332 formations at tributaries of the Kootenai River may be causing upstream fish passage barriers
1333 to bull trout seeking spawning grounds during late spring and summer months. In 2021, the co-
1334 lead agencies would contribute funding for an initial assessment of blocked passage to bull
1335 trout key spawning tributaries identified by USFWS. Upon completion of the initial assessment,
1336 tributaries identified as having blocked passage would be prioritized based on biological
1337 effectiveness provided by passage of adult bull trout and feasibility of restoration actions that
1338 are unlikely to result in long-term operations and maintenance needs. The co-lead agencies
1339 would work with USFWS and cooperating agencies to complete the assessment and initiate two
1340 restoration or improvement projects benefitting upstream passage opportunities over the
1341 period of 2021–2026. Any additional improvement opportunities to benefit bull trout passage
1342 in Kootenai River tributaries would be evaluated based on biological priorities and available
1343 funding.

1344 **STUDY OFFSEASON SURFACE SPILL FOR DOWNSTREAM PASSAGE OF ADULT STEELHEAD (AND**
1345 **BULL TROUT)**

1346 Based on recent conversations with the NMFS, the Corps would continue to refine and
1347 implement a multi-year research study to determine the frequency, timing, and duration of off-
1348 season surface spill needed to effectively pass adult steelhead downstream of McNary Dam.

1349 The co-lead agencies would assume that modifications to operations or structures designed to
1350 safely and effectively pass adult steelhead via surface spill would also benefit bull trout that are
1351 attempting to migrate downstream past McNary Dam.

1352 • Pending results of the evaluation, the co-lead agencies would, in coordination with NMFS,
1353 USFWS, and the Fish Passage Operations and Maintenance (FPOM) workgroup, develop and
1354 implement an off-season surface spill operation at McNary Dam.

1355 • The Corps would use existing information and, if warranted, targeted studies to determine
1356 whether other lower Columbia or lower Snake River dams should be considered for similar
1357 off- season surface spill operations. The co-lead agencies may also investigate potential
1358 structural modifications to spillway weirs that would allow reduced off-season spill volumes,
1359 while providing effective and safe passage of adult steelhead (and bull trout).

1360 • For all actions and studies, steelhead, or in the case of hydroacoustic evaluations,
1361 steelhead-sized targets, would be used as surrogates for adult bull trout. The co-lead
1362 agencies would assume that modifications to operations or structures designed to safely
1363 and effectively pass adult steelhead via surface spill would also benefit adult bull trout.

1364 **MAINTENANCE IMPROVEMENTS TO LITTLE GOOSE DAM JETTY AND RETAINING WALL**

1365 The Corps would repair the existing jetty and retaining wall located near the north shore adult
1366 ladder entrance where erosion has occurred.

1367 **ENHANCED DEBRIS MANAGEMENT AT LOWER SNAKE RIVER DAMS AND MCNARY PROJECTS**

1368 Based on recent conversations with the NMFS, the Corps would continue to investigate
1369 potential operational or structural solutions for effective forebay debris management at
1370 McNary Dam and the lower Snake River dams. Seasonally, pulses of woody debris and
1371 vegetation (both aquatic and terrestrial) enter the Snake River and drift downstream. This
1372 debris can accumulate on turbine unit trash racks and enter bypass systems, and can injure
1373 ESA-listed salmonids. Woody debris causes considerable operations and maintenance
1374 challenges for dam operators. Corps personnel use trash rakes and other tools to remove debris
1375 from trash racks and gatewells. Air burst systems are used to flush debris from orifices that
1376 guide fish from gatewells into bypass systems. In recent years, Lower Granite Dam's removable
1377 spillway weirs (RSWs) have effectively passed large amounts of debris, increasing debris loads
1378 at downstream lower Snake River dams and McNary Dam. In response, the Corps, in
1379 coordination with NMFS and the FPOM workgroup, has begun to identify potential new
1380 operational or structural solutions for managing debris. Where necessary and feasible, the
1381 Corps would design and implement cost-effective solutions designed to minimize and reduce
1382 ESA-listed salmonid injury and mortality associated with debris accumulation.

1383 **INVESTIGATE SHAD DETERRENCE AT LOWER GRANITE DAM**

1384 The Corps would investigate the feasibility of deterring adult shad from approaching and
1385 entering the Lower Granite Dam adult fish trap, alleviating the need to remove shad from the

1386 trap while processing adult salmon and steelhead, and thereby reducing stress and delay for
1387 ESA-listed target species. Measures for consideration may include acoustic deterrents and
1388 operational changes, such as instituting plunging flows or blocking overflow weirs. If feasible,
1389 the Corps would implement operational or small-scale structural measures to address this
1390 issue. Any associated evaluations or changes in fishway operations or configurations would be
1391 coordinated with the appropriate regional coordination forums (e.g., FPOM).

1392 **REDUCE MORTALITY ASSOCIATED WITH DWORSHAK DAM TURBINE MAINTENANCE AND**
1393 **TESTING**

1394 To further minimize and avoid Snake River B-run steelhead injury and mortality, the Corps
1395 would continue to implement and improve protocols regarding Dworshak Dam turbine unit
1396 operation and maintenance and associated FPOM coordination, consistent with the 2019 FPP.

1397 **Adult Fish Ladder Temperature Differentials**

1398 The Corps would continue the following actions:

- 1399 • Continue monitoring and reporting of all mainstem fish ladder temperatures and identify
1400 ladders that have substantial temperature differentials (>1.0°C).
- 1401 • Where beneficial and feasible, develop and implement operational or structural solutions to
1402 address high temperatures and temperature differentials in adult fish ladders at mainstem
1403 lower Snake and Columbia River dams identified as having these problems.
- 1404 • After development of a contingency plan by NMFS and state and tribal fish managers,
1405 complete a study that evaluates alternatives to assess the potential to trap-and-haul adult
1406 sockeye salmon at lower Snake River dams. The study would recommend the least-cost
1407 method to meet the goal and objectives of a contingency plan.
- 1408 • The Corps would maintain or improve the adult trap at Ice Harbor Dam to allow for
1409 emergency trapping of adult salmonids as necessary. The Corps may refurbish the trap in
1410 the future to prepare for the implementation of emergency trap-and-haul activities (e.g.,
1411 sockeye during high temperature water years similar to 2015).

1412 **ADJUST REFILL AT GRAND COULEE TO OFFSET RECLAMATION WATER WITHDRAWAL REQUEST**

1413 To reduce impacts from the *Lake Roosevelt Additional Water Supply* measure, when the water
1414 is withdrawn, Reclamation would adjust the refill target of the reservoir by up to 0.25 feet of
1415 stored water released downstream in the spring period. Without a decrease in the refill target
1416 elevation, downstream flows would decrease by the volume of the additional water supply
1417 delivery. This measure is not modeled as the changes to flows and elevations are very small;
1418 additionally, this would be implemented along with the water supply deliveries of this
1419 additional 45 thousand acre-feet (kaf).

1420 **ADULT SEPARATOR AT THE LOWER GRANITE DAM JUVENILE BYPASS SYSTEM (JBS)**

1421 The Corps would complete follow-on modifications to a new adult separator integrated into the
1422 Lower Granite Dam JBS to reduce delay, injury, and stress to salmon and steelhead, bull trout,
1423 and non-target species.

1424 **7.7 EFFECTS OF THE PREFERRED ALTERNATIVE**

1425 The environmental, economic, and social effects of the Preferred Alternative were evaluated
1426 following its initial development. The effects of the Preferred Alternative have been evaluated
1427 both quantitatively and qualitatively, depending on the resource. The effects analyses of the
1428 existing MOs detailed in Chapter 3 reflect the range of possible effects associated with the
1429 Preferred Alternative. The Final EIS may include updated information in response to public
1430 comment when it is published.

1431 The Affected Environment described in Chapter 3 is still applicable for the Preferred
1432 Alternative. The alternatives were evaluated using the same scale of effects that was applied in
1433 Chapter 3. The changes are measured in relation to the No Action Alternative (No Action
1434 Alternative). The following same descriptors are used in this chapter to describe the level of
1435 effects:

- 1436 • **No Effect:** The action would result in no effect as compared to the No Action Alternative.
- 1437 • **Negligible Effect:** The effect would not change the resource character in a perceptible way.
1438 Negligible is defined as of such little consequence as to not require additional consideration
1439 or mitigation.
- 1440 • **Minor Effect:** The effect to the resource would be perceptible; however, it may result in a
1441 small overall change in resource character.
- 1442 • **Moderate Effect:** The effect to the resource would be perceptible and may result in an
1443 overall change in resource character.
- 1444 • **Major Effect:** The effect to the resource would likely result in a large overall change in
1445 resource character.

1446 The results of this evaluation are described below, and may reference comparatively similar
1447 effects as those modeled and described in Chapter 3.

1448 **7.7.1 Hydrology and Hydraulics**

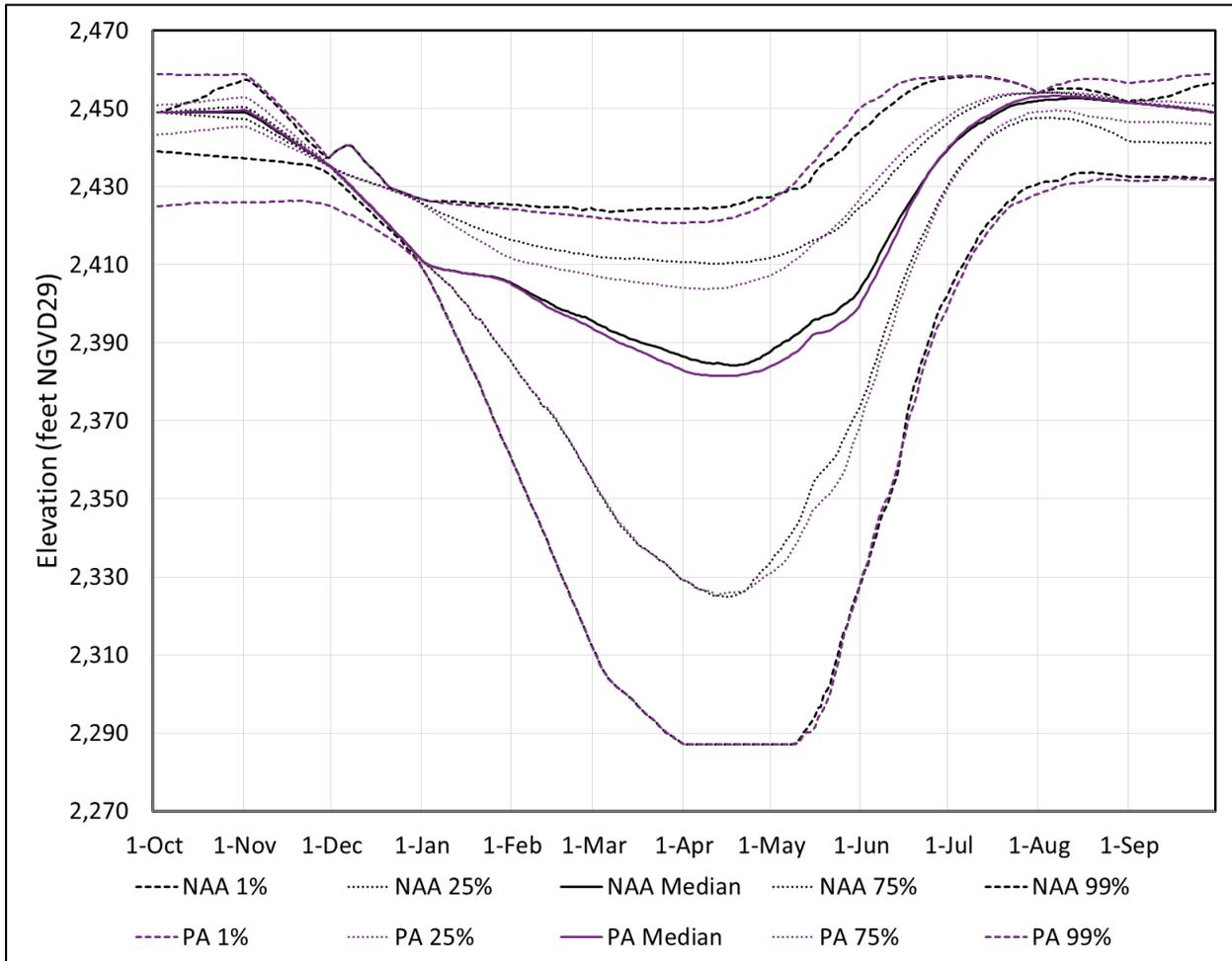
1449 As the effects of the Preferred Alternative are presented, they will be displayed along with the
1450 No Action Alternative to illuminate the timing and magnitude of differences in water conditions
1451 between it and the No Action Alternative. The operational measure (or measures) from the
1452 Preferred Alternative which would result in changes from the No Action Alternative are
1453 identified to the extent that this is possible based on experience with system operation and
1454 hydroregulation modeling. However, because the measures were combined into an alternative

1455 that was then modeled, isolating the effect of a single measure would have is not possible in
1456 many cases.

1457 **7.7.1.1 Region A – Libby, Hungry Horse, and Albeni Falls Dams**

1458 **LAKE KOOCANUSA (LIBBY DAM RESERVOIR) ELEVATION**

1459 Under the Preferred Alternative, the *Modified Draft at Libby* and *Sliding Scale at Libby and*
1460 *Hungry Horse* measures would have a direct effect on Libby Dam operations and reservoir
1461 elevations. Reservoir water levels in Lake Kooconusa would differ from the No Action
1462 Alternative, as shown in Figure 7-1.



1463 **Figure 7-1. Lake Kooconusa Summary Hydrograph for the Preferred Alternative**

1465 The *Modified Draft at Libby* measure would begin influencing reservoir elevations after
1466 December 31, and its effects are best understood by looking at the spring, when the lowest
1467 reservoir elevation typically occurs. The *Modified Draft at Libby* measure causes the spring
1468 reservoir elevation to be lower than the No Action Alternative when the seasonal water supply
1469 forecast is less than 6.9 Maf at Libby Dam. The intent of the deeper draft is to help the reservoir

1470 warm faster in the spring so that warmer water will be available for flows to benefit Kootenai
1471 River White Sturgeon (the Sturgeon Pulse) that starts in mid-May.

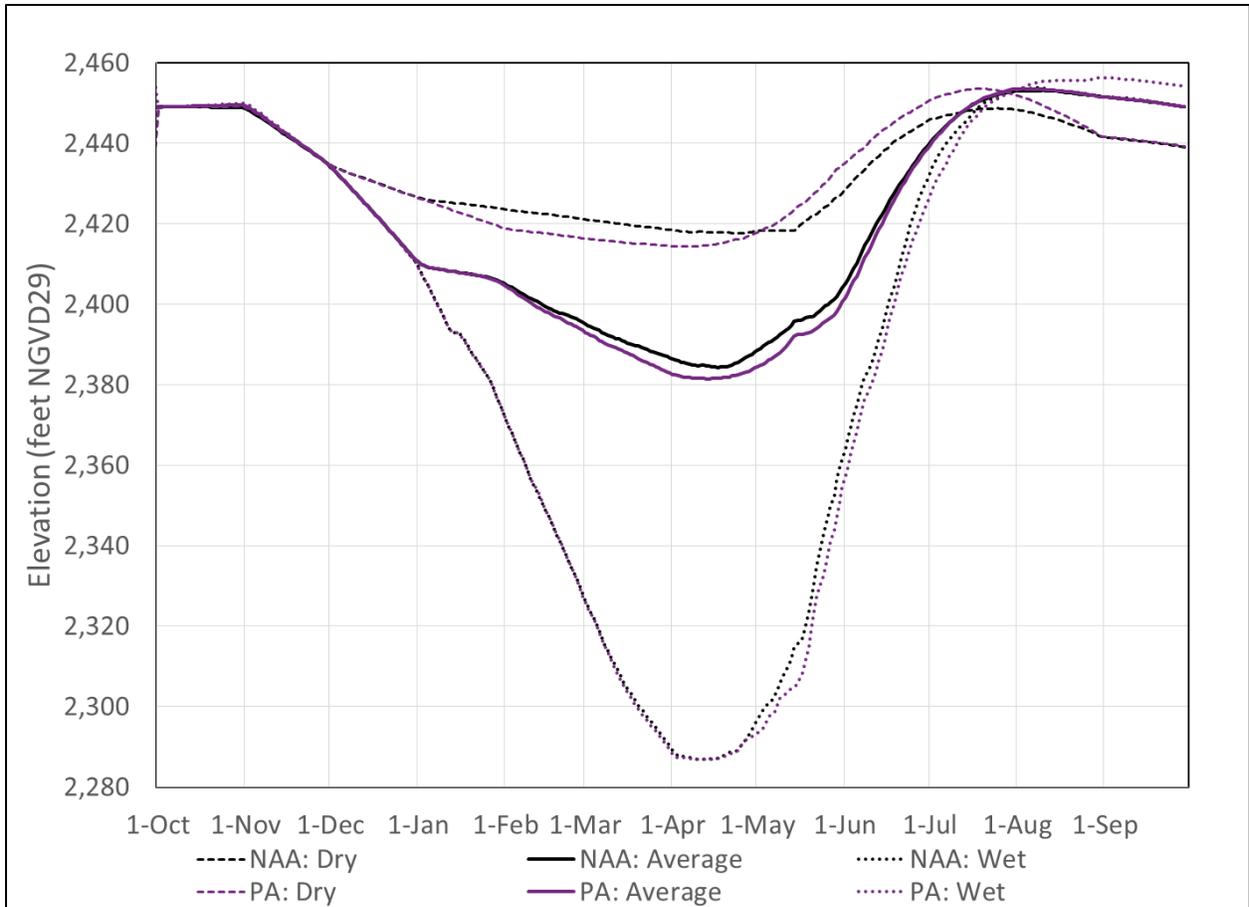
1472 The *Modified Draft at Libby* measure then adjusts the refill equations for all years, which results
1473 in increased likelihood of reservoir refill in all but the lowest 5 percent of years. The change in
1474 refill shaping is most notable prior to the Sturgeon Pulse, and then again after it. The Sturgeon
1475 Pulse shape and volume remain unchanged from the No Action Alternative, which starts in mid-
1476 May and continues through sometime in June depending on the required volume to be
1477 released.

1478 For the Preferred Alternative, there would be a 4 percent increased chance of the reservoir
1479 reaching elevation 2,454 feet NGVD29 or higher (within 5 feet of the full pool elevation of 2,459
1480 feet NGVD29) by July 31, as compared to the No Action Alternative. The peak reservoir
1481 elevation would usually be achieved in July or early August.

1482 In August and September, the reservoir elevation for the Preferred Alternative would generally
1483 be about 1 to 4 feet higher than for the No Action Alternative. The reason for this is the
1484 *Modified Draft at Libby* measure, which tends to increase the peak refill elevation, and the
1485 *Sliding Scale at Libby and Hungry Horse* measure which calls for a sliding scale end-of-
1486 September target elevation that would be dependent on the Libby Dam water supply forecast,
1487 rather than the system-wide water supply forecast at The Dalles. The *Sliding Scale at Libby and*
1488 *Hungry Horse* measure targets a higher elevation than the No Action Alternative in the wettest
1489 25 percent of years. These changes can carry over into October and November in some years.

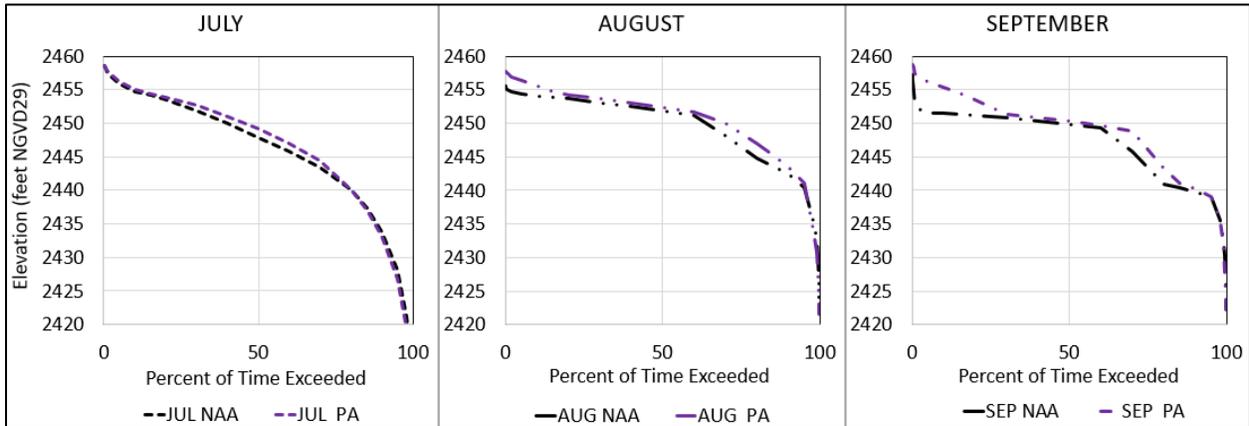
1490 Reservoir water levels in Lake Koochanusa under the Preferred Alternative would differ from the
1491 No Action Alternative to varying extents, depending on the water year type. Median
1492 hydrographs of the reservoir level for dry, average, and wet years are shown in Figure 7-2.

1493 Finally, the three panels in Figure 7-3 show monthly elevation duration curves for July, August,
1494 and September, respectively. The curve for the Preferred Alternative is plotted along with the
1495 curve for the No Action Alternative in each month, showing that the reservoir level would be
1496 higher in each of the 3 months for the Preferred Alternative. In July, this is attributable to the
1497 *Modified Draft at Libby* measure, which tends to increase the peak refill elevation. In August the
1498 higher reservoir levels are attributable to a combination of the *Modified Draft at Libby* and
1499 *Sliding Scale at Libby and Hungry Horse* measures. In September, the higher reservoir levels are
1500 attributable to the *Sliding Scale at Libby and Hungry Horse* measure, which has fewer years
1501 drafting to 2,449 feet NGVD29 than the No Action Alternative (due to the change in forecast
1502 location), and many more years with elevations above 2,452 feet NGVD29 (described in Chapter
1503 3) than the No Action Alternative.



1504
1505

Figure 7-2. Lake Kocanusa Water Year Type Hydrographs for the Preferred Alternative



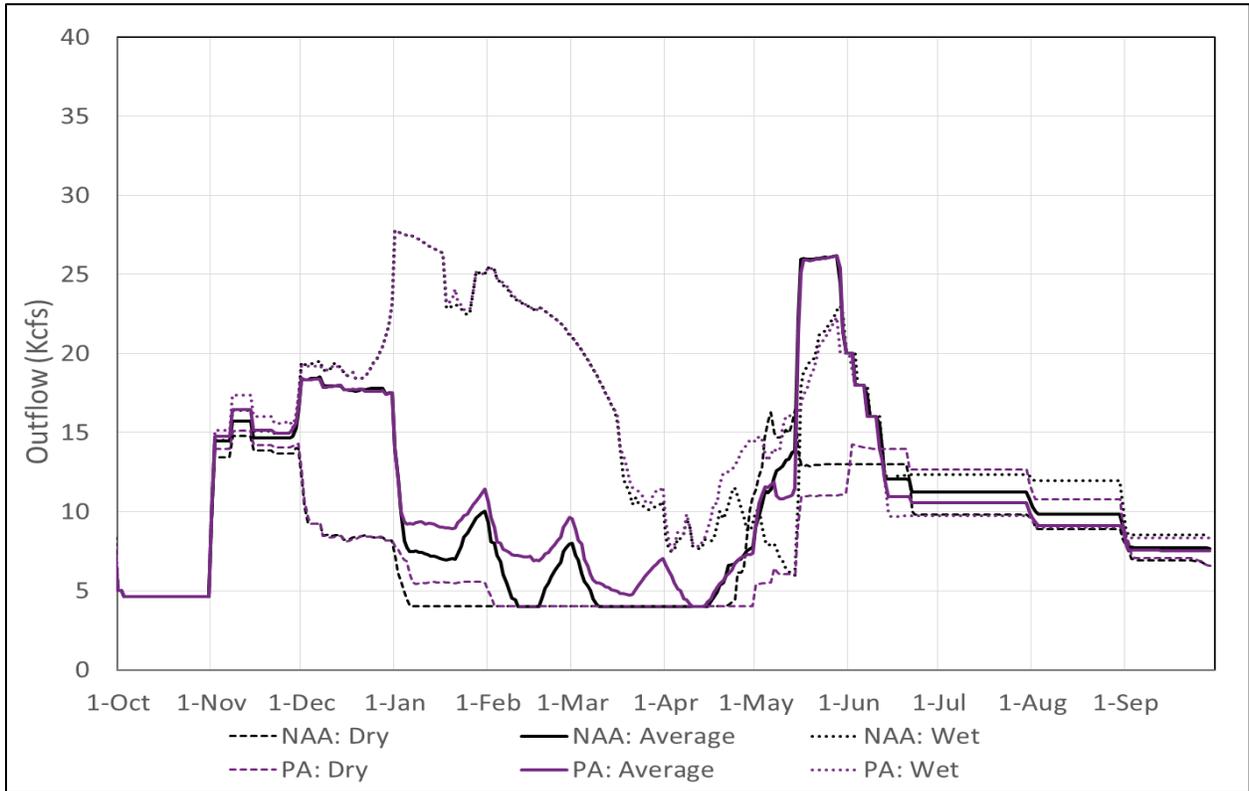
1506
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Figure 7-3. Lake Kocanusa Summer Elevations for the Preferred Alternative

1508 **Libby Dam Outflow**

1509 Under the Preferred Alternative, the *Modified Draft at Libby* and *Sliding Scale at Libby* measures
1510 would have a direct effect on Libby Dam outflows. The outflows would differ from the No
1511 Action Alternative in a variety of ways throughout the year. Figure 7-4 shows median

1512 hydrographs for Libby Dam outflow in dry, average, and wet years. Notably, in dry years Libby
 1513 releases lower flows in late April and May and higher flows in June, July and August and in wet
 1514 years Libby releases higher flows in late April and lower flows in late June, July and August.



1515
 1516 **Figure 7-4. Libby Dam Outflow Water Year Type Hydrographs for the Preferred Alternative**

1517 The change in average monthly outflow throughout the water year is presented in Table 7-7. A
 1518 range of exceedance percentiles is presented because in some months, the direction and
 1519 magnitude of change varies depending on whether one looks at flows more likely to be
 1520 exceeded (99 percent exceedance, 75 percent exceedance) or flows less likely to be exceeded
 1521 (25 percent exceedance, 1 percent exceedance).

1522 **Table 7-7. Libby Dam Monthly Average Outflow for the Preferred Alternative (as change from**
1523 **No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
No Action Alternative	Ave. mo. outflow (kcfs)	1%	4.9	23.5	22.0	27.1	25.8	23.0	20.8	22.7	22.6	22.9	17.8	12.0
		25%	4.7	16.2	18.9	18.3	20.0	12.2	9.9	19.2	17.1	14.3	12.1	8.8
		50%	4.7	14.3	17.7	8.8	6.3	5.5	7.0	16.4	14.2	11.5	10.3	7.9
		75%	4.7	12.0	9.9	5.6	4.0	4.0	4.4	14.0	12.9	9.0	9.0	6.8
		99%	4.7	7.0	8.2	4.3	4.0	4.0	4.0	11.6	8.8	7.1	7.1	6.0
Preferred Alternative	Change (kcfs)	1%	2.0	0.4	0.2	0.0	0.0	-0.4	-0.6	-0.6	0.7	0.2	-2.2	0.0
		25%	0.0	1.8	0.0	0.0	-0.2	0.2	0.6	0.0	-1.0	-0.2	-0.9	-0.1
		50%	0.0	0.4	0.1	1.6	1.6	1.0	-1.0	0.0	-0.7	-0.6	-0.9	-0.3
		75%	0.0	-0.4	0.1	0.7	0.5	0.0	-0.4	-2.1	-0.4	0.0	0.0	-0.4
		99%	0.0	-1.3	0.0	0.5	0.0	0.0	0.0	-5.0	1.3	0.9	0.7	0.1
	Percent change	1%	40%	2%	1%	0%	0%	-2%	-3%	-2%	3%	1%	-12%	0%
		25%	0%	11%	0%	0%	-1%	2%	6%	0%	-6%	-2%	-8%	-1%
		50%	0%	3%	0%	19%	26%	18%	-14%	0%	-5%	-5%	-8%	-4%
		75%	0%	-3%	1%	13%	13%	0%	-9%	-15%	-3%	0%	0%	-5%
		99%	0%	-19%	-1%	11%	0%	0%	0%	-43%	14%	12%	9%	1%

1524 Note: Ave. = average; mo. = monthly. Values for the No Action Alternative are shaded gray. Orange shading
1525 denotes Preferred Alternative flows that are lower than the No Action Alternative flows; green shading denotes
1526 Preferred Alternative flows that are higher than the No Action Alternative flows.

1527 Monthly average outflow from Libby Dam increased in January, February, and March in typical
1528 to dry years, followed by a reduction in outflow in April and May as refill begins. These changes
1529 are all caused by the *Modified Draft at Libby* measure. The Sturgeon Pulse volume and shape
1530 remain unchanged from the No Action Alternative, which happens in all but the 20 percent
1531 driest years. The reduction in outflows in those years happens prior to the mid-May start of the
1532 Sturgeon Pulse. The Sturgeon Pulse continues through sometime in June depending on the
1533 water supply forecast. In dry years, the summer outflows can be 2 to 3 kcfs higher compared to
1534 the No Action Alternative due to the higher refill elevations resulting from the *Modified Draft at Libby*
1535 measure. After the annual Sturgeon Pulse is completed, changes in outflow occur as a
1536 result of the *Sliding Scale at Libby and Hungry Horse* and *Modified Draft at Libby* measures. The
1537 *Sliding Scale at Libby and Hungry Horse* measure calls for a higher end-of-September target
1538 elevation in the wettest 25 percent of years based on the Libby Dam water supply forecast.

1539 **Bonnors Ferry Flow**

1540 Under the Preferred Alternative, the *Modified Draft at Libby* and *Sliding Scale at Libby and*
1541 *Hungry Horse* measures would affect flows at Bonnors Ferry. In general, the flows would differ
1542 from the No Action Alternative in much the same way as at Libby Dam, albeit to a smaller
1543 degree due to dilution effects of major tributaries downstream of the dam. The reason for the
1544 changes seen at Bonnors Ferry are the same as those described for Libby Dam outflow. The
1545 change in average monthly flow at Bonnors Ferry throughout the water year is presented in
1546 Table 7-8.

1547 **Table 7-8. Bonners Ferry Monthly Average Flow for the Preferred Alternative (as change from**
1548 **No Action Alternative)**

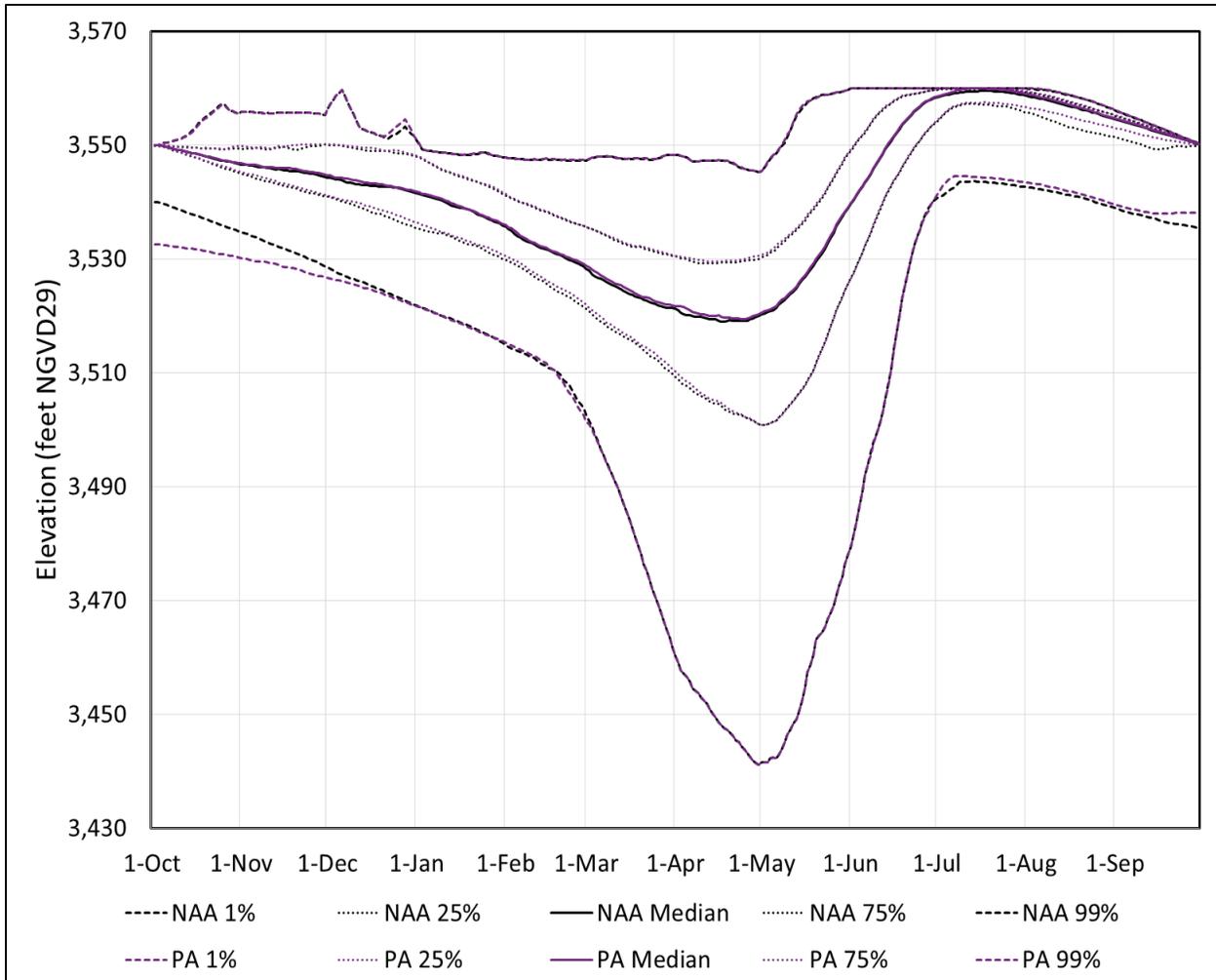
		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
No Action Alternative	Ave. mo. outflow (kcfs)	1%	9.0	26.6	29.2	31.3	29.7	27.5	30.4	40.8	40.7	27.2	19.0	13.3
		25%	6.1	18.1	20.7	21.0	23.2	15.3	19.4	34.3	27.8	17.3	13.3	9.7
		50%	5.6	15.4	18.9	10.4	8.5	8.4	14.6	31.1	23.8	14.6	11.4	8.6
		75%	5.4	13.0	11.4	6.5	5.1	5.9	10.2	27.6	20.3	11.8	9.9	7.4
		99%	5.1	7.7	9.0	5.1	4.5	4.9	7.0	18.3	12.6	9.0	8.1	6.7
Preferred Alternative	Change (kcfs)	1%	0.7	0.6	0.0	0.0	0.0	0.1	2.8	1.3	1.0	-0.4	-2.6	0.3
		25%	0.0	1.7	0.0	-0.1	-0.3	0.3	0.4	0.3	-1.0	-0.8	-0.9	-0.1
		50%	0.0	0.6	-0.1	1.5	1.3	1.0	-0.7	0.0	-0.5	-0.4	-0.8	-0.4
		75%	0.0	-0.2	0.0	1.1	0.6	0.3	-0.3	-3.7	-0.4	0.1	0.0	-0.2
		99%	0.0	-0.9	-0.1	0.5	0.1	0.0	0.0	-3.8	1.1	0.4	0.3	-0.1
	Percent change	1%	8%	2%	0%	0%	0%	0%	9%	3%	2%	-2%	-13%	2%
		25%	0%	9%	0%	-1%	-1%	2%	2%	1%	-4%	-5%	-7%	-1%
		50%	0%	4%	-1%	14%	16%	12%	-5%	0%	-2%	-3%	-7%	-4%
		75%	0%	-1%	0%	16%	11%	5%	-3%	-13%	-2%	1%	0%	-3%
		99%	0%	-11%	-1%	10%	2%	0%	0%	-21%	9%	5%	4%	-1%

1549 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes the Preferred Alternative
1550 flows lower than the No Action Alternative flows; green shading denotes the Preferred Alternative flows higher
1551 than the No Action Alternative flows.

1552 **Hungry Horse Reservoir Elevation**

1553 Under the Preferred Alternative, the *Sliding Scale at Libby and Hungry Horse* measure would
1554 have a direct effect on Hungry Horse Dam operations and reservoir elevations. Reservoir water
1555 levels would differ from the No Action Alternative, as shown in Figure 7-5.

1556 The *Sliding Scale at Libby and Hungry Horse* measure reduces the draft requirements in some
1557 years by setting a higher elevation target for summer flow augmentation than the No Action
1558 Alternative. As a result, reservoir levels could be several feet higher than those under the No
1559 Action Alternative in the summer and into the fall months in low water level years. In most
1560 years, reservoir levels would be drafted slightly less deep (less than a foot) compared to the No
1561 Action Alternative for most of the year.



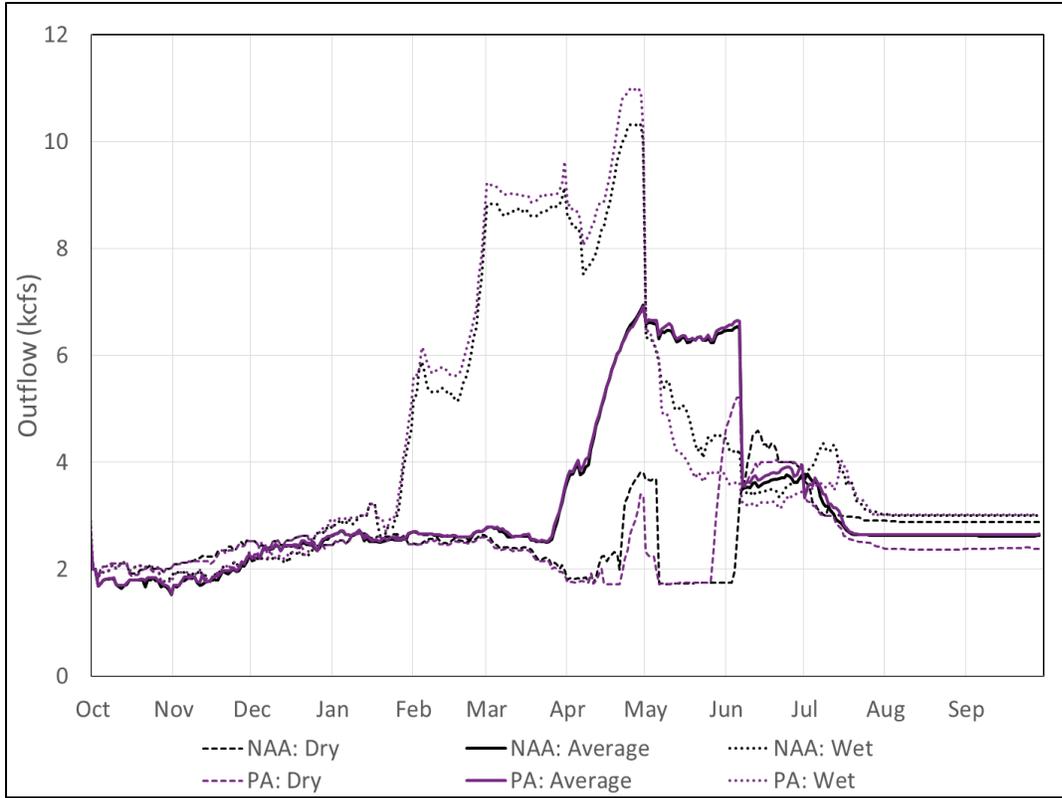
1562
1563 **Figure 7-5. Hungry Horse Reservoir Summary Hydrograph for the Preferred Alternative**

1564 **Hungry Horse Dam Outflow**

1565 Under the Preferred Alternative, the *Sliding Scale at Libby and Hungry Horse* measure would
1566 have a direct effect on Hungry Horse Dam outflows. The outflows would differ from the No
1567 Action Alternative depending on the time of year. Figure 7-6 shows median hydrographs for
1568 Hungry Horse Dam outflow in dry, average, and wet years. The change in average monthly
1569 outflow from Hungry Horse Dam throughout the water year is presented in Table 7-9.

1570 Average outflow from Hungry Horse Dam would differ from the No Action Alternative:

- 1571 • In July, August, and September, the monthly average outflow would decrease as compared
1572 to the No Action Alternative by less than 100cfs in most years.
- 1573 • After September and through the spring, the median monthly average outflow would
1574 generally be slightly higher (up to 1 percent) compared to the No Action Alternative. The
1575 higher outflows would occur because the reservoir would be higher at the end of
1576 September than under the No Action Alternative.



1577
1578 **Figure 7-6. Hungry Horse Dam Outflow Water Year Type Hydrographs for the Preferred**
1579 **Alternative**

1580 **Table 7-9. Hungry Horse Dam Monthly Average Outflow for the Preferred Alternative (as**
1581 **change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	
No Action Alternative	Ave. mo. outflow (kcfs)	1%	2.5	4.7	6.9	7.1	11.5	14.5	15.6	9.6	10.7	6.9	4.4	4.4	
		25%	2.2	2.4	2.7	3.1	4.0	5.7	8.1	7.0	6.1	4.2	3.1	3.1	
		50%	1.9	2.0	2.4	2.6	2.7	2.7	5.4	5.7	4.3	3.4	2.7	2.7	
		75%	1.4	1.4	2.1	2.3	2.4	2.2	3.1	4.1	3.2	2.6	2.4	2.4	
		99%	0.8	0.8	1.6	2.0	1.7	1.5	1.7	1.7	1.7	1.7	1.8	1.9	2.0
Preferred Alternative	Change (kcfs)	1%	0.0	-0.3	0.0	-0.1	0.1	0.0	0.0	0.0	0.0	-0.1	-0.7	-0.7	
		25%	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	
		50%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	0.0	
		75%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	-0.1	0.0	0.0
		99%	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1
	Percent change	1%	0%	-7%	0%	-1%	1%	0%	0%	0%	0%	-1%	-15%	-15%	
		25%	0%	0%	1%	2%	2%	1%	0%	1%	1%	-3%	-3%	-3%	
		50%	0%	1%	0%	1%	0%	0%	1%	1%	1%	-5%	-1%	-1%	
		75%	0%	0%	0%	1%	0%	0%	2%	1%	0%	-3%	-2%	-1%	
		99%	0%	1%	3%	1%	1%	0%	0%	0%	0%	-3%	-5%	-7%	

1582 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes the Preferred Alternative
1583 flows lower than the No Action Alternative flows; green shading denotes the Preferred Alternative flows higher
1584 than the No Action Alternative flows.

1585 **Columbia Falls Flow**

1586 Under the Preferred Alternative, the *Sliding Scale at Libby and Hungry Horse* measure would
1587 affect flows at Columbia Falls. Compared to the No Action Alternative, there would be
1588 decreased flow in July, August, and September in some years, while the other months of the
1589 year would have flows similar to or slightly higher than those under the No Action Alternative,
1590 while still meeting minimum flow requirements. The change in average monthly flow at
1591 Columbia Falls throughout the water year, as compared to the No Action Alternative, is
1592 presented in Table 7-10.

1593 **Table 7-10. Columbia Falls Monthly Average Flow for the Preferred Alternative (as change**
1594 **from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	
No Action Alternative	Ave. mo. outflow (kcfs)	1%	8.9	14.4	14.8	11.0	14.2	17.4	30.5	38.0	43.2	23.9	8.8	8.7	
		25%	4.0	4.2	4.5	5.0	5.8	7.9	15.9	29.7	31.5	15.1	6.9	5.4	
		50%	3.8	3.7	3.7	3.8	3.8	4.5	12.3	25.5	24.8	11.5	5.8	4.7	
		75%	3.6	3.6	3.6	3.6	3.6	3.7	8.5	21.4	20.0	8.4	4.9	4.2	
		99%	3.5	3.5	3.5	3.5	3.5	3.5	5.4	15.7	12.4	5.5	3.9	3.6	
Preferred Alternative	Change (kcfs)	1%	0.0	-0.3	0.0	-0.2	0.2	0.0	0.0	0.0	-0.2	-0.1	0.0	-0.7	
		25%	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	
		50%	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.1	
		75%	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	-0.2	-0.2	-0.1	
		99%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	-0.1	
	Percent change	1%	0%	-2%	0%	-2%	1%	0%	0%	0%	0%	0%	0%	0%	-8%
		25%	0%	0%	3%	1%	1%	1%	0%	0%	0%	0%	-1%	0%	
		50%	0%	0%	0%	1%	1%	1%	1%	0%	0%	-1%	-2%	-1%	
		75%	0%	0%	0%	0%	0%	0%	1%	0%	0%	-2%	-5%	-3%	
		99%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	-1%	-5%	-3%

1595 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes the Preferred Alternative
1596 flows lower than the No Action Alternative flows; green shading denotes the Preferred Alternative flows higher
1597 than the No Action Alternative flows.

1598 **Lake Pend Oreille Elevation**

1599 While the *Sliding Scale at Libby and Hungry Horse* measure in the Preferred Alternative would
1600 affect Hungry Horse Dam operations, the changes would not impact annual peak reservoir
1601 levels in Lake Pend Oreille, nor would they impact the timing of refill or drawdown. Thus, there
1602 would not be any noticeable difference in the level of Lake Pend Oreille as compared to the No
1603 Action Alternative.

1604 **Albeni Falls Outflow**

1605 Under the Preferred Alternative, the *Sliding Scale at Libby and Hungry Horse* measure would
1606 affect the monthly average outflow from Albeni Falls Dam, but to a lesser degree than at

1607 Hungry Horse Dam or Columbia Falls. In the summer months, the monthly average outflow
1608 from Albeni Falls Dam under the Preferred Alternative would be similar to the No Action
1609 Alternative in higher flow years and up to several hundred cfs lower in lower water years. The
1610 changes in median monthly average flows are shown in Table 7-11.

1611 **Table 7-11. Pend Oreille Basin Median Monthly Average Flows for the Preferred Alternative**
1612 **(as change from No Action Alternative)**

	Location	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
No Action Alternative (kcfs)	Hungry Horse	1.9	2.0	2.4	2.6	2.7	2.7	5.4	5.7	4.3	3.4	2.7	2.7
	Columbia Falls, MT	3.8	3.7	3.7	3.8	3.8	4.5	12.3	25.5	24.8	11.5	5.8	4.7
	Albeni Falls	23.7	16.7	15.3	14.5	16.6	19.8	25.2	50.7	55.6	27.4	12.0	13.7
Change (kcfs)	Hungry Horse	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	0.0
	Columbia Falls, MT	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	-0.1	-0.1	-0.1
	Albeni Falls	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.2
Percent Change	Hungry Horse	0%	1%	0%	1%	0%	0%	1%	1%	1%	-5%	-1%	-1%
	Columbia Falls, MT	0%	0%	0%	1%	1%	1%	1%	0%	0%	-1%	-2%	-1%
	Albeni Falls	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-2%

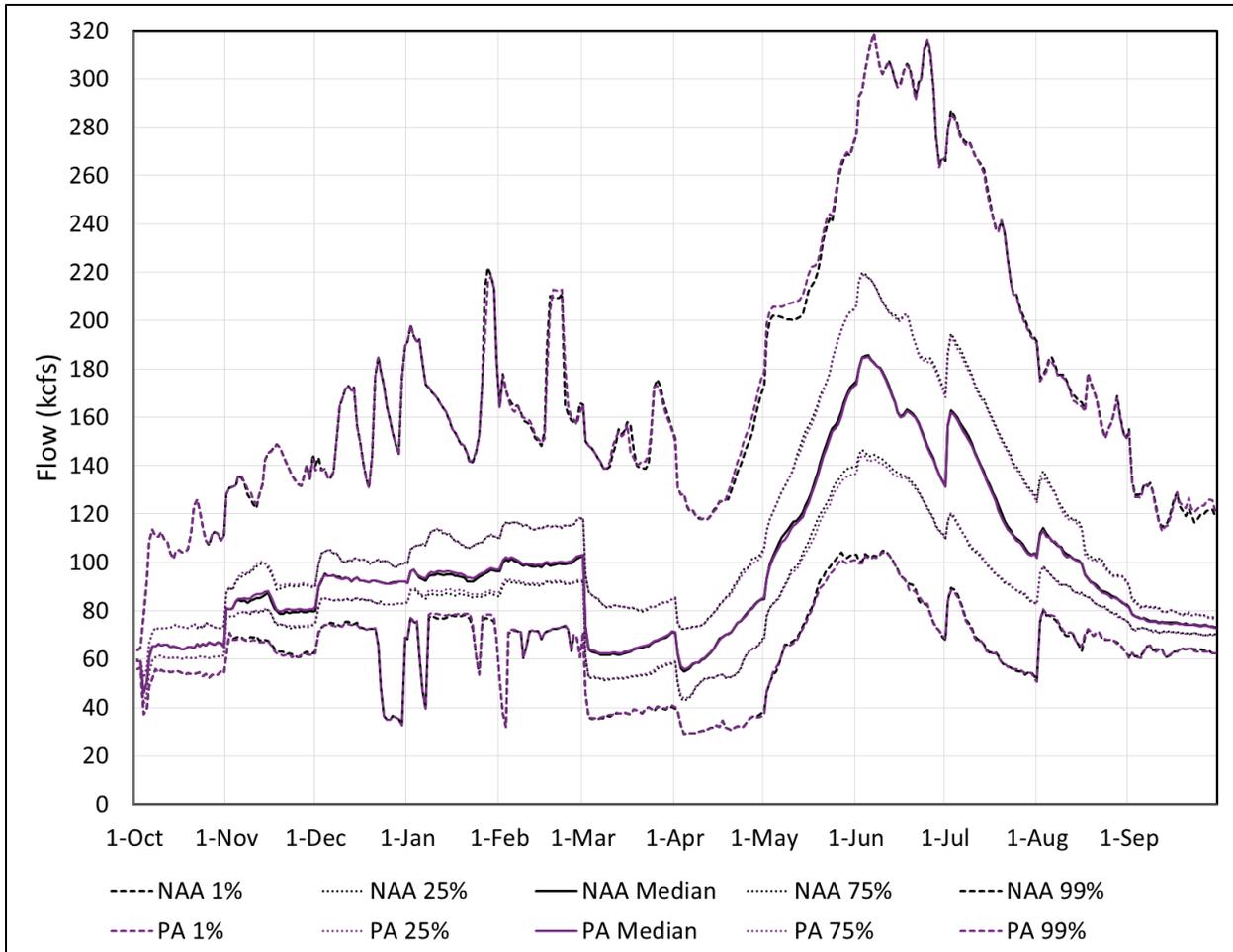
1613 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes the Preferred Alternative
1614 flows lower than the No Action Alternative flows; green shading denotes the Preferred Alternative flows higher
1615 than the No Action Alternative flows.

1616 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

1617 **Columbia River flow upstream of Grand Coulee Dam**

1618 Under the Preferred Alternative, the *Modified Draft at Libby* and *Sliding Scale at Libby and*
1619 *Hungry Horse* measures from Region A would affect Columbia River flow upstream of Grand
1620 Coulee Dam. The flows are depicted in Figure 7-7, which shows flows near RM 748 (just
1621 downstream of the U.S.-Canada border, about 151 river miles upstream of Grand Coulee Dam).

1622 Figure 7-7 characterizes the timing and magnitude of flow changes between the No Action
1623 Alternative and the Preferred Alternative due to the combined effect of measures at Libby Dam
1624 and Hungry Horse Dam. A majority of these changes in winter and spring months is due to the
1625 *Modified Draft at Libby* measure. Changes in Lake Roosevelt inflow between Preferred
1626 Alternative and the No Action Alternative are small, typically within 1 percent, with increases
1627 being more prevalent in the winter months and decreases occurring in the spring and summer
1628 months. However, as discussed in the Grand Coulee Dam Outflow section, the change in
1629 upstream flow accounts for much of the change seen in the Grand Coulee outflow.



1630

1631

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

1632

Lake Roosevelt (Grand Coulee Dam Reservoir) Elevation

1633

Under the Preferred Alternative, the *Update System FRM Calculation, Planned Draft Rate at Grand Coulee, Fall Operational Flexibility for Hydropower (Grand Coulee), and Lake Roosevelt Additional Water Supply* measures relate directly to Grand Coulee Dam, and all of these (with the exception of *Lake Roosevelt Additional Water Supply*) would influence reservoir elevations at Lake Roosevelt. Although not modeled, the *Adjust Refill at Grand Coulee to Offset Reclamation Water Withdrawal Request* mitigation measure to adjust the refill elevation would have minor effects to reservoir elevations (maximum impact would be 0.25 feet). Operational changes in Region A upstream may also have a slight effect on Lake Roosevelt water levels. The *Grand Coulee Maintenance Operations* measure would not impact reservoir elevations or total outflows, but would affect power generation, frequency of spill, and water quality. Reservoir water levels in Lake Roosevelt under the Preferred Alternative would differ from the No Action Alternative, as shown in Figure 7-8.

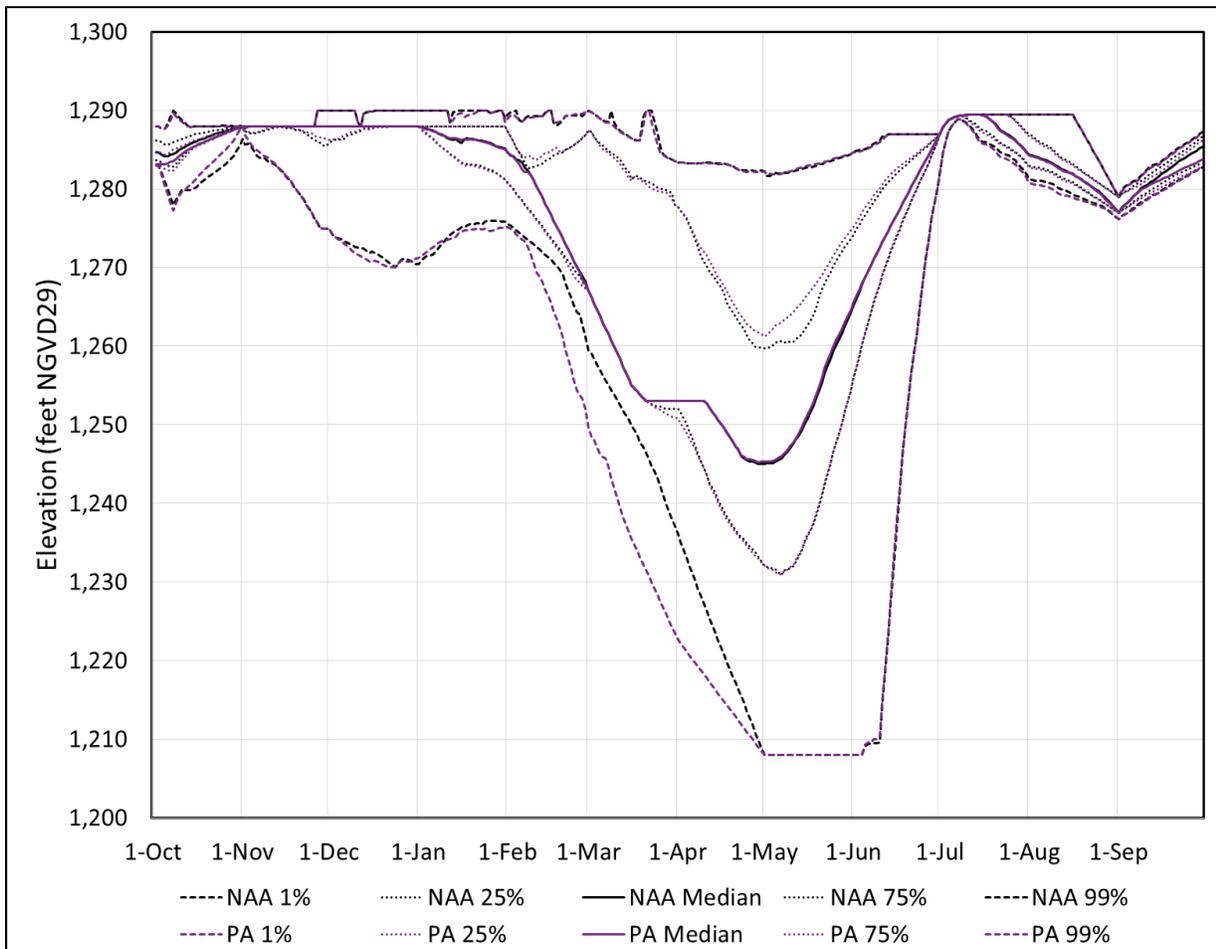
1645

The *Planned Draft Rate at Grand Coulee* measure under the Preferred Alternative calls for earlier deeper drafts for years with larger water supply forecast. It does this by decreasing the

1646

1647 daily draft rate in planning drawdown to the deepest draft point so that the reservoir has to
 1648 start drafting sooner in the winter, but can draft less each day than it would under the No
 1649 Action Alternative. This causes the lower reservoir levels in January and February in wet years.
 1650 The median Preferred Alternative elevation is about 5 feet lower at the end of February than
 1651 the No Action Alternative in the wettest 20 percent of years. The *Planned Draft Rate at Grand*
 1652 *Coulee* does not change the deepest draft of the season values. The deepest draft point of the
 1653 season may change either due to change in the start of refill timing or the *Update System FRM*
 1654 *Calculation* measure, which adjusts the Grand Coulee elevation to account for storage space
 1655 within the system. The *Update System FRM Calculation* can cause the Preferred Alternative
 1656 elevation to be slightly different than the No Action Alternative in April and May.

1657 Median reservoir levels under the Preferred Alternative are about a half foot lower compared
 1658 to No Action Alternative in September and October due to the *Fall Operational Flexibility for*
 1659 *Hydropower (Grand Coulee)* measure. The end of September elevation is below 1,283 feet in
 1660 approximately 40 percent of years; and in October the elevation is projected to be below 1,283
 1661 feet in approximately 10 percent of the days.

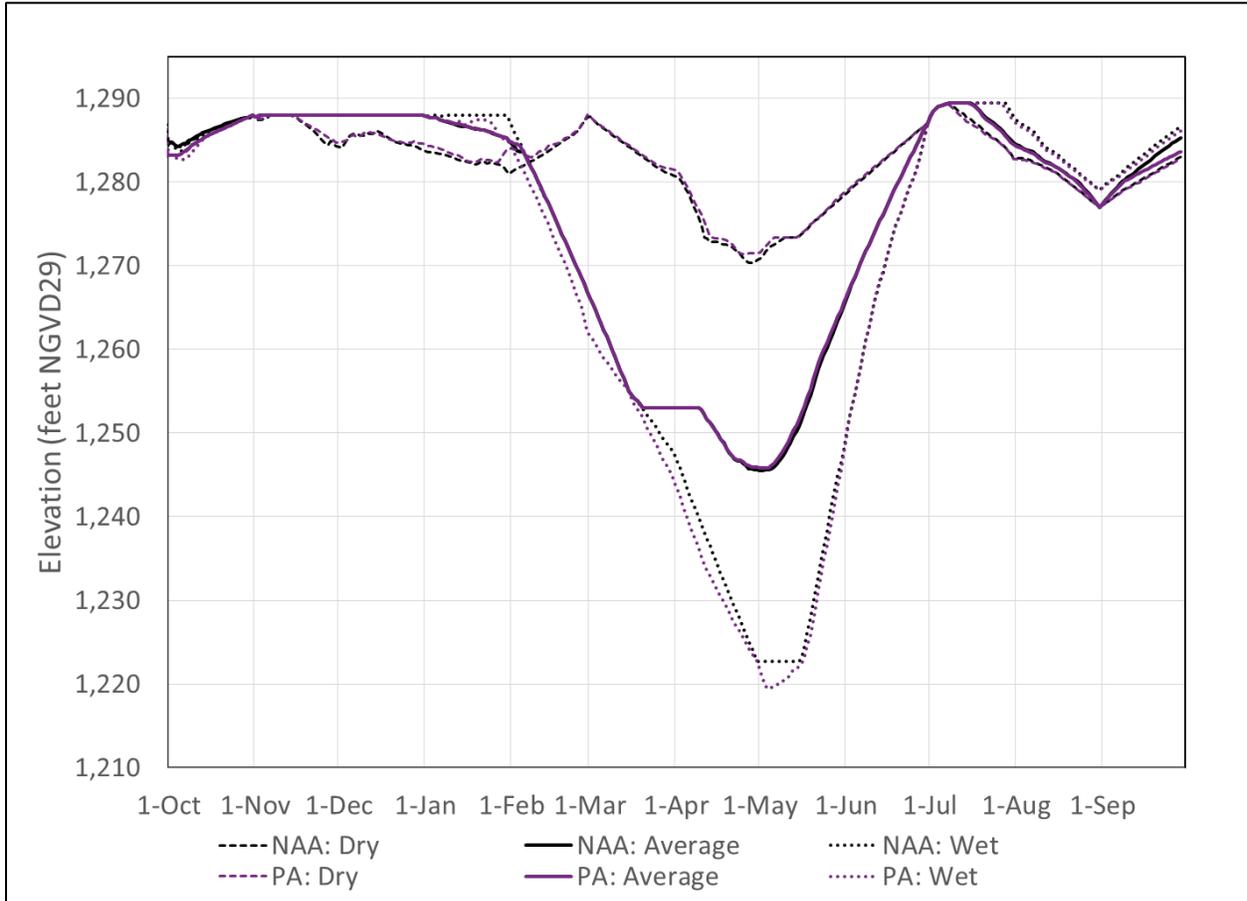


1662

1663

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

1664 For the No Action Alternative, the reservoir was modeled to be at or above 1,283 feet by the
 1665 end of September each year; however, during dry years this may not be possible to meet all
 1666 operational objectives. Finally, Figure 7-9 shows median hydrographs for Lake Roosevelt in dry,
 1667 average, and wet years. The figure provides another way to picture the effects described above,
 1668 this time categorized by water year type.



1669
 1670 **Figure 7-9. Lake Roosevelt Water Year Type Hydrographs for the Preferred Alternative**

1671 **Grand Coulee Dam Drum Gate Maintenance**

1672 Under the Preferred Alternative, the *Update System FRM Calculation, Planned Draft Rate at*
 1673 *Grand Coulee, and Fall Operational Flexibility for Hydropower (Grand Coulee)* measures would
 1674 influence reservoir elevations during spring months. The *Grand Coulee Maintenance Operations*
 1675 measure would not impact reservoir elevations or total outflows, but would affect power
 1676 generation, frequency of spill, and water quality. The ability to perform some inspection and
 1677 maintenance has a direct link to Lake Roosevelt water levels, requiring water levels to be at or
 1678 below critical elevations for a certain period of time. Drum gate maintenance at Grand Coulee
 1679 Dam is planned to occur annually during March, April, and May, but is not conducted in all
 1680 years. The reservoir must be at or below elevation 1,255 feet NGVD29 for 8 weeks to complete
 1681 drum gate maintenance. In addition to the annual drum gate maintenance, an annual
 1682 inspection and maintenance activity is planned for the 57-inch butterfly drum gate intake valves

1683 in late April or early May. The external inspection and maintenance requires water levels at or
1684 below 1,219 feet NGVD29. This inspection and maintenance must occur once every 10 years.

1685 The changes in elevations for the Preferred Alternative that influence the decision to conduct
1686 drum gate maintenance would not change substantially relative to the No Action
1687 Alternative(April 30 FRM elevation targets and drum gate initiation methodology is discussed in
1688 more detail in Part 1 of Appendix B). The decision to conduct drum gate maintenance is based
1689 on the February water supply forecast and the resulting April 30 FRM elevation projection (April
1690 30 flood risk management elevation target at or below 1,255 or 1,265 feet NGVD29 depending
1691 on how recently the maintenance has been conducted.) In both the Preferred Alternative and
1692 the No Action Alternative, drum gate maintenance would be achievable in 65 percent of the
1693 years; maintenance for the 57-inch butterfly drum gate intake valves would be achievable in 8
1694 to 13 percent of years (corresponding to elevation 1,219 and 1,222.7 feet NGVD29).

1695 **Grand Coulee Dam Outflow**

1696 Under the Preferred Alternative, the *Update System FRM Calculation, Planned Draft Rate at*
1697 *Grand Coulee, Fall Operational Flexibility for Hydropower (Grand Coulee), and Lake Roosevelt*
1698 *Additional Water Supply*⁷ measures would directly affect outflows from Grand Coulee Dam. In
1699 addition, the *Modified Draft at Libby and Sliding Scale at Libby and Hungry Horse* measures
1700 from Region A upstream would affect inflows and outflows at Grand Coulee Dam.

1701 The outflows from Grand Coulee Dam would differ from the No Action Alternative depending
1702 on the time of year, as seen in Figure 7-10. The change in average monthly outflow throughout
1703 the water year is presented in Table 7-12.

1704 In almost every month of the year, the outflow from Grand Coulee Dam under the Preferred
1705 Alternative would differ from the No Action Alternative due to various measures at Grand
1706 Coulee Dam and in Region A upstream. However, these changes are relatively small, with
1707 median monthly average flows typically within 1 percent of those under the No Action
1708 Alternative. A more detailed description is provided below for completeness, and attempts are
1709 made to identify individual measures responsible for specific changes wherever possible:

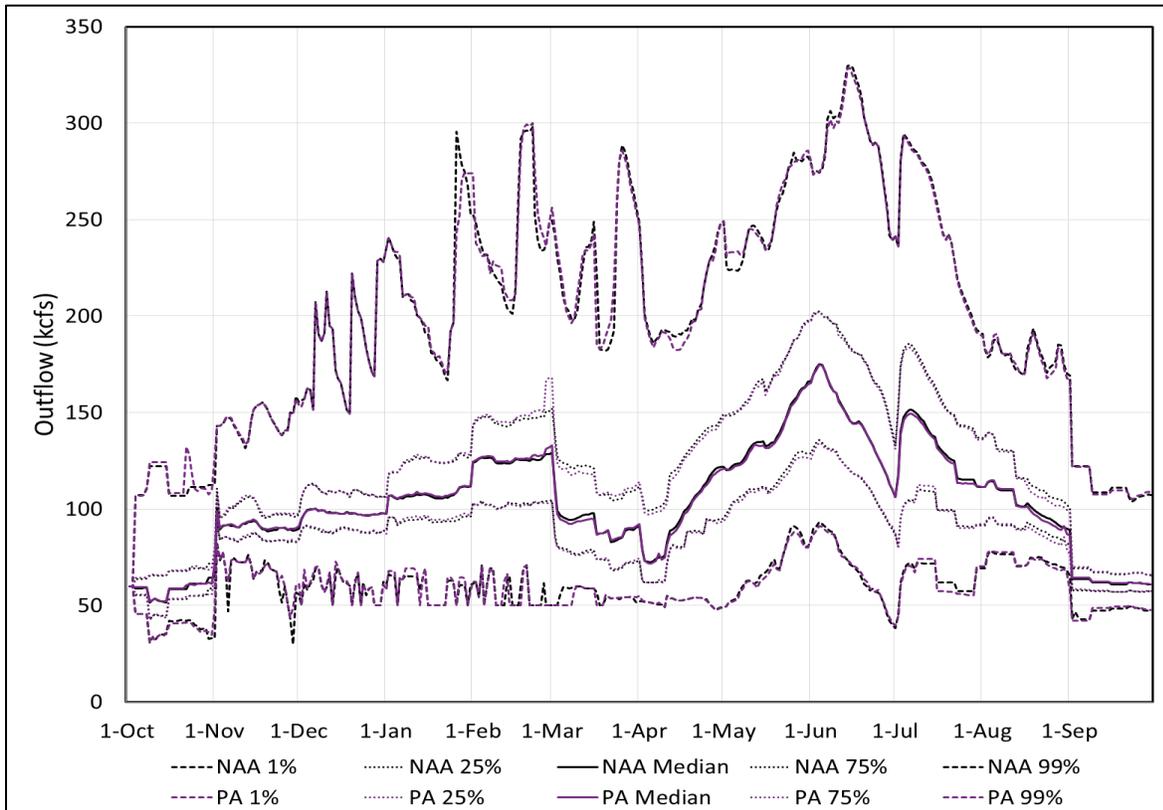
- 1710 • Increases in January and February outflow (typically less than 1 percent) are largely
1711 attributed to the increase in outflow released from Libby Dam as a result of the *Modified*
1712 *Draft at Libby* measure. The *Update System FRM Calculation* and *Planned Draft Rate at*
1713 *Grand Coulee* measures also contribute to this increase in larger forecast years.
- 1714 • In the early spring, a reduction in Grand Coulee outflow is expected, especially in April
1715 where the median decrease in outflow is 1.6 kcfs (-2 percent). This is partially attributed to
1716 the earlier drafts linked to the *Planned Draft Rate at Grand Coulee* and *Update System FRM*

⁷ The *Lake Roosevelt Additional Water Supply* measure in this Preferred Alternative calls for an increased volume of 45 kaf to be pumped from Lake Roosevelt into Banks Lake. This is a notably smaller volume than that described in Chapter 2 and modeled under the various MOs.

1717 Calculation measures. Some of these flow decreases would be reduced due to the measure
1718 to *Adjust Refill at Grand Coulee to Offset Reclamation Water Withdrawal Request*, which is
1719 not modeled.

- 1720 • May through August, outflow continues to be lower in most years. This is due to the
1721 combined effect of the *Modified Draft at Libby, Sliding Scale at Libby and Hungry Horse*, and
1722 *Lake Roosevelt Additional Water Supply* measures. The change in median monthly average
1723 flow ranges from -0.3 kcfs to -1.8 kcfs. Although some of these flow decreases would be
1724 reduced due to the *Adjust Refill at Grand Coulee to Offset Reclamation Water Withdrawal*
1725 *Request*.

1726 Figure 7-11 shows median hydrographs for Grand Coulee Dam outflow in dry, average, and wet
1727 years. The figure provides another way to picture the effects described above, this time
1728 categorized by water year type.

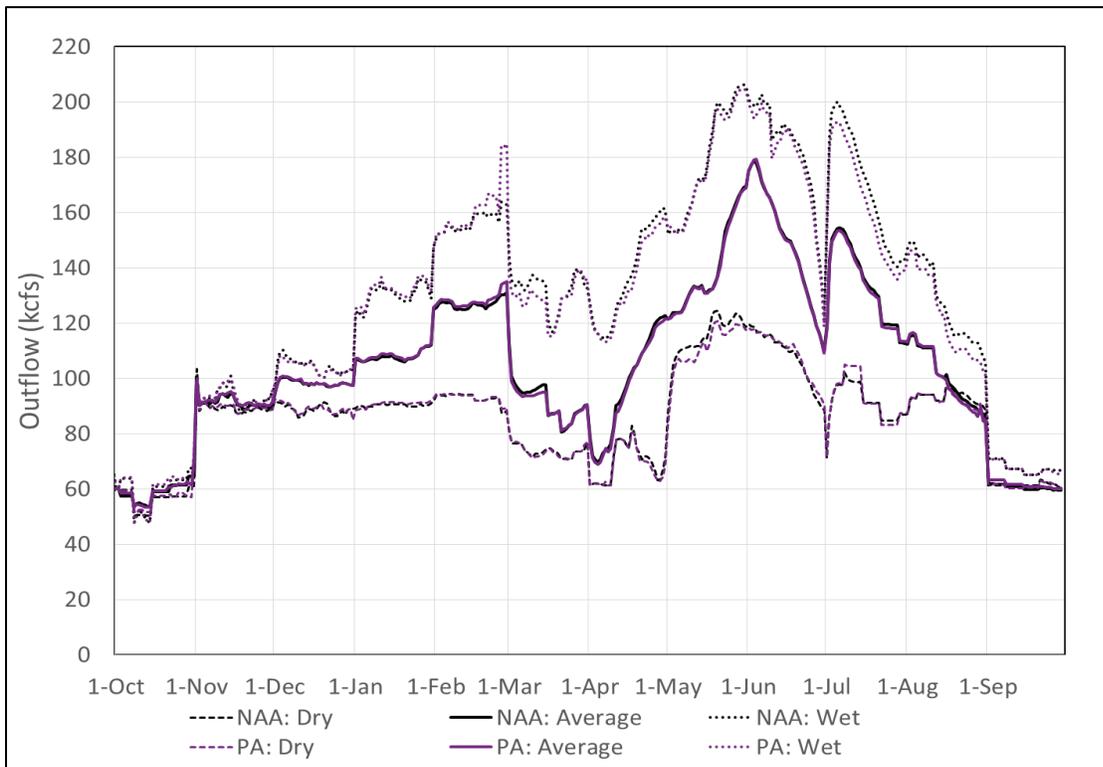


1729
1730 **Figure 7-10. Grand Coulee Dam Outflow Summary Hydrograph for the Preferred Alternative**

1731 **Table 7-12. Grand Coulee Dam Monthly Average Outflow for the Preferred Alternative (as**
1732 **change from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
No Action Alternative	Ave. mo. outflow (kcfs)	1%	94	130	174	190	213	186	191	231	275	247	175	111
		25%	67	99	109	124	147	117	120	165	181	158	118	68
		50%	59	91	97	108	126	93	97	138	150	134	102	63
		75%	54	84	88	96	105	78	79	118	121	98	92	59
		99%	49	78	79	76	81	66	60	97	91	81	81	53
Preferred Alternative	Change (kcfs)	1%	0.8	0.7	0.0	1.3	8.8	0.8	-6.9	-0.8	2.0	-1.5	-1.8	-0.5
		25%	0.1	0.6	0.0	0.5	1.8	-0.4	-1.8	-1.5	-0.3	-1.5	-2.4	0.4
		50%	0.4	0.3	-0.1	0.5	1.6	-0.4	-1.6	-1.0	-0.3	-1.8	-0.9	0.0
		75%	0.2	0.6	0.1	1.1	-0.6	-0.1	0.0	-1.3	-0.3	-0.3	-0.6	0.2
		99%	0.4	0.6	0.5	1.6	0.0	0.1	0.3	-3.0	0.8	0.3	-0.5	0.3
	Percent change	1%	1%	1%	0%	1%	4%	0%	-4%	0%	1%	-1%	-1%	0%
		25%	0%	1%	0%	0%	1%	0%	-1%	-1%	0%	-1%	-2%	1%
		50%	1%	0%	0%	0%	1%	0%	-2%	-1%	0%	-1%	-1%	0%
		75%	0%	1%	0%	1%	-1%	0%	0%	-1%	0%	0%	-1%	0%
		99%	1%	1%	1%	2%	0%	0%	1%	-3%	1%	0%	-1%	1%

1733 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes the Preferred Alternative
1734 flows lower than the No Action Alternative flows; green shading denotes Preferred Alternative flows higher than
1735 the No Action Alternative flows.



1736 **Figure 7-11. Grand Coulee Dam Outflow Water Year Type Hydrographs for the Preferred**
1737 **Alternative**
1738

1739 Under the Preferred Alternative, the pattern of flow changes from Grand Coulee Dam outflow
1740 would continue through the middle Columbia River. Table 7-13 shows changes in the median
1741 values of monthly average flows for Lake Roosevelt Inflow, Grand Coulee Dam outflow, and
1742 other dam outflow locations downstream in Region B.

1743 **Table 7-13. Middle Columbia River Monthly Average Flows for the Preferred Alternative (as**
1744 **change from No Action Alternative)**

	Location	OCT	NO V	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
No Action Alternative (kcfs)	Lake Roosevelt Inflow	64	82	92	95	100	65	69	131	166	133	98	75
	Grand Coulee	59	91	97	108	126	93	97	138	150	134	102	63
	Chief Joseph	58	91	96	108	127	94	98	139	150	135	103	63
	Wells	59	93	98	110	129	95	101	150	163	141	105	65
	Priest Rapids	60	96	102	115	133	100	108	162	178	147	108	68
Change (kcfs)	Lake Roosevelt Inflow	0.0	1.3	0.0	0.6	0.9	0.4	-0.7	-1.2	-0.2	-1.0	-0.6	-0.2
	Grand Coulee	0.4	0.3	-0.1	0.5	1.6	-0.4	-1.6	-1.0	-0.3	-1.8	-0.9	0.0
	Chief Joseph	0.3	0.4	0.1	0.6	1.4	-0.6	-1.4	-1.4	-0.4	-1.9	-0.5	0.1
	Wells	0.1	0.3	0.0	0.6	1.5	-0.4	-1.3	-1.9	-0.3	-2.2	-0.5	0.0
	Priest Rapids	0.3	0.3	0.1	0.5	1.3	-0.2	-1.3	-1.7	0.0	-1.9	-0.6	0.0
Percent Change	Lake Roosevelt Inflow	0%	2%	0%	1%	1%	1%	-1%	-1%	0%	-1%	-1%	0%
	Grand Coulee	1%	0%	0%	0%	1%	0%	-2%	-1%	0%	-1%	-1%	0%
	Chief Joseph	0%	0%	0%	1%	1%	-1%	-1%	-1%	0%	-1%	-1%	0%
	Wells	0%	0%	0%	1%	1%	0%	-1%	-1%	0%	-2%	-1%	0%
	Priest Rapids	0%	0%	0%	0%	1%	0%	-1%	-1%	0%	-1%	-1%	0%

1745 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes the Preferred Alternative
1746 flows lower than the No Action Alternative flows; green shading denotes the Preferred Alternative flows higher
1747 than the No Action Alternative flows.

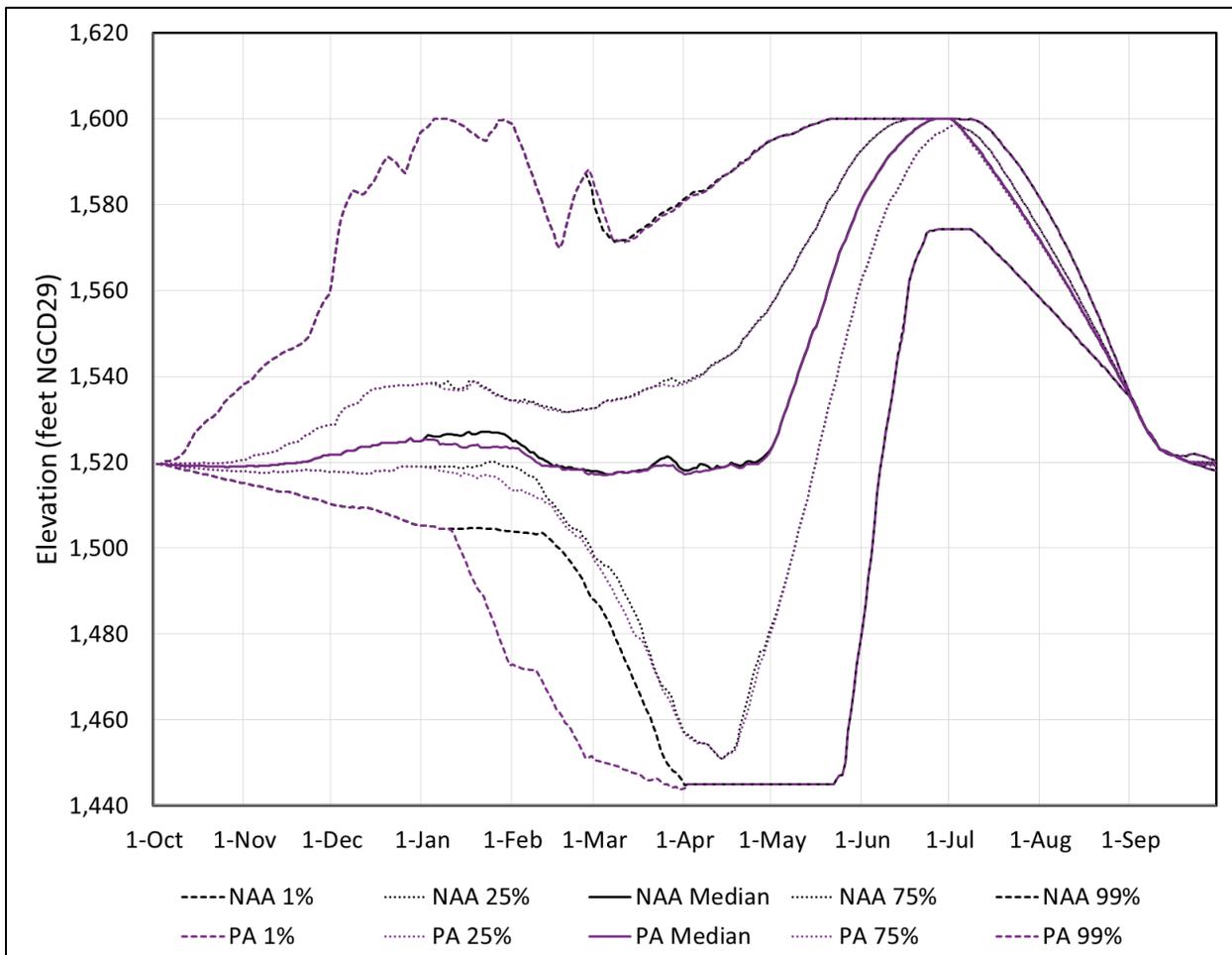
1748 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE**
1749 **HARBOR DAMS**

1750 **Dworshak Reservoir Elevation**

1751 Under the Preferred Alternative, the *Slightly Deeper Draft for Hydropower at Dworshak*
1752 measure would have a direct effect on Dworshak Dam operations and reservoir elevations.
1753 Water levels would differ from the No Action Alternative, as shown in Figure 7-12.

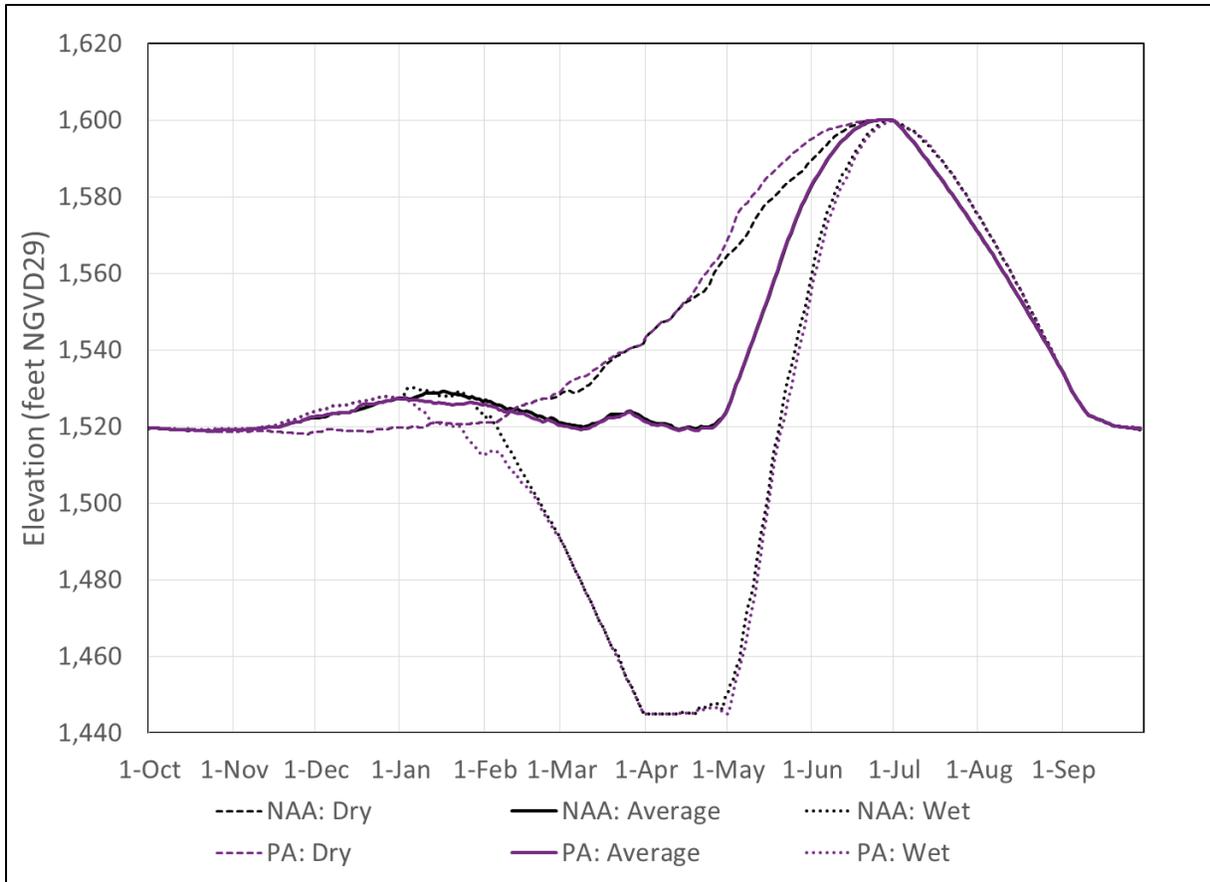
1754 In the Preferred Alternative, the *Slightly Deeper Draft for Hydropower at Dworshak* measure
1755 would allow for additional hydropower generation and hydropower flexibility by drafting the
1756 reservoir to elevations lower than what is required for FRM purposes. This measure would
1757 result in lower water levels than the No Action Alternative in larger forecast years in the
1758 months January, February, and March, and then similar water levels for the rest of the year.

1759 After no changes through December, the reservoir would start to be drafted deeper in January
 1760 in about 60 percent of years. Generally, the larger the forecasted runoff volume, the deeper the
 1761 draft, and the greater the change from the No Action Alternative. January 31 water levels
 1762 would be lower than No Action Alternative by 10 feet or more in the wettest 10 percent of
 1763 years, and 20 feet or more in the wettest 5 percent of years. By the end of February, only the
 1764 wettest 10 percent of years would have deeper drafts than the No Action Alternative, but the
 1765 difference could exceed 30 feet. By the end of March, reservoir levels are effectively the same
 1766 as the No Action Alternative, typically less than a foot lower. There is no change in refill
 1767 probability under the Preferred Alternative. Similar to the No Action Alternative, the drawdown
 1768 of Dworshak Reservoir over the summer months to provide cool water to the lower Snake
 1769 River, provide flows for salmon migration, and meet the flows per the Agreement between the
 1770 U.S. and the Nez Perce Tribe would continue unchanged from current operations.



1771
 1772 **Figure 7-12. Dworshak Reservoir Summary Hydrograph for the Preferred Alternative**

1773 Water levels at Dworshak Reservoir under the Preferred Alternative would differ from the No
 1774 Action Alternative to varying extents, depending on the water year type. Median hydrographs
 1775 of the reservoir level for dry, average, and wet years are shown in Figure 7-13.



1776

1777

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

1778

DWORSHAK DAM OUTFLOW

1779

Under the Preferred Alternative, the *Slightly Deeper Draft for Hydropower at Dworshak* measure would have a direct effect on Dworshak Dam outflows. The outflows would differ from the No Action Alternative primarily in January, February, and March, as seen in Figure 7-14. The change in average monthly outflow is characterized in Table 7-14.

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The month of January would have a notable increase in project outflow as compared to the No Action Alternative. The median (50th percentile) increase in monthly average flow is 0.3 kcfs (12 percent), and there is a 3.3 kcfs (77 percent) increase in the 25th percentile. In February and March, decreases in monthly average flow are 1 kcfs or less (up to 15 percent).

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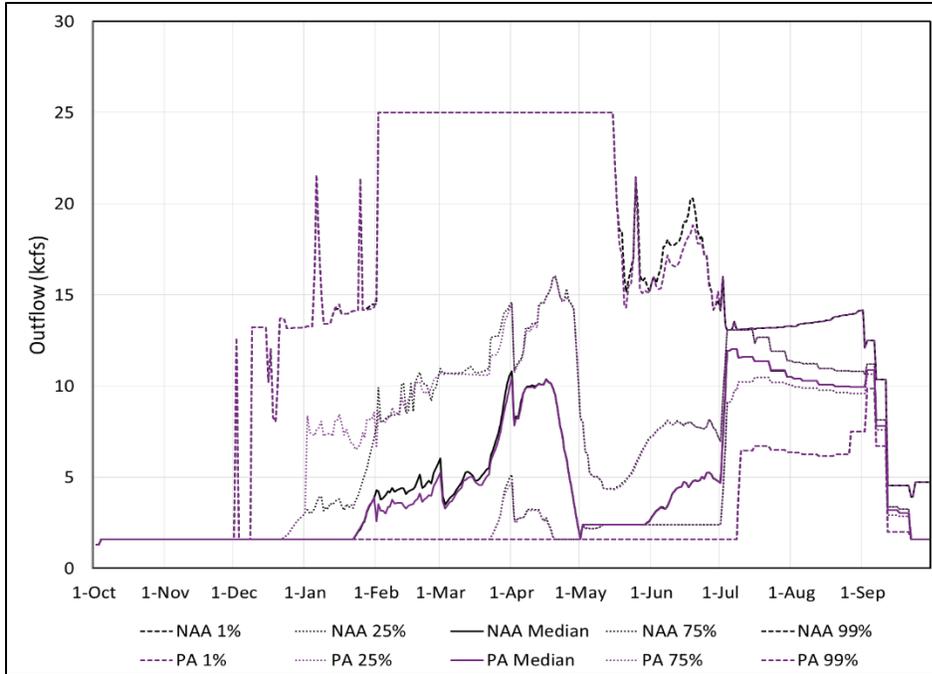
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Finally, Figure 7-15 shows median hydrographs for Dworshak Dam outflow in dry, average, and wet years. The figure provides another way to picture the effects described above, this time categorized by water year type.

1788

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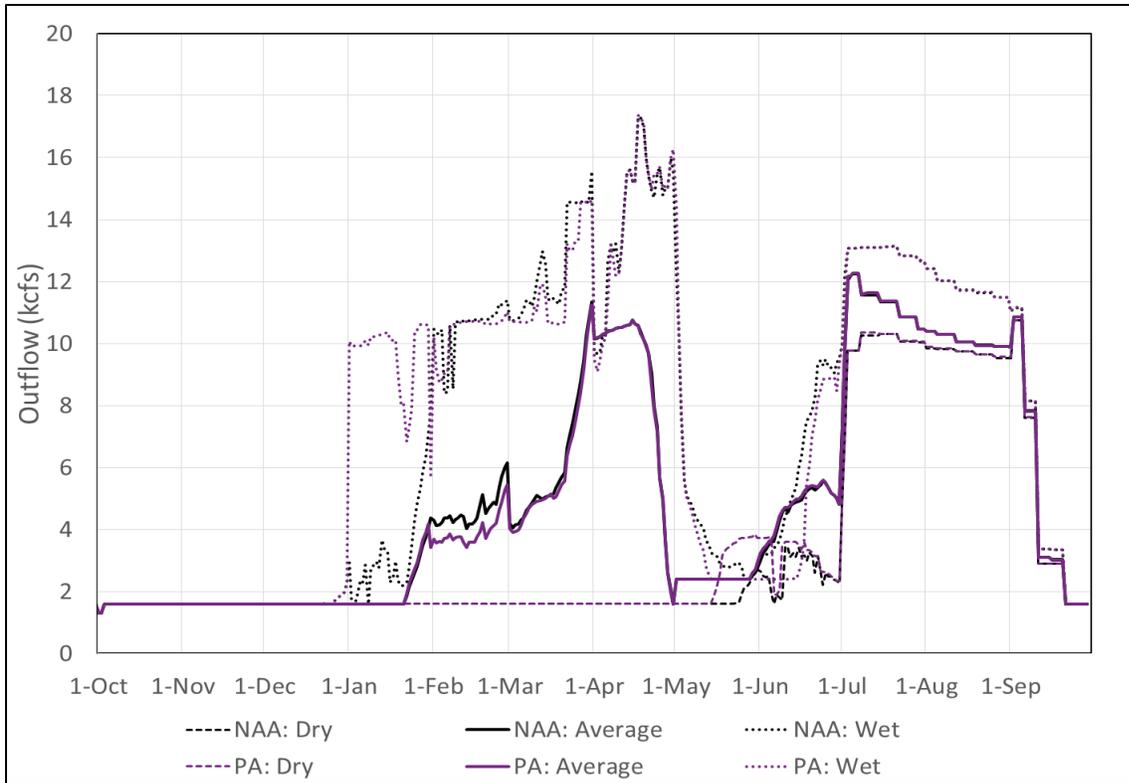


1790
1791 **Figure 7-14. Dworshak Dam Outflow Summary Hydrograph for the Preferred Alternative**

1792 **Table 7-14. Dworshak Dam Monthly Average Outflow for the Preferred Alternative (as change**
1793 **from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
No Action Alternative	Ave. mo. outflow (kcfs)	1%	1.7	1.6	8.7	13.5	23.3	25.0	25.0	17.3	15.6	13.2	13.6	6.4
		25%	1.6	1.6	1.9	4.2	9.3	11.8	13.2	6.2	7.5	11.9	11.0	5.2
		50%	1.6	1.6	1.6	2.1	5.1	6.2	9.6	3.5	4.8	10.7	10.2	5.0
		75%	1.6	1.6	1.6	1.6	1.6	2.3	4.6	2.4	2.4	9.6	9.8	4.8
		99%	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	7.4	9.3	4.5
Preferred Alternative	Change (kcfs)	1%	0.0	0.0	0.0	0.0	-1.0	0.0	-1.0	0.0	-0.2	0.0	0.0	0.0
		25%	0.0	0.0	0.0	3.3	-0.7	-0.8	0.0	0.0	0.0	0.0	0.0	0.0
		50%	0.0	0.0	0.0	0.3	-0.8	-0.3	0.0	0.0	0.0	0.0	0.0	0.0
		75%	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0
		99%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Percent change	1%	0%	0%	0%	0%	-4%	0%	-4%	0%	-1%	0%	0%	0%
		25%	0%	0%	0%	77%	-7%	-6%	0%	0%	0%	0%	0%	0%
		50%	0%	0%	0%	12%	-15%	-5%	0%	-1%	0%	0%	0%	0%
		75%	0%	0%	0%	0%	0%	0%	-1%	0%	0%	0%	0%	0%
		99%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

1794 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes the Preferred Alternative
1795 flows lower than the No Action Alternative flows; green shading denotes the Preferred Alternative flows higher
1796 than the No Action Alternative flows.



1797
1798 **Figure 7-15. Dworshak Dam Outflow Water Year Type Hydrographs for the Preferred**
1799 **Alternative**

1800 **Lower Snake River Reservoir Elevations**

1801 Under the Preferred Alternative, the operating reservoir elevation restrictions at the four lower
1802 Snake River projects would be changed to provide operating flexibility during the fish passage
1803 season April 3 through August 31 due to the *Increased Forebay Range Flexibility* measure. At all
1804 four projects, the seasonal MOP range is increased from a 1.0-foot range to a 1.5-foot range,
1805 each with a 0.5-foot increase in the upper end of the range. The proposed elevation ranges for
1806 April 3 to August 31 at each of the four projects are described below:

- 1807 • Lower Granite Dam: the Preferred Alternative would have a MOP range of 733.0 to 734.5
1808 feet NGVD29, compared to 733.0 to 734.0 feet NGVD29 under the No Action Alternative.
- 1809 • Little Goose Dam: the Preferred Alternative would have MOP range of 633.0 to 634.5 feet
1810 NGVD29, compared to 633.0 to 634.0 feet NGVD29 under the No Action Alternative.
- 1811 • Lower Monumental Dam: the Preferred Alternative would have a MOP range of 537.0 to
1812 538.5 feet NGVD29, compared to 537.0 to 538.0 feet NGVD29 under the No Action
1813 Alternative).
- 1814 • Ice Harbor Dam: the Preferred Alternative would have MOP range of 437.0 to 438.5 feet
1815 NGVD29, compared to 437.0 to 438.0 feet NGVD29 under the No Action Alternative).

1816 **Clearwater River below Dworshak Dam and the Lower Snake River**

1817 Under the Preferred Alternative, the pattern of outflow changes from Dworshak Dam in
1818 January through March would continue downstream. While the percent changes in flow from
1819 the No Action Alternative would be pronounced in the Clearwater River system, they would
1820 become diluted at the confluence of the Clearwater River and the Snake River near Lewiston,
1821 Idaho. The *Increased Forebay Range Flexibility* measure at the lower Snake River dams has a
1822 negligible effect on flow through the reach, so all changes are attributable to the *Slightly*
1823 *Deeper Draft for Hydropower at Dworshak* measure in the Preferred Alternative. This is seen in
1824 Table 7-15, which shows changes in median values of monthly average flows.

1825 **Table 7-15. Lower Snake Basin Monthly Average Flows for the Preferred Alternative (as**
1826 **change from No Action Alternative)**

	Location	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
No Action Alternative (kcfs)	Dworshak	1.6	1.6	1.6	2.1	5.1	6.2	9.6	3.5	4.8	10.7	10.2	5.0
	Spalding, ID	3.4	4.5	4.7	5.9	10.6	15.5	26.8	33.4	28.7	17.0	12.2	6.5
	Snake+Clearwater	19.7	20.9	23.9	28.3	39.0	47.2	69.7	94.4	96.4	47.9	29.2	22.6
	Lower Granite	19.8	21.0	23.7	28.4	39.3	48.0	71.8	95.6	97.4	48.6	29.1	22.5
	Ice Harbor	20.2	21.4	24.5	29.4	42.0	50.7	73.0	95.4	97.2	48.4	28.1	21.2
Change (kcfs)	Dworshak	0.0	0.0	0.0	0.3	-0.8	-0.3	0.0	0.0	0.0	0.0	0.0	0.0
	Spalding, ID	0.0	0.0	0.0	0.8	-0.3	-0.7	0.0	0.0	0.0	0.0	0.0	0.0
	Snake+Clearwater	0.0	0.0	0.0	1.6	-0.5	-0.2	-0.1	0.0	0.0	0.0	0.0	0.0
	Lower Granite	0.0	0.0	0.0	1.2	-0.8	-0.2	-0.2	0.0	0.0	0.0	0.0	0.0
	Ice Harbor	0.0	0.0	0.0	1.0	-0.8	-0.3	-0.2	0.0	0.0	0.0	0.0	0.1
Percent Change	Dworshak	0%	0%	0%	12%	-15%	-5%	0%	-1%	0%	0%	0%	0%
	Spalding, ID	0%	0%	0%	13%	-3%	-4%	0%	0%	0%	0%	0%	0%
	Snake+Clearwater	0%	0%	0%	6%	-1%	0%	0%	0%	0%	0%	0%	0%
	Lower Granite	0%	0%	0%	4%	-2%	-1%	0%	0%	0%	0%	0%	0%
	Ice Harbor	0%	0%	0%	3%	-2%	-1%	0%	0%	0%	0%	0%	0%

1827 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes the Preferred Alternative
1828 flows greater than the No Action Alternative flows; green shading denotes the Preferred Alternative flows less than
1829 the No Action Alternative flows.

1830 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

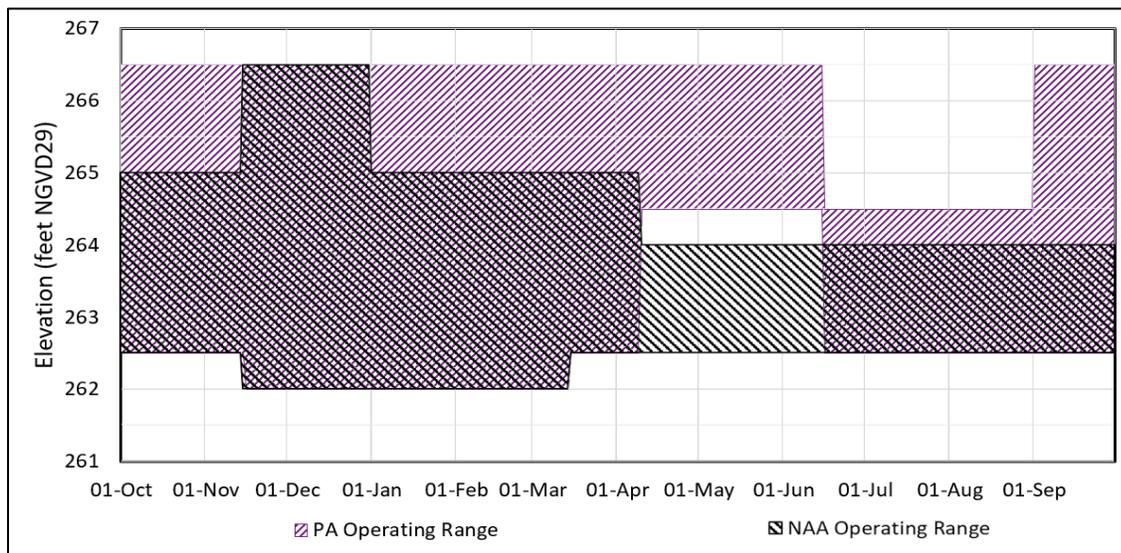
1831 **Lower Columbia River Reservoir Elevations**

1832 Under the Preferred Alternative, there would be no change to the reservoir elevations at
 1833 McNary Dam, The Dalles Dam, or Bonneville Dam. At John Day Dam, the *John Day Full Pool*,
 1834 *Predator Disruption Operations*, and *Increased Forebay Range Flexibility* measures relate to the
 1835 reservoir operating range. The *John Day Full Pool* allows for operation across the full range
 1836 possible outside of fish passage season (September 1 to April 9); the *Predator Disruption*
 1837 *Operations* measure increases the operating range compared to the No Action Alternative from
 1838 April 10 to June 15 to disrupt Caspian tern nesting in the Columbia River Plateau; and the
 1839 *Increased Forebay Range Flexibility* measure provides slightly more forebay operating flexibility
 1840 between June 15 and August 31 by eliminating MOP restrictions when spill is reduced in late
 1841 summer. The John Day Dam operating ranges associated with these measures are listed in
 1842 Table 7-16 and shown graphically in Figure 7-16.

1843 **Table 7-16. Normal Operating Ranges at John Day Reservoir for the Preferred Alternative**

Period	Elevation (feet NGVD29)		Measure
	Minimum	Maximum	
September 1 to November 15	262.5	266.5	John Day Full Pool
November 16 to March 14	262	266.5	
March 15 to April 9	262.5	266.5	
April 10 to June 15	264.5	266.5	Predator Disruption Operations
June 15 to August 31	262.5	264.5	Increased Forebay Range Flexibility

1844 The full operating range (257–268 feet NGVD29) may be used throughout the year if needed for flood risk
 1845 management.



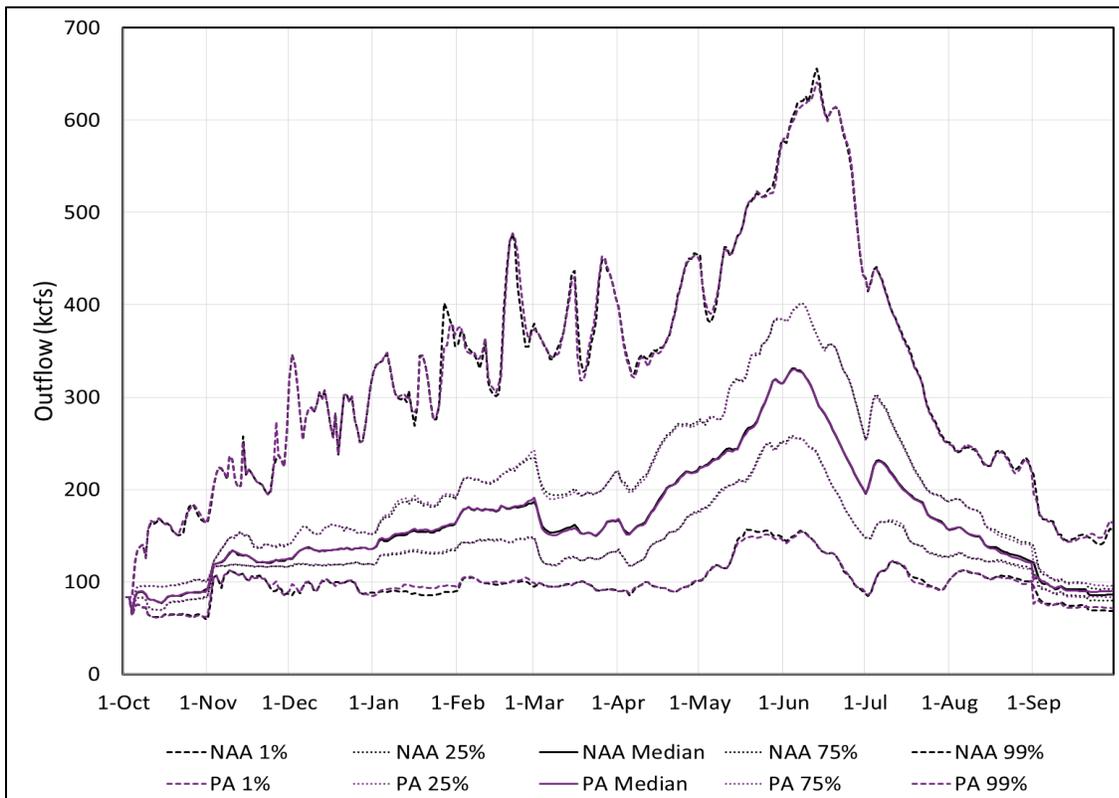
1846 **Figure 7-16. Normal Operating Range at John Day Dam for the Preferred Alternative and the**
 1847 **No Action Alternative**
 1848

1849 Note: John Day may be operated between 257 feet and 268 feet NGVD29 for FRM purposes. These limits are not
 1850 shown on this figure in order to show greater detail in the vertical scale.

1851 **Lower Columbia River Flows**

1852 Under the Preferred Alternative, the *Modified Draft at Libby, Sliding Scale at Libby and Hungry*
 1853 *Horse, Update System FRM Calculation, Planned Draft Rate at Grand Coulee, Lake Roosevelt*
 1854 *Additional Water Supply, Fall Operational Flexibility for Hydropower (Grand Coulee), and Slightly*
 1855 *Deeper Draft for Hydropower at Dworshak* measures would cause changes in flow patterns in
 1856 the lower Columbia River at McNary Dam. Changes in operations at John Day Dam, including
 1857 the *John Day Full Pool, Predator Disruption Operations, and Increased Forebay Range Flexibility*
 1858 measures, would affect John Day outflow and flow through the Columbia River to the Pacific
 1859 Ocean.

1860 At McNary Dam, the outflows under the Preferred Alternative would differ from the No Action
 1861 Alternative to various extents through the water year. The magnitude and timing of differences
 1862 in flow are displayed in Figure 7-17. The change in average monthly outflow is characterized in
 1863 Table 7-17.



1864 **Figure 7-17. McNary Dam Outflow Summary Hydrograph for the Preferred Alternative**
 1865

1866 **Table 7-17. McNary Dam Monthly Average Outflow for the Preferred Alternative (as change**
1867 **from No Action Alternative)**

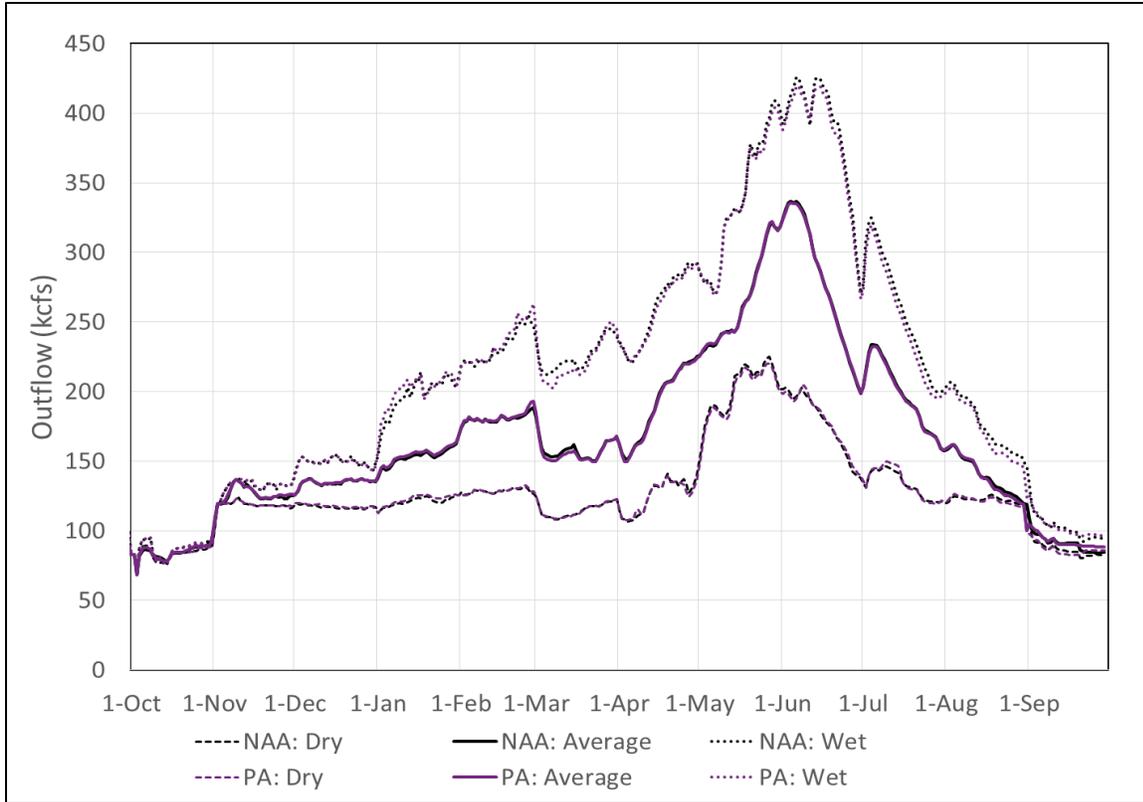
		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
No Action Alternative	Ave. mo. outflow (kcfs)	1%	141	187	279	280	327	329	346	451	562	342	231	152
		25%	95	143	155	181	216	200	236	313	352	243	163	100
		50%	85	124	136	154	182	159	192	260	285	198	141	93
		75%	79	116	118	133	147	130	147	231	217	147	124	87
		99%	73	112	109	108	115	107	106	178	160	122	114	81
Preferred Alternative	Change (kcfs)	1%	0.5	0.3	0.0	3.9	2.2	1.3	-3.5	-0.2	-1.5	-1.7	-0.7	-0.8
		25%	0.4	0.2	0.1	2.7	1.2	-0.9	-2.3	0.3	-1.6	-1.7	-2.3	0.4
		50%	0.4	0.3	0.0	1.9	1.7	-1.0	-1.2	-1.3	-0.2	-1.4	-0.9	0.1
		75%	0.4	0.7	0.8	1.4	-0.8	-0.1	0.1	-1.3	-0.8	0.6	-0.2	0.7
		99%	0.5	0.1	0.3	-1.1	0.6	0.4	0.5	-4.4	-0.9	0.4	-0.7	-0.5
	Percent change	1%	0%	0%	0%	1%	1%	0%	-1%	0%	0%	-1%	0%	-1%
		25%	0%	0%	0%	1%	1%	0%	-1%	0%	0%	-1%	-1%	0%
		50%	0%	0%	0%	1%	1%	-1%	-1%	0%	0%	-1%	-1%	0%
		75%	0%	1%	1%	1%	-1%	0%	0%	-1%	0%	0%	0%	1%
		99%	1%	0%	0%	-1%	1%	0%	0%	-2%	-1%	0%	-1%	-1%

1868 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes the Preferred Alternative
1869 flows greater than the No Action Alternative flows; green shading denotes the Preferred Alternative flows less than
1870 the No Action Alternative flows.

1871 In general, flows in January and February under the Preferred Alternative tend to be higher
1872 than the No Action Alternative, especially in wetter years, and spring and summer flows tend to
1873 be lower than the No Action Alternative. The winter increases are related to the operational
1874 changes at Libby, Grand Coulee, and Dworshak dams, as are the decreases seen in early spring
1875 months. The summer decreases are related mostly to operational changes at Libby, Hungry
1876 Horse, and Grand Coulee dams. The largest increase and decrease in median monthly average
1877 flow, as compared to the No Action Alternative, occurs in January (1.9 kcfs, 1.3 percent) and
1878 July (-1.4 kcfs, -0.7 percent), respectively. All changes are within 2 percent of the No Action
1879 Alternative.

1880 Finally, Figure 7-18 shows median hydrographs for McNary Dam outflow in dry, average, and
1881 wet years. The figure provides another way to picture the effects described above, this time
1882 categorized by water year type.

1883 Changes in flow below John Day Dam are caused by both flow changes coming from upstream
1884 in the Columbia River, evident in McNary Dam outflow, and the flow changes resulting from
1885 operational changes at John Day Dam. Modification to the normal operating range throughout
1886 the years (see the Lower Columbia River Reservoir Elevations section) result in notable changes
1887 in monthly average flows in all seasons. The change in average monthly outflow from John Day
1888 Dam is characterized in Table 7-18. The flow changes seen in John Day Dam outflow generally
1889 continue downstream through The Dalles and Bonneville dams to the Pacific Ocean. Table 7-19
1890 shows the change in median monthly average flows in the Columbia River from the Snake River
1891 confluence to the Cowlitz River confluence 40 miles downstream of Portland.



1892
1893 **Figure 7-18. McNary Dam Outflow Water Year Type Hydrographs for the Preferred**
1894 **Alternative**

1895 **Table 7-18. John Day Dam Monthly Average Outflow for the Preferred Alternative (as change**
1896 **from No Action Alternative)**

		Exceedance Probability	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
No Action Alternative	Ave. mo. outflow (kcfs)	1%	140	192	283	283	335	342	355	452	573	340	225	147
		25%	95	143	158	186	221	205	243	320	355	241	162	100
		50%	85	125	140	156	185	165	198	267	288	197	141	93
		75%	78	116	121	136	150	136	152	235	218	146	123	88
		99%	72	112	111	110	116	110	110	180	162	122	113	80
Preferred Alternative	Change (kcfs)	1%	2.0	0.2	-0.8	4.1	1.2	-0.9	-6.4	0.8	-0.8	-0.6	-0.8	-2.1
		25%	1.5	0.3	-0.8	2.8	1.3	-0.7	-3.7	0.0	0.5	-1.8	-2.7	-0.8
		50%	1.8	0.2	-0.6	1.6	1.6	-0.9	-1.8	-1.5	1.5	-1.2	-0.9	-0.9
		75%	1.7	0.5	-0.9	1.4	-1.3	-0.3	-1.0	-1.8	0.7	-0.1	-0.5	-1.0
		99%	1.8	0.2	-0.4	0.0	1.0	-0.1	0.4	-3.7	0.8	0.1	-1.0	-1.7
	Percent change	1%	1%	0%	0%	1%	0%	0%	-2%	0%	0%	0%	0%	-1%
		25%	2%	0%	-1%	1%	1%	0%	-2%	0%	0%	-1%	-2%	-1%
		50%	2%	0%	0%	1%	1%	-1%	-1%	-1%	1%	-1%	-1%	-1%
		75%	2%	0%	-1%	1%	-1%	0%	-1%	-1%	0%	0%	0%	-1%
		99%	2%	0%	0%	0%	1%	0%	0%	0%	-2%	1%	0%	-1%

1897 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes the Preferred Alternative
1898 flows lower than the No Action Alternative flows; green shading denotes the Preferred Alternative flows higher
1899 than the No Action Alternative flows.

1900 **Table 7-19. Lower Columbia River Median Monthly Average Flows for the Preferred**
1901 **Alternative (as change from No Action Alternative)**

	Location	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
No Action Alternative (kcs)	Columbia + Snake	83	122	134	151	181	157	188	260	288	199	140	91
	McNary	85	124	136	154	182	159	192	260	285	198	141	93
	John Day	85	125	140	156	185	165	198	267	288	197	141	93
	The Dalles	90	130	146	163	192	172	206	273	293	202	146	97
	Bonneville	91	135	152	170	199	179	213	275	296	204	149	99
	Columbia + Willamette	108	178	225	252	267	233	260	314	319	216	159	111
	Columbia + Cowlitz	115	196	257	282	295	255	283	334	336	226	165	117
Change (kcs)	Columbia + Snake	0.2	0.1	0.0	1.6	1.3	-0.9	-1.7	-1.3	-0.2	-1.6	-1.1	0.2
	McNary	0.4	0.3	0.0	1.9	1.7	-1.0	-1.2	-1.3	-0.2	-1.4	-0.9	0.1
	John Day	1.8	0.2	-0.6	1.6	1.6	-0.9	-1.8	-1.5	1.5	-1.2	-0.9	-0.9
	The Dalles	1.5	0.2	-0.5	1.6	1.3	-1.3	-1.8	-1.5	1.5	-1.2	-1.2	-0.9
	Bonneville	1.8	0.6	-0.9	1.1	1.6	-1.4	-1.9	-1.8	1.6	-1.4	-1.1	-1.2
	Columbia + Willamette	2.0	1.5	-0.8	1.5	1.5	-1.1	-2.1	-0.8	1.6	-1.2	-1.1	-1.2
	Columbia + Cowlitz	1.8	1.4	-0.7	1.0	0.5	-1.2	-1.9	-0.4	0.9	-0.9	-0.9	-1.2
Percent Change	Columbia + Snake	0%	0%	0%	1%	1%	-1%	-1%	-1%	0%	-1%	-1%	0%
	McNary	0%	0%	0%	1%	1%	-1%	-1%	0%	0%	-1%	-1%	0%
	John Day	2%	0%	0%	1%	1%	-1%	-1%	-1%	1%	-1%	-1%	-1%
	The Dalles	2%	0%	0%	1%	1%	-1%	-1%	-1%	1%	-1%	-1%	-1%
	Bonneville	2%	0%	-1%	1%	1%	-1%	-1%	-1%	1%	-1%	-1%	-1%
	Columbia + Willamette	2%	1%	0%	1%	1%	0%	-1%	0%	1%	-1%	-1%	-1%
	Columbia + Cowlitz	2%	1%	0%	0%	0%	0%	-1%	0%	0%	0%	-1%	-1%

1902 Note: Values for the No Action Alternative are shaded gray. Orange shading denotes the Preferred Alternative
1903 flows lower than the No Action Alternative flows; green shading denotes the Preferred Alternative flows higher
1904 than the No Action Alternative flows.

1905 The largest changes in median monthly flow in the Lower Columbia River below John Day Dam
1906 occur in October and April, though both typically have less than 2 kcs change. The percent
1907 change in median monthly average flow below John Day Dam is within 1 percent of the No
1908 Action Alternative for all months except October, which is 2 percent. The flow changes for
1909 various months are linked to the measures most responsible below:

- 1910 • The flow change in October, which can mostly be attributed to the *John Day Full Pool*
1911 measure, translates to a 2 percent increase in average monthly flow downstream of the
1912 project. This measure is also responsible for the smaller changes in average monthly flow in
1913 December and September. This is because John Day is modeled to hold a single elevation
1914 from September to early April instead of filling and drafting as it does in the No Action
1915 Alternative during that time.
- 1916 • The increase in January and February flows are caused by operational changes further
1917 upstream at Grand Coulee and Libby dams, as are the decreases in March, May, July, and
1918 August.

1919 • The decrease in April flow is attributed to combined effect of the *Modified Draft at Libby*
1920 measure, the *Update System FRM Calculation* and *Lake Roosevelt Additional Water Supply*
1921 measures at Grand Coulee Dam, and the *Predator Disruption Operations* measure at John
1922 Day Dam.

1923 • The increase in June flow is mostly attributed to the *Predator Disruption Operations*
1924 measure.

1925 **SUMMARY OF EFFECTS**

1926 Water level changes under the Preferred Alternative are generally much smaller than those
1927 under the other MOs, with moderate changes common only at Libby, and major changes
1928 occurring only at Dworshak in the winter in some years. At Libby Dam, Lake Kocanusa has
1929 minor to moderate decreases in water levels in lower and average forecast years in the winter
1930 and spring, followed by a minor increase in water levels in the summer with increased refill
1931 probability. Hungry Horse has negligible increases in reservoir levels throughout the year with
1932 minor to moderate increases occurring in the late summer and early fall in the lower 20 percent
1933 of years. At Grand Coulee Dam, Lake Roosevelt water levels can be slightly lower from February
1934 through April in very high forecast years, otherwise changes are negligible. Dworshak water
1935 levels can also be moderately lower January through February in larger forecast years, with
1936 major decreases occurring in 5 percent of years. Change in operating ranges at John Day Dam
1937 result in minor but consistent increases in the elevation range over which water levels can
1938 fluctuate under normal operations. Elevations at the lower Snake and other lower Columbia
1939 River projects are not projected to change substantially.

1940 The largest changes to river flow occur immediately below Libby and Dworshak dams, and the
1941 largest total flow changes occur below Grand Coulee and through the lower Columbia River
1942 projects. At Libby Dam, there are minor to moderate flow increases in January, February, and
1943 March, followed by negligible to minor flow decreases in April and May. Most years have a
1944 negligible to minor decrease in the summer flows, but dry years in the summer have a minor
1945 flow increases at Libby Dam. Negligible to minor flow decreases occur immediately downstream
1946 of Hungry Horse Dam in the summer, resulting in negligible changes downstream through the
1947 Flathead, Clark Fork, and Pend Oreille River systems. Flow changes downstream of Grand
1948 Coulee are negligible, within 2 percent of the No Action Alternative. Dworshak Dam has a
1949 moderate increase in January outflow in wetter years, followed by minor decreases in February
1950 and March. Flow changes below John Day Dam are negligible, typically within 1 percent of the
1951 No Action Alternative. Flows at the lower Snake and other lower Columbia River projects are
1952 not projected to change substantially.

1953 The amount of water spilled at each project was modeled using a spill allocation methodology
1954 described in the H&H Appendix (Appendix B, Part 2, *Spill Analysis*). Table 7-20 summarizes the
1955 spill operations for the Preferred Alternative and the No Action Alternative. Further details and
1956 modeling results from the extended year dataset (water years 2008 through 2016) are
1957 presented and discussed in the H&H Appendix (Appendix B, Part 2, *Spill Analysis*).

1958 **Table 7-20. Summary of Spill Operations for the Preferred Alternative and No Action**
1959 **Alternative**

Project	Alternative	Start Date	End Date	Spill Operation
Bonneville (Region D)	No Action Alternative	April 10	June 15	100 kcfs
		June 16	August 31	Alternating between 85/121 kcfs day/night and 95 kcfs in 2-day treatments
	Preferred Alternative	April 10	June 15	125% Daily Flex: 150 kcfs (spillway limitation) 16 hrs/100 kcfs 8 hrs
		June 16	August 14	95 kcfs
		August 15	August 31	55 kcfs
The Dalles (Region D)	No Action Alternative	April 10	August 31	40% Total Outflow
	Preferred Alternative	April 10	August 14	40% Total Outflow
		August 15	August 31	30% Total Outflow
John Day (Region D)	No Action Alternative	April 10	April 26	30% Total Outflow
		April 27	July 20	Alternating between 30% and 40% in 2-day treatments
		July 21	August 31	30% Total Outflow
	Preferred Alternative	April 10	June 15	120% Daily Flex: 146 kcfs 16 hrs/32% Total Outflow 8 hrs
		June 16	August 14	35% Total Outflow
		August 15	August 31	20 kcfs
McNary (Region D)	No Action Alternative	April 10	June 15	40% Total Outflow
		June 16	August 31	50% Total Outflow
	Preferred Alternative	04-10	06-15	125% Daily Flex: 265 kcfs 16 hrs/48% Total Outflow 8 hrs
		06-16	08-14	57% Total Outflow
08-15	08-31	20 kcfs		
Ice Harbor (Region C)	No Action Alternative	April 03	April 27	45 kcfs day/gas cap night
		April 28	July 13	Alternating between 45 kcfs/gas cap day/night and 30% in two/day treatments
		July 14	August 31	45 kcfs day/gas cap night
	Preferred Alternative	April 03	June 20	125% Daily Flex: 119 kcfs 16 hrs/30% Total Outflow 8 hrs
		June 21	August 14	30% Total Outflow
		August 15	August 31	8.5 kcfs
Lower Monumental (Region C)	No Action Alternative	April 03	June 20	33 kcfs (Waiver Gas Cap)
		June 21	August 31	17 kcfs
	Preferred Alternative	April 03	June 20	125% Daily Flex: 98 kcfs 16 hrs/30 kcfs 8 hrs
		June 21	August 14	17 kcfs
		August 15	August 31	7 kcfs

Project	Alternative	Start Date	End Date	Spill Operation
Little Goose (Region C)	No Action Alternative	April 03	August 31	30% Total Outflow
	Preferred Alternative	April 03	June 20	125% Daily Flex: 79 kcfs 16 hrs/30% Total Outflow 8 hrs
		June 21	August 14	30% Total Outflow
		August 15	August 31	overridden by ASW req: 7.2 kcfs
Lower Granite (Region C)	No Action Alternative	April 03	June 20	20 kcfs
		June 21	August 31	18 kcfs
	Preferred Alternative	April 03	June 20	125% Daily Flex: 72 kcfs 16 hrs/20 kcfs 8 hrs
		June 21	August 14	18 kcfs
		August 15	August 31	7 kcfs

1960 Note: ASW = adjustable spillway weir; TDG = total dissolved gas. The Region B run-of-river projects (Wells, Rocky
1961 Reach Rock Island, Wanapum, and Priest Rapids dams) are unchanged from No Action Alternative. The major
1962 storage projects do not include modeled fish spill.

1963 **7.7.2 River Mechanics**

1964 Consistent with Chapter 3.3, the effects to river mechanics were evaluated against seven
1965 metrics for the four physiographic regions of the CRS study area. Detailed information is
1966 presented in Appendix C. The storage reservoirs were evaluated for three of the seven metrics:
1967 trap efficiency (the rate at which the reservoir holds sediment); shoreline exposure, which
1968 describes the change in the number of days that a reservoir spends at any elevation to identify
1969 change in shoreline exposure and indicate the potential for change in shoreline erosion; and
1970 head of reservoir mobilization, which describes the potential change in sediment scour and
1971 deposition patterns at the head (most upstream portion) of a reservoir. Under the Preferred
1972 Alternative, the effects to the storage projects in Region A is estimated to be negligible with the
1973 exception of the Kootenai River entering Lake Kookanusa upstream of Libby Dam where there is
1974 potential for a minor change in depositional patterns with temporary head-of-reservoir
1975 deposits shifting downstream. The ultimate long-term fate of head-of-reservoir sediments
1976 within the reservoir is unchanged given no changes in the Libby Dam operational range. The
1977 storage project effects in Regions B and C are estimated to be negligible due to the combined
1978 operational changes upstream and within this region would not translate into movement of
1979 sediments as compared to the No Action Alternative. In Region D, the effects to the storage
1980 projects were estimated to be negligible with the exception of the Columbia River entering John
1981 Day Reservoir where there is potential for a minor decrease in head-of-reservoir sediment
1982 mobilization due to deposits becoming finer.

1983 The run-of-river reservoirs and free-flowing reaches were evaluated using three metrics to
1984 determine the potential for changes in the size of bed material (e.g., transition from medium
1985 grained to fine grained sediment), the potential for sediment passing through a reservoir or
1986 reach, and the potential for change to the width-to-depth ratio as a surrogate for geomorphic
1987 change. With the exception of a minor change in the John Day reservoir, the Preferred
1988 Alternative effects to CRS run-of-river projects for these three metrics relative to the No Action

1989 Alternative are estimated to be negligible indicating that related processes will continue at the
1990 magnitudes and rates to those historically experienced. In the John Day reservoir, there is
1991 potential for a minor amount of bed sediment to become finer due to changes in reservoir
1992 elevations relative to the No Action Alternative. The final run-of-river metric evaluated
1993 potential changes to navigation channel dredging volumes in the Snake River and Lower
1994 Columbia River. Estimated results for the Preferred Alternative indicate negligible impacts due
1995 to the operational changes resulting in less than 1 percent dredging volume change relative to
1996 the No Action Alternative for both rivers.

1997 **7.7.3 Water Quality**

1998 **7.7.3.1 Region A – Libby, Hungry Horse, and Albeni Falls Dams**

1999 **WATER QUALITY**

2000 **Water Temperature**

2001 In general, the water temperature response at the Libby and Hungry Horse Dams are expected
2002 to be similar to the No Action Alternative. However, slight changes in water temperature
2003 downstream of Libby Dam could occur from Preferred Alternative operations that cause an
2004 increase in median monthly outflows, from January through March, to draft the reservoir
2005 deeper (Appendix D, *Water Quality*). During the cold winter months, Kootenai River water can
2006 cool by several degrees between Libby Dam and Bonners Ferry if flows are held low. By
2007 increasing winter flows to draft the reservoir deeper, the Preferred Alternative may prevent the
2008 natural cooling of the river as it moves downstream. These higher winter temperatures in the
2009 Kootenai River may affect certain fish species, such as burbot, which require near freezing river
2010 temperatures (<35°F or <2°C) to spawn. Overall, the Preferred Alternative is expected to result
2011 in negligible to minor changes in water temperature as compared to the No Action Alternative
2012 downstream of Libby Dam, and negligible to no effects downstream of Hungry Horse Dam.

2013 There are no changes to operations expected at Albeni Falls Dam under the Preferred
2014 Alternative, so the temperature conditions in Lake Pend Oreille and the Pend Oreille River are
2015 expected to remain unchanged and reflect conditions as described in the No Action Alternative.

2016 **Total Dissolved Gas**

2017 In general, the Preferred Alternative would have little to no impact on TDG conditions below
2018 Libby, Hungry Horse, and Albeni Falls Dams as compared to the No Action Alternative.

2019 Libby Dam is operated to minimize spill. Under the Preferred Alternative, Libby Dam's draft and
2020 refill operations would be modified, resulting in a minor increase in spill compared to the No
2021 Action Alternative. For the 80-year period from 1928 to 2008, model results predict 11 years
2022 with spill under the Preferred Alternative compared to 2 years when spill would occur for the
2023 No Action Alternative. In those years identified as having spill at Libby Dam, the model predicts
2024 35 days with TDG exceeding 110 percent for the Preferred Alternative versus 8 days with TDG

2025 exceedances under the No Action Alternative. Regardless, Libby Dam is not expected to spill
2026 frequently under the Preferred Alternative, so downstream TDG saturations should remain less
2027 than 110 percent the majority of time (Appendix D, *Water Quality*).

2028 TDG below Hungry Horse Dam under the Preferred Alternative is expected to be relatively
2029 similar to the No Action Alternative in most years. Spill at Hungry Horse Dam would increase
2030 slightly in a few years due to the increase in carryover in some dry years from the *Sliding Scale*
2031 *at Libby and Hungry Horse* measure; the duration of spill would decrease in most years
2032 compared to the No Action Alternative. Overall, the Preferred Alternative and No Action
2033 alternatives are similar in the number of exceedance days; the effects are considered negligible.

2034 Albeni Falls Dam spill is highly dependent on runoff volumes. Historically, Albeni Falls Dam spills
2035 most years. Because there is no change in Albeni Falls Dam operations between the Preferred
2036 Alternative and the No Action Alternative, spillway operations and TDG conditions under the
2037 Preferred Alternative are expected to remain unchanged.

2038 **Other Physical, Chemical, and Biological Processes**

2039 The Preferred Alternative modifies operations at Libby Dam resulting in changes in the drafting
2040 depth and refill elevations of Lake Kooconusa that may impact physical, chemical, and biological
2041 water quality parameters when compared to the No Action Alternative. The Preferred
2042 Alternative reservoir elevations and outflows during median and high water supply years would
2043 be relatively similar to the No Action Alternative, and water quality changes are not anticipated.
2044 However, for low water supply years, the reservoir would be drafted deeper with mid-April
2045 water elevations up to 8 feet lower in the driest 40 percent of years. Reservoir refill and
2046 summer reservoir elevations for all water supply years are improved over the No Action
2047 Alternative with the reservoir reaching full by the end of July and maintaining higher elevations
2048 (about 1 to 4 feet higher) in August and September. For water quality concerns, of particular
2049 interest are the 8 foot lower mid-April water elevations for low water supply years because
2050 they equate to less volume of water in Lake Kooconusa during the spring runoff and a shorter
2051 water retention time. Retention time, which is the inverse of the flushing rate, refers to the
2052 length of time water remains in a waterbody. It is possible that shorter retention times may
2053 allow certain chemical constituents (nutrients such as phosphorus and nitrogen or metals such
2054 as selenium) to move farther down-reservoir toward the forebay and outflow before settling
2055 out or transforming. Overall, these impacts are anticipated to be negligible.

2056 Negligible impacts to the physical, chemical, or biological processes at Hungry Horse Reservoir
2057 and the South Fork Flathead River downstream of the dam, are expected under the Preferred
2058 Alternative as compared to the No Action Alternative. This is because the *Sliding Scale at Libby*
2059 *and Hungry Horse* only result in slight changes in elevations and flows compared to the No
2060 Action Alternative.

2061 There are no proposed changes to operations in the Preferred Alternative at Albeni Falls. Water
2062 quality conditions of Lake Pend Oreille and the Pend Oreille River are not expected to change

2063 under the Preferred Alternative as compared to the No Action Alternative. Conditions would
2064 remain as described in Chapter 3, Section 3.4.2, and Appendix D, Section 3.1.3.

2065 **SEDIMENT QUALITY**

2066 Operational changes at Libby and Hungry Horse Dams under the Preferred Alternative are not
2067 expected to affect sediment movement downstream in the Kootenai and Flathead Rivers,
2068 respectively. The Preferred Alternative would not impact Albeni Falls Dam operations and
2069 would not affect sediment sources or movement.

2070 **7.7.3.2 Region B – Grand Coulee and Chief Joseph Dams**

2071 **WATER QUALITY**

2072 **Water Temperature**

2073 Under the Preferred Alternative, the *Update System FRM Calculation, Planned Draft Rate at*
2074 *Grand Coulee, Fall Operational Flexibility for Hydropower (Grand Coulee), Lake Roosevelt*
2075 *Additional Water Supply, and Grand Coulee Maintenance Operations* measures would be
2076 implemented at Grand Coulee Dam. All of these measures (with the exception of *Lake*
2077 *Roosevelt Additional Water Supply and Grand Coulee Maintenance Operations*) would influence
2078 reservoir elevations at Lake Roosevelt; negligible effects to water temperature are anticipated
2079 (Appendix D, *Water Quality*).

2080 Model results predict little change in Rufus Woods Lake forebay elevations for the Preferred
2081 Alternative when compared to the No Action Alternative (Appendix D, *Water Quality*). Monthly
2082 outflows from Chief Joseph Dam are predicted to be similar to or about 1 percent less than the
2083 No Action Alternative for all types of water years. Consequently, modeled temperatures under
2084 the Preferred Alternative downstream of Chief Joseph Dam are similar to the No Action
2085 (Appendix D, *Water Quality*). Tailrace temperatures under both the Preferred Alternative and
2086 No Action Alternative are predicted to exceed the Washington State water quality standard of
2087 63.5F (17.5°C) as measured by the 7-day average of the daily maximum temperature in August
2088 and September. Existing water quality monitoring would continue under the Preferred
2089 Alternative. Similar to the No Action Alternative, there is little difference in temperature
2090 between Grand Coulee Dam and Chief Joseph Dam under the Preferred Alternative, showing
2091 that water temperatures below Lake Roosevelt are unchanged through Rufus Woods Lake.

2092 **Total Dissolved Gas**

2093 Under the Preferred Alternative, TDG downstream of Grand Coulee Dam ranges from 95
2094 percent to 125 percent; historically TDG in excess of 125 percent has been recorded and is still
2095 possible under the Preferred Alternative depending on inflowing TDG and flow conditions. The
2096 *Grand Coulee Maintenance Operations* measure reduces power plant hydraulic capacity and
2097 the *Planned Draft Rate at Grand Coulee* measure allows for earlier draft in wetter years. The
2098 combination of these two measures could affect TDG below the dam, but these measures tend

2099 to partially offset each other in this analysis resulting in negligible changes from the No Action
2100 Alternative Preferred Alternative (Appendix D, *Water Quality*).

2101 In general, predicted Preferred Alternative TDG saturations in Lake Roosevelt are similar to the
2102 No Action Alternative for the different flow and air temperature conditions modeled (Appendix
2103 D, *Water Quality*). Operations of the spill deflectors at Chief Joseph Dam would continue to
2104 decrease TDG saturations between the forebay and tailrace during high flow and high spill
2105 years, consistent with the Preferred Alternative. Overall TDG impacts at Chief Joseph Dam
2106 under the Preferred Alternative as compared to the No Action Alternative are expected to be
2107 negligible.

2108 **Other Physical, Chemical, and Biological Processes**

2109 Turbidity from bank erosion within Lake Roosevelt, is correlated to the rate of drawdown and
2110 refill at Grand Coulee Dam. The operational measure to decrease the *Planned Draft Rate at*
2111 *Grand Coulee* changes the target maximum drawdown from 1.0 ft/day to a target of 0.8 ft/day.
2112 A slower drawdown rate may result in lower turbidity throughout the reservoir. Under the
2113 Preferred Alternative, the *Update System FRM Calculation, Planned Draft Rate at Grand Coulee,*
2114 *and Fall Operational Flexibility for Hydropower* measures are all predicted to influence Lake
2115 Roosevelt reservoir elevations. However, changes in reservoir elevation are small and are not
2116 predicted to impact mercury cycling (Appendix D, *Water Quality*). Overall, impacts to water
2117 quality within Lake Roosevelt are anticipated to be negligible as compared to the No Action
2118 Alternative.

2119 Under the Preferred Alternative, only minor changes to operations, reservoir elevations, and
2120 flows at Chief Joseph Dam are expected. Given this, the physical, chemical, and biological water
2121 quality of Rufus Woods Lake and the Columbia River downstream of Chief Joseph Dam under
2122 the Preferred Alternative are expected to remain relatively unchanged from the No Action
2123 Alternative.

2124 **SEDIMENT QUALITY**

2125 Under the Preferred Alternative, the *Update System FRM Calculation, Planned Draft Rate at*
2126 *Grand Coulee,* and *Fall Operational Flexibility for Hydropower* measures are all predicted to
2127 influence Lake Roosevelt reservoir elevations. However, changes in reservoir elevation are small
2128 (Appendix D, *Water Quality*). No operational changes are proposed for Chief Joseph project in
2129 the Preferred Alternative. Negligible changes are expected to sediment quality in Region B
2130 under the Preferred Alternative.

2131 **7.7.3.3 Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice**
2132 **Harbor Dams**

2133 **WATER QUALITY**

2134 **Water Temperature**

2135 Outflow water temperatures from Dworshak Dam under the Preferred Alternative would be
2136 very similar to No Action Alternative conditions (Appendix D, Water Quality). Daily average and
2137 maximum temperatures would be less than 52°F throughout the year. Water temperatures in
2138 the lower Snake River under the Preferred Alternative would be very similar to the No Action
2139 Alternative as well; any differences predicted between the two alternatives are due to the way
2140 reservoir elevations were modeled under the Preferred Alternative (these differences are
2141 discussed in more detail in Appendix D, see Table 8-2). Differences between the Preferred
2142 Alternative and No Action Alternative are not anticipated during implementation. Water
2143 temperatures, as predicted by the ResSim and water quality models, show maximum daily
2144 temperatures of less than 68°F most of the time between April and September downstream of
2145 Lower Granite Dam; the water quality standard would be exceeded for about 5 days during a
2146 LF/AT (low flow, average air temperature) year, and 17 days during a LF/HT (low flow, high air
2147 temperature) year. At the Little Goose and Lower Monumental projects, the frequency of
2148 exceeding the water quality standard downstream from the dam during an average-flow year
2149 would be 38 and 45 days, respectively. The frequency of exceedances downstream of Little
2150 Goose Dam would increase during low flow years to 47 and 60 days under average and high air
2151 temperature conditions, respectively. Exceedances downstream of Lower Monumental Dam
2152 would increase to 69 days regardless of the air temperatures. Water temperatures downstream
2153 of Ice Harbor Dam would be warmer than the other three projects, with the frequency of
2154 exceeding 68°F (20°C) ranging from 28 days during a high flow year to 73 days during a low
2155 flow, high air temperature year. Tailrace temperatures could surpass 72°F (22°C) at Ice Harbor
2156 Dam during AF/AT and LF /HT years. Overall, however, water temperature impacts are
2157 expected to be negligible under the Preferred Alternative and similar to that of the No Action
2158 Alternative.

2159 **Total Dissolved Gas**

2160 TDG downstream from Dworshak Dam under the Preferred Alternative would be very similar to
2161 the No Action Alternative model results. TDG would remain below the 110 percent water
2162 quality standard the majority of the time for each of the five flow and air temperature
2163 conditions modeled. TDG impacts downstream of Dworshak Dam are negligible.

2164 The Preferred Alternative contains the *Juvenile Fish Passage Spill* measure, which is based on
2165 the results of the spring 2019 Flexible Spill Test Operation and analyses of the four MO
2166 Alternatives. The *Juvenile Fish Passage Spill* measure would be implemented during the spring
2167 juvenile salmonid migration season at the lower Snake River and involve 16 hours of spill

2168 operations up to the 125 percent TDG gas cap at most projects for juvenile outmigration. For
2169 the remaining 8 hours, the projects would spill at a lower level (this level is referred to as
2170 performance standard spill). These performance standard spill levels are slightly variable
2171 depending on the project, and may be slightly higher or lower depending on river conditions
2172 and the opportunity to spill. This operation would allow hydropower generation during times of
2173 peak demand, while still providing for higher spill for fish when it is expected to be most
2174 important (generally in the evenings and very early morning hours). These operations would be
2175 implemented during the downstream juvenile migration season, which at the lower Snake River
2176 projects occurs from April 3 through June 20. When *Juvenile Fish Passage Spill* ceases, the
2177 projects would transition to summer spill operations.

2178 Tailrace TDG would increase at the four lower Snake River projects under the Preferred
2179 Alternative due to the *Juvenile Fish Passage Spill* measure that would allow for spill up to 125
2180 percent TDG 16 hours per day, from the beginning of April through the third week of June.
2181 Under the No Action Alternative, spill was limited to 120 percent TDG (Appendix D, *Water*
2182 *Quality*). During the April through August fish passage season, there would be increases in the
2183 percent of time that TDG would be between 120 percent and 125 percent during each of the
2184 five flow and air temperature conditions modeled.

2185 **Other Physical, Chemical, and Biological Processes**

2186 *Slightly Deeper Draft for Hydropower (Dworshak)* has small impacts to flow and elevations in
2187 the spring. These changes are not anticipated to impact physical, chemical and biological
2188 conditions in Dworshak Reservoir and the four lower Snake River reservoirs under the Preferred
2189 Alternative as compared to the No Action Alternative.

2190 **SEDIMENT QUALITY**

2191 Consistent with *Slightly Deeper Draft for Hydropower (Dworshak)* as described, negligible
2192 changes are expected to sediment quality in Region C under the Preferred Alternative.

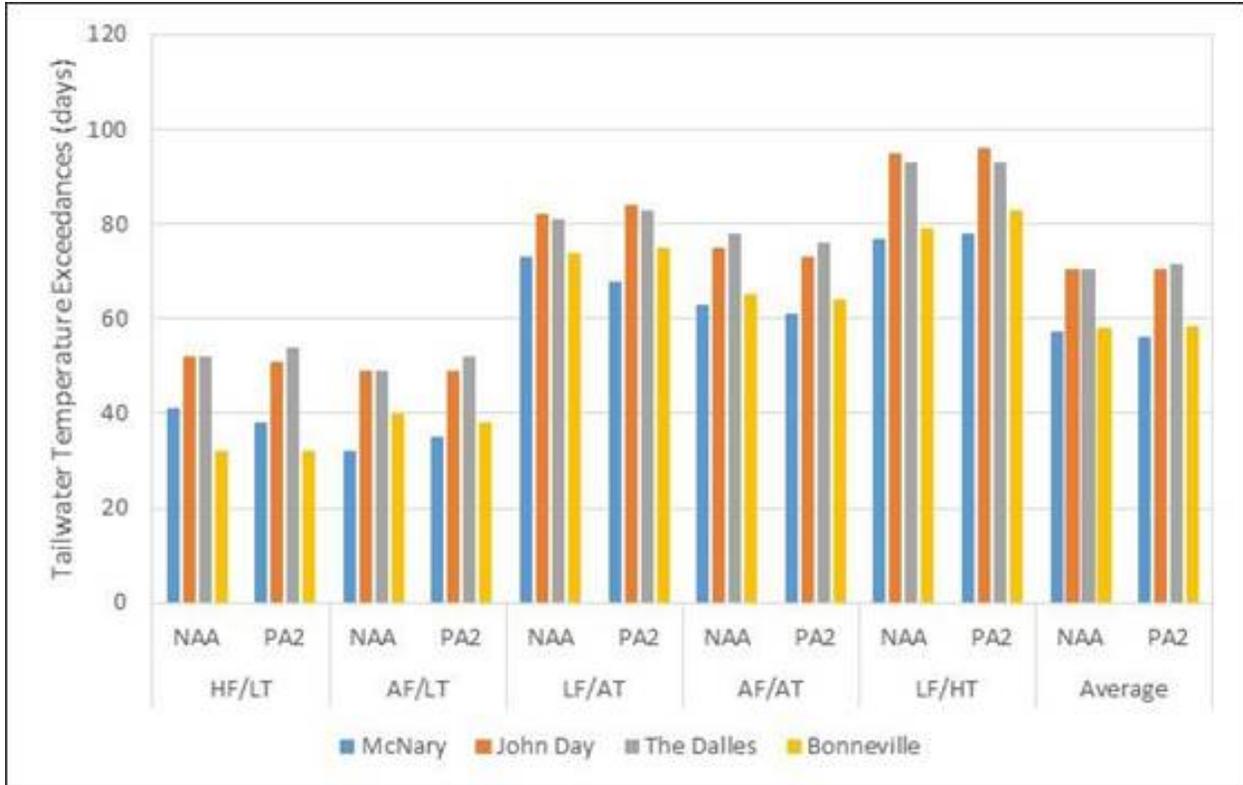
2193 **7.7.3.4 Region D – McNary, John Day, The Dalles, and Bonneville Dams**

2194 **WATER QUALITY**

2195 **Water Temperature**

2196 Water temperatures in the lower Columbia River under the Preferred Alternative would be very
2197 similar to the No Action Alternative. Just as with the No Action Alternative model results, the
2198 Preferred Alternative model results show that tailwater temperatures can exceed 68°F at all
2199 four dams during any of the years and conditions presented; and maximum water
2200 temperatures, and the frequency of water temperature violations of state water quality
2201 standards would be higher during a year when river flows are lower than normal and summer
2202 ambient air temperatures are higher (as in LF/HT). The average frequency of water temperature
2203 violations of the state water quality standards would be nearly identical for the No Action

2204 Alternative and the PA for all four lower Columbia River dams (Figure 7-19). Under the No
2205 Action, the State water quality standard for temperature is violated on average (for the five
2206 years simulated) 57, 71, 71 and 58 days downstream of McNary, John Day, The Dalles and
2207 Bonneville dams, respectively. As comparison, under the Preferred Alternative, the State water
2208 quality standard is violated (on average for the five years simulated) 63, 71, 72, and 59 days
2209 downstream of McNary, John Day, The Dalles and Bonneville dams, respectively. The
2210 differences in tailwater temperatures under the No Action Alternative and the Preferred
2211 Alternative are considered negligible.



2212
2213 **Figure 7-19. Frequency of Modeled Tailwater Temperature Violations of State Water Quality**
2214 **Standards the Preferred Alternative and No Action Alternative at McNary, John Day, The**
2215 **Dalles, and Bonneville Dams Under a 5-year Range of River and Meteorological Conditions**

2216 **Dissolved Gas**

2217 Similar to that described for the lower Snake River projects in Region C, the *Juvenile Fish*
2218 *Passage Spill* measure would be implemented at the lower Columbia River projects during the
2219 downstream juvenile outmigration season from April 10 through June 16. When *Juvenile Fish*
2220 *Passage Spill* ceases, the projects would transition to summer spill operations.

2221 Maximum forebay TDG saturations would be higher during a year when river flows were higher
2222 than normal (Appendix D, *Water Quality*). Forebay TDG saturations would be similar under the
2223 Preferred Alternative and the No Action Alternative for McNary Dam during spill season. At
2224 John Day, The Dalles, and Bonneville, forebay TDG saturations would be similar under the

2225 Preferred Alternative as compared to the No Action Alternative, except for some periods in the
2226 early parts of juvenile fish passage spill season when TDG saturations under the Preferred
2227 Alternative would be higher than those for the No Action Alternative. Tailrace TDG saturations
2228 in the Preferred Alternative would be generally similar to those for the No Action Alternative
2229 for all four dams during juvenile fish passage spill season, though there are periods during
2230 juvenile fish passage spill season where Preferred Alternative TDG saturations would be higher
2231 or lower than for the No Action Alternative. This is likely due to the assumed higher amount of
2232 lack of market spill used in the analysis of the No Action Alternative; model results do not show
2233 a notable difference in tailrace TDG in the Preferred Alternative as compared to the No Action
2234 Alternative. TDG effects are negligible in Region D.

2235 **Other Physical, Chemical, and Biological Processes**

2236 For Region D, the combination of all operational changes upstream result in similar flows and
2237 elevations in this region. An exception is the small change in elevation at the John Day Reservoir
2238 due to *Predator Disruption Operation* and *John Day Full Pool* measures. Therefore, the
2239 Preferred Alternative would result in no change to the physical, chemical, or biological water
2240 quality impairments.

2241 **SEDIMENT QUALITY**

2242 Negligible changes are expected to sediment quality in Region D under the Preferred
2243 Alternative.

2244 **7.7.3.5 Summary of Effects**

2245 Although the effects of the Preferred Alternative differ across the various projects in terms of
2246 water and sediment quality, they can generally be categorized as follows:

2247 In Region A, the Preferred Alternative is expected to have negligible to minor effects to water
2248 temperatures and TDG conditions at the projects when compared to what would occur under
2249 the No Action Alternative. Minimal changes to the physical, chemical, or biological processes in
2250 most locations in Region A would occur. Elevated concentrations of selenium and nitrate-
2251 nitrogen in Lake Koochanusa and the Kootenai River downstream may occur due to the reduced
2252 reservoir elevations and residence time of water within the reservoir. Lastly, the Preferred
2253 Alternative would not impact turbidity or sediment concentrations in the region. Overall, these
2254 effects are expected to be negligible to minor.

2255 In Region B, the Preferred Alternative is expected to have negligible effects on water
2256 temperatures and TDG when compared to the No Action Alternative. In addition, changes in
2257 reservoir elevation within Lake Roosevelt and Rufus Woods Lake are small and are not
2258 predicted to impact the physical, chemical, or biological processes in the reservoirs as
2259 compared to the No Action Alternative. Overall, impacts are anticipated to be negligible.

2260 In Region C, the Preferred Alternative is expected to have negligible effects to water
2261 temperature at Dworshak and all four lower Snake River projects. For TDG, moderate increases
2262 are anticipated due to the *Juvenile Fish Passage Spill* measure that would allow for spill up to
2263 125 percent TDG 16 hours per day, from the beginning of April through the third week of June.
2264 Impacts to other water quality parameters would be negligible.

2265 In Region D, the Preferred Alternative is expected to result in little to no change to water
2266 temperatures, TDG, sediment quality, or other water quality parameters when compared to the
2267 No Action Alternative. These effects are expected to be negligible.

2268 For further details, please refer to the Water Quality Technical Appendix D.

2269 **7.7.4 Anadromous Fish**

2270 **7.7.4.1 Salmon and Steelhead**

2271 There are no anadromous fish in Region A (Bull Trout are evaluated in the resident fish section)
2272 and upstream of Chief Joseph Dam in Region B. The effects of the Preferred Alternative on
2273 anadromous fish are expected to be negligible in Region B downstream of Chief Joseph Dam
2274 due to minor changes in operations, and depending on the model and Evolutionarily Significant
2275 Unit (ESU)/Distinct Population Segment (DPS), the effects to anadromous fish in Regions C and
2276 D have the potential to range from a moderate adverse impact to a major beneficial effect. The
2277 ranges in potential effects are due to uncertainty and spread between modeled estimates for
2278 the *Juvenile Fish Passage Spill* measure because of the unknown magnitude of latent mortality
2279 and an unknown level of reduction in transportation for some species.

2280 The increased levels of spill included in the Preferred Alternative are intended to provide a
2281 more effective passage method to avoid direct injury from turbine or bypass passage. Results
2282 for upper Columbia River stocks are beneficial based on LCM estimates. In-river survival and
2283 SARs are anticipated to increase. The CSS model predicts higher Smolt to Adult Return (SARs)
2284 rates from increased spill largely due to reductions in latent mortality (delayed death of salmon
2285 following passage through the CRS). The predicted level of benefit from increased spill differs
2286 between the two suites of models used to evaluate impacts to anadromous fish. For example,
2287 the CSS model predicts the Preferred Alternative would result in a relative increase of 35
2288 percent for Snake River Spring/Summer Chinook compared to the No Action Alternative. In
2289 contrast, NMFS' Life Cycle Model (LCM) shows a reduction in SARs of -7.5 percent for Snake
2290 River Spring/Summer Chinook relative to the No Action Alternative. This predicted reduction in
2291 SARs by the NMFS LCM is primarily a function of reduced transportation rates (see below for
2292 more discussion). The LCM also assessed SARs under several levels of assumed latent mortality
2293 reductions (10, 25, and 50 percent). If latent mortality is decreased by more than 10 percent,
2294 the LCM predicts increased SARs compared to the No Action Alternative. As noted in Chapter 3,
2295 the science continues to evolve on the causal factors and the magnitude of latent effects
2296 caused by passage through the CRS. This Preferred Alternative is anticipated to, and is
2297 specifically designed to improve the region's understanding of this issue.

2298 Increased levels of spill are generally associated with lower transport rates as fish are diverted
2299 from turbine and bypass routes to spill routes. Past data has shown that transported fish can
2300 have higher adult return rates than in-river fish depending on species and time of year, but the
2301 relationship is especially relevant for Snake River steelhead. However, as in-river conditions
2302 improve, the difference in adult return rates between fish that were transported and those that
2303 remained in-river becomes smaller. The co-lead agencies are proposing to continue to monitor
2304 this relationship, and manage transportation adaptively to continue to improve effectiveness.

2305 Increase in gas bubble trauma can result in injury or even death of juvenile and adult salmonids
2306 if TDG exposure is of sufficient magnitude and duration. In addition, spill levels being proposed
2307 in the Preferred Alternative have been shown to delay adult migrants as they search for fishway
2308 entrances. Increased incidence of adult fish falling back over spillways would also be expected
2309 with the higher spill levels. Monitoring would be in place to help the co-lead agencies identify
2310 and remedy any of the potential adverse effects noted above. Other measures in the
2311 alternative intended to reduce adult delay at dams and increase juvenile survival were
2312 determined to provide negligible to minor positive effects for anadromous fish.

2313 Several different ESU/DPS units of salmon and steelhead share a similar life cycle and
2314 experience similar effects from the Preferred Alternative, but also have ESU-DPS specific traits
2315 that drive effects differently from one another. Common effects analyses across all salmon and
2316 steelhead are discussed first, and then those ESU/DPS specific effects are displayed.

2317 **EFFECTS COMMON ACROSS SALMON AND STEELHEAD⁸**

2318 **Summary of Key Effects**

2319 The Preferred Alternative includes several structural measures intended to improve juvenile
2320 migration. Juvenile fish spill generally increases the amount of spill at each of the lower
2321 Columbia River and lower Snake River projects for improved juvenile survival, and predator
2322 disruption operations at John Day would reduce predation by birds on juvenile salmon and
2323 steelhead. Latent effects may be reduced that could increase ocean survival. Structural
2324 measures in the Preferred Alternative would make small, incremental improvements in adult
2325 migration.

⁸ On February 4, 2020, the co-lead agencies viewed a presentation prepared by NMFS regarding returns for the 2019 fish passage season and the Adaptive Management Implementation Plan (see Section 3.5 for more information). Although not all adult returns occurred prior to the presentation, NMFS utilized current return numbers to estimate final return numbers if current return rates continued in 2020 and 2021. These projects signaled that returns are low, especially for Snake River steelhead. The co-lead agencies are currently evaluating the draft information provided by NMFS and will have a more detailed discussion of this information in the Final EIS, including any updates that NMFS may provide once all returns have occurred, if appropriate.

2326 **Juvenile Fish Migration/Survival**

2327 There are structural measures in the Preferred Alternative that may affect juvenile salmon and
2328 steelhead.

2329 • Improved Fish Passage (IFP) turbines at John Day Dam (up to 16) are scheduled for
2330 replacement after similar replacements have been completed at Ice Harbor (up to 3
2331 turbines) and at McNary Dam. Ice Harbor and McNary Dam turbine replacements are part
2332 of the No Action Alternative. As John Day turbine replacement would follow Ice Harbor and
2333 McNary improvements, these improvements are currently scheduled to occur between
2334 2025 and 2039. The new IFP turbines would have similar improvements in fish passage
2335 performance as the replacement turbines designed for install at Ice Harbor Dam. The Ice
2336 Harbor Dam turbines were specifically designed for fish passage using a process similar to
2337 what may be used for future turbine runners at John Day Dam. Turbine mortality was split
2338 into direct and indirect mortality. Direct turbine mortality includes injuries that occur during
2339 turbine passage while indirect turbine mortality can include effects like predation that occur
2340 as a result of disorientation or poor egress following turbine passage. The primary sources
2341 of direct turbine mortality come from mechanical-, shear-, or pressure-related injuries.

2342 Physical hydraulic models were used to evaluate the potential for mechanical and shear
2343 related injuries, while potential for pressure related injuries were evaluated using
2344 sensor fish or computation fluid dynamic models. These analyses suggested that IFP
2345 turbines could reduce injury and mortality by as much as 68 percent for fixed-blade
2346 turbines and as much as 49 percent for adjustable blade turbines.

2347 For modeling and analysis purposes, a value of 50 percent was used to evaluate
2348 reductions in injuries to juvenile salmon and steelhead that pass through turbine routes.
2349 COMPASS modeling incorporates these values directly into the model, and the results
2350 reflect the change in survival. For non-modeled species, qualitative analyses and
2351 surrogate species were used to evaluate effects of new IFP turbines. See Appendix E for
2352 more information regarding these assumptions.

2353 Several operational measures warrant discussion here individually, regarding effects to juvenile
2354 fish. Measures that would result in changes to spill, flows, passage routes, or temperatures
2355 were incorporated into the fish models. Others are not readily incorporated into modeling for
2356 effects analysis, or are modeled but may be difficult to separate from other factors, and so
2357 effects of these measures are discussed qualitatively.

2358 • Cease installation of fish screens to increase the efficiency of new hydropower turbines at
2359 Ice Harbor, McNary, and John Day Dams once IFP turbines are installed. This measure is
2360 intended to consider running the new IFP turbines unscreened if acceptable biologically.
2361 The co-lead agencies would collaborate with NMFS and USFWS to develop a Turbine Intake
2362 Bypass Screen Management and Future Strategy process to monitor success of the IFP
2363 turbines and determine if and when best to remove fish screens at these projects. For this

2364 analysis, it is assumed that fish screens would not be removed if appropriate testing
2365 demonstrated a reduction in juvenile fish survival.

- 2366 • Manipulation of John Day reservoir elevations to deter nesting of bird predators at Blalock
2367 Islands: Caspian terns have been shown to consume large numbers of juvenile salmon and
2368 steelhead during their downstream migration to the ocean. Blalock Islands are situated in
2369 the John Day Dam reservoir and provide nesting habitat for Caspian terns. Under the No
2370 Action Alternative, approximately 500 breeding pairs of Caspian terns consume nearly
2371 150,000 steelhead at these small islands annually. This measure calls for a change in
2372 operations to raise water levels in the John Day Dam reservoir in April and May to
2373 elevations between 263.5 and 265 feet. Effects of this operation would greatly reduce
2374 potential nesting habitat for Caspian terns at the Blalock Islands. In fact, an increase in
2375 elevation of 1 foot, from 263.5 to 264.5 feet, would reduce habitat by approximately 90
2376 percent. Recent studies show that regional efforts to dissuade Caspian tern nesting have led
2377 to a 44 percent decline in the number of Caspian terns nesting in the Columbia Plateau
2378 region (Collis et al. 2019). Continued reductions in nesting habitat would likely be associated
2379 with continued reductions in nesting predators and increases in juvenile salmon and
2380 steelhead survival.
- 2381 • *Juvenile Fish Passage Spill* would be implemented to aid juvenile salmonid migration at the
2382 lower Snake River projects and the lower Columbia River projects (see Table 7-21 and
2383 Table 7-22 for more details). The implementation of the *Juvenile Fish Passage Spill*
2384 operations is intended to decrease the number of juvenile fish that pass the dams through
2385 non-spillway routes, decrease fish travel time through the forebays, gain scientific
2386 information on latent (delayed) mortality, and provide flexibility for hydropower
2387 generation. The effects vary by model and ESU/DPS.
- 2388 • The transport of juvenile salmon collected at Lower Granite, Little Goose, and Lower
2389 Monumental projects could begin as early as April 15, approximately 2 weeks earlier than
2390 current fish transport operations described in the No Action Alternative. Transport
2391 operations would end September 30 at Lower Monumental and October 31 at Lower
2392 Granite and Little Goose. Collected juvenile fish would be transported to a location below
2393 Bonneville Dam via barge or truck on a daily or every-other-day schedule, depending on the
2394 numbers of fish collected at the collector projects. This measure does not preclude the co-
2395 lead agencies from implementing a cessation of juvenile transportation June 21 through
2396 August 14 with allowance for adaptive management adjustments through TMT as was
2397 contemplated in the *2019-2021 Spill Operation Agreement (Agreement)*. This action could
2398 increase the number of juvenile fish transported to the estuary.

2399 **Adult Fish Migration/Survival**

2400 There are several structural measures in the Preferred Alternative that may affect adult salmon
2401 and steelhead. Many of these structures are in one or more other MOs as well. The effects of
2402 these measures are described here.

- 2403 • Design and implement structural modifications to the Lower Granite Dam adult fish trap
2404 gate to reduce delay and stress for adult salmonids and non-target species such as Pacific
2405 Lamprey. The Corps would replace the existing trap gate with a gate operated by a
2406 dedicated hoist to improve efficiency. The new gate would be designed to more efficiently
2407 shed debris and would include a gap in the bottom to allow upstream passage of lamprey.
2408 This measure is intended to increase adult salmon and steelhead survival by reducing
2409 upstream travel times.
- 2410 • The Corps would modify the serpentine-style flow control sections of Bonneville Dam’s
2411 Washington Shore and Bradford Island fish ladders, converting them to an Ice Harbor-style
2412 vertical slot fishway with in-line submerged orifices. This modification would increase
2413 passage success for adult lamprey and reduce stress and delay for adult salmon, steelhead
2414 and bull trout. This action has potential to increase adult salmon and steelhead survival by
2415 reducing upstream passage time at the dam. A similar modification at John Day Dam, the
2416 only other CRS dam to use this type of ladder, resulted in significant passage time
2417 reductions for salmon and steelhead. Similar improvements are expected for Bonneville
2418 Dam.
- 2419 • Install closeable gates on Bonneville Powerhouse 2 floating orifice gates to reduce the
2420 occurrence of lamprey falling out of the powerhouse adult fish collection channel. Closeable
2421 gates would allow seasonal closure during the lamprey passage season. This measure is
2422 intended to increase adult lamprey upstream passage success. While this measure is
2423 intended to improve adult lamprey passage success at Bonneville Dam, it may affect adult
2424 salmon and steelhead passage as well. Studies of similar powerhouse adult fish collection
2425 systems at Bonneville Powerhouse 1, The Dalles Dam, and Priest Rapids Dam (Keefer et al.
2426 2008; Bjornn et al. 1997) suggest that this action could improve overall adult salmon and
2427 steelhead passage. The floating orifice gates at those projects were permanently closed as a
2428 result of this research. However the co-lead agencies are proposing to install gates that can
2429 be closed during the adult lamprey migration (June to September), and opened during the
2430 rest of the year, due to concerns over springtime sea lion predation on adult salmon and
2431 steelhead that are attempting to pass Bonneville Dam.

2432 While the Preferred Alternative contains structural measures at lower Columbia River and
2433 lower Snake River projects that may reduce delay for adult fish passing those projects, juvenile
2434 fish passage spill may increase adult fallback rates under the Preferred Alternative due to
2435 higher spill levels. Higher fallback rates would increase adult fish mortality and delay their
2436 migration through the system (Boggs et al. 2004; Keefer et al. 2005). Higher spill may also delay
2437 adult passage at some dams by causing unfavorable tailrace hydraulic patterns such as eddies,
2438 that mask adult fish ladder attraction flow. It is important to note that regional managers use
2439 in-season adaptive management to identify and remedy any excessive fallback and delay.

2440 **UPPER COLUMBIA RIVER SALMON AND STEELHEAD**

2441 Upstream of McNary Dam, upper Columbia salmon and steelhead migrate past as many as five
2442 non-federal dams and reservoirs which also impact the survival and passage of this species. The

2443 federal parties do not dictate generation or spill levels at these projects so metrics such as
2444 powerhouse encounter rate are not directly affected, but are influenced by river flow levels
2445 coming through the Upper Basin. The timing and volume of flow levels affected by CRS
2446 operational decisions are reflected in model analysis. COMPASS and LCM estimates of
2447 powerhouse encounter rate and SARs include passage effects from a combination of federal
2448 and non-federal dam passage (Rock Island Dam to Bonneville Dam).

2449 Unless otherwise noted, quantitative results from COMPASS and the LCM are based on a
2450 combination of hatchery and natural origin fish. This applies for both juvenile and adult results.
2451 CSS cohort analysis for upper Columbia River salmon and steelhead are not included because
2452 no model exists.

2453 **Upper Columbia Spring-Run Chinook Salmon**

2454 ***Summary of Key Effects***

2455 For juvenile fish passage under the Preferred Alternative, the COMPASS modeling results show
2456 slightly increased survival rates (+0.9 percent) from McNary Dam to Bonneville Dam, and
2457 reduced travel times (-0.5 days) relative to the No Action Alternative. *Juvenile Fish Passage Spill*
2458 under the Preferred Alternative would increase compared to the No Action Alternative.
2459 Predator disruption operations would further increase juvenile survival. Structural
2460 improvements would increase adult migration success, but higher spill may cause additional
2461 fallback and delay compared to the No Action Alternative. Exposure to supersaturated TDG
2462 would increase slightly for both adult and juvenile fish as they migrate through the CRS.
2463 Abundance would increase by 7 percent assuming no reduction in latent mortality to about 155
2464 percent if latent mortality were reduced by 50 percent.

2465 ***Juvenile Fish Migration/Survival***

2466 This population migrates through the Columbia River downstream past the four lower CRS
2467 projects and up to five non-federal dams. Structural and operational measures in the *Effects*
2468 *Common Across Salmon and Steelhead (Common Effects)* section that describe changes from
2469 the No Action Alternative at McNary, John Day, The Dalles, and Bonneville projects would apply
2470 to these fish. COMPASS modeling estimates that the Preferred Alternative could result in a 0.9
2471 percent increase in average juvenile survival, an 8 percent decrease in average juvenile travel
2472 time from McNary Dam to Bonneville Dam, and a 10 percent decrease in the number of
2473 powerhouse passage events. Predator disruption operations, also described in *Common Effects*,
2474 would further increase juvenile survival by reducing predation on out-migrating smolts. TDG
2475 exposure would increase 1.3 percent compared to the No Action Alternative for these fish.

2476 Table 7-21 summarizes COMPASS and University of Washington's TDG model results for upper
2477 Columbia River spring-run Chinook salmon under the Preferred Alternative.

2478 **Table 7-21. Preferred Alternative Juvenile Model Metrics for Upper Columbia River Spring-**
2479 **Run Chinook Salmon**

Metric (Model)	NAA	Preferred Alternative	Change from NAA	% Change
Juvenile Survival (COMPASS) McNary to Bonneville	69.5%	70.4%	+0.9%	+1%
Juvenile Travel Time (COMPASS) McNary to Bonneville	6.1 days	5.6 days	-0.5 days	-8%
% Transported (COMPASS)	0%	0%	0	0%
Powerhouse Passages (COMPASS) Rock Island to Bonneville	3.29	2.96	-0.33	-10%
TDG Average Exposure (TDG Tool)	116.0% TDG	117.3% TDG	+1.3% TDG	+1%

2480 **Adult Fish Migration/Survival**

2481 The *Modify Bonneville Ladder Serpentine Weir* measure, described in the Common Effects
2482 section, would decrease delay of upstream migration, although higher spill could increase
2483 fallback rates. Adult exposure to TDG would be higher than the No Action Alternative.

2484 The LCM estimated SARs and abundance of the Wenatchee population which are used here as
2485 an index population for Upper Columbia River spring Chinook salmon (Table 7-22). SARs are
2486 estimated to increase from 0.94 percent under the No Action Alternative to 0.97 percent under
2487 the Preferred Alternative. The LCM results predict that abundance of the Wenatchee
2488 population, would increase relative to the No Action Alternative, ranging from about 7 percent
2489 assuming no reduction in latent mortality to 155 percent assuming a 50 percent reduction in
2490 latent mortality. CSS modeling was not available for this population, but the theory in CSS
2491 modeling indicating fewer powerhouse encounters would reduce latent mortality can be
2492 considered here.

2493 **Table 7-22. Preferred Alternative Model Metrics for Adult Upper Columbia River Spring**
2494 **Chinook Salmon**

Metric (Model)	No Action Alternative	Preferred Alternative	Change from No Action Alternative	% Change
Rock Island to Bonneville SARs (NMFS LCM)	0.94%	0.97%	0.03%	3.2%
NMFS LCM abundance range for Wenatchee spring Chinook, with decreased latent mortality ^{1/} (number of adults)	498	536 (0%) 642 (10%) 855 (25%) 1,268 (50%)	+38 (0%) +144(10%) +357 (25%) +770 (50%)	+7% (0%) +30% (10%) +72% (25%) +155% (50%)

2495 Note: Percentages in parentheses indicate assumed potential decreases in latent mortality.
2496 1/ NMFS LCM does not factor latent mortality due to the Columbia River System into the SARs or abundance
2497 output. For discussion purposes, potential decreases in latent mortality of 10 percent, 25 percent, and 50 percent
2498 are shown for abundance estimates. The value for 0 percent is the actual model output, the 10 percent, 25
2499 percent, and 50 percent values represent scenarios of what abundance hypothetically could be under the
2500 increased ocean survival if changes in the alternative were to decrease latent mortality by that much.

2501 **Upper Columbia River Steelhead**

2502 **Summary of Key Effects**

2503 There are no life cycle models for upper Columbia steelhead to estimate adult returns, only
2504 COMPASS model estimates of juvenile downstream survival. Upper Columbia River steelhead
2505 juvenile migration would be similar the No Action Alternative. Predator disruption operations in
2506 the John Day reservoir would further increase juvenile survival. Structural improvements could
2507 increase adult migration success.

2508 **Juvenile Fish Migration/Survival**

2509 Juveniles from this population migrate through the Columbia River downstream past the four
2510 lower CRS projects and up to five non-federal dams. COMPASS modeling estimates that the
2511 Preferred Alternative results in a 0.1 percent decrease in average juvenile survival for upper
2512 Columbia steelhead, travel time would be the same as the No Action Alternative, and
2513 powerhouse passage events would decrease by 5 percent. Predator disruption operations, also
2514 described in Common Effects, would increase juvenile survival by reducing predation on out-
2515 migrating smolts. TDG exposure would be 1.5 percent higher than in the No Action Alternative.
2516 Table 7-23 summarizes COMPASS and TDG model results for upper Columbia River steelhead
2517 under the Preferred Alternative.

2518 **Table 7-23. Preferred Alternative Model Metrics for Juvenile Upper Columbia Steelhead**

Metric (Model)	NAA	Preferred Alternative	Change from NAA	% Change
Juvenile Survival (COMPASS) McNary to Bonneville	65.8%	65.7%	-0.1%	-0.2%
Juvenile Travel Time (COMPASS) McNary to Bonneville	6.6 days	6.6 days	0 days	0%
% Transported (COMPASS)	No transport of upper Columbia steelhead			
Powerhouse Passages (COMPASS) Rock Island to Bonneville	2.72	2.58	-0.14	-5%
TDG Average Exposure (TDG Tool)	116.0% TDG	117.5% TDG	+1.5% TDG	+1%

2519 **Adult Fish Migration/Survival**

2520 The *Modify Bonneville Ladder Serpentine Weir* measure, described in the Common Effects
2521 section, could decrease delay of upstream migration. Higher spill could increase survival of kelts
2522 by increasing their passage through non-turbine routes. Adult steelhead exposure to
2523 supersaturated TDG would be higher than in the No Action Alternative. River temperatures
2524 would be similar to No Action Alternative.

2525 **Upper Columbia River Coho Salmon (Non ESA-listed)**

2526 See Upper Columbia spring-run Chinook salmon analysis as a surrogate for juvenile Upper
2527 Columbia coho salmon and Upper Columbia fall Chinook salmon analysis as a surrogate for
2528 adult Upper Columbia coho salmon.

2529 **Summary of Key Effects**

2530 Effects on Upper Columbia coho salmon include the conditions they encounter during upstream
2531 and downstream migrations. Downstream survival and migration for juveniles is dependent on
2532 water flow and routing at the dams. Higher flows and higher spills generally lead to higher
2533 survival. Juvenile coho survival would be similar to Upper Columbia spring-run Chinook salmon,
2534 with structural measures and spill increases potentially increasing juvenile survival and
2535 additional increases in survival due to lower predation by birds in the John Day reservoir. Adult
2536 coho salmon migration timing is similar to Upper Columbia fall Chinook salmon so that species
2537 is used as a surrogate for upstream migration effects.

2538 **Juvenile Fish Migration/Survival**

2539 See Upper Columbia spring-run Chinook salmon results as a surrogate for juvenile Upper
2540 Columbia coho salmon.

2541 **Adult Fish Migration/Survival**

2542 Upper Columbia fall Chinook, are used as a surrogate for adult Upper Columbia coho in this
2543 analysis. Adult migration conditions would be similar to the No Action Alternative. The
2544 Preferred Alternative water quality modeling showed no change in the frequency of water
2545 temperatures exceeding 20°C (68°F) relative to the No Action Alternative. Structural
2546 improvements could increase adult migration success compared to the No Action Alternative.
2547 Based on Upper Columbia spring Chinook juvenile migration, powerhouse encounter rates
2548 would be reduced, and this could result in increased adult return rates.

2549 **Upper Columbia River Sockeye Salmon (Non ESA-listed)**

2550 **Summary of Key Effects**

2551 Changes to Upper Columbia sockeye salmon would be similar to estimated changes for Upper
2552 Columbia Spring Chinook: survival rates from McNary Dam to Bonneville Dam would increase,
2553 travel times would be reduced, and predator disruption operations could further increase
2554 juvenile survival. Structural improvements would increase adult migration success, but higher
2555 spill may cause additional fallback and delay compared to the No Action Alternative. Exposure
2556 to high levels of TDG would increase for both adult and juvenile fish as they migrate through
2557 the CRS.

2558 **Juvenile Fish Migration/Survival**

2559 Juvenile survival of Upper Columbia sockeye salmon are estimated using COMPASS juvenile
2560 modeling results for Upper Columbia spring Chinook salmon as a surrogate. Operational and
2561 structural measures described in *Common Effects* would increase survival by increasing the
2562 proportion of spillway passage, increasing survival of sockeye juveniles that pass through John
2563 Day Dam turbines and reducing the risk of predation by birds. Exposure to elevated TDG would
2564 increase relative to the No Action Alternative.

2565 ***Adult Fish Migration/Survival***

2566 The *Modify Bonneville Ladder Serpentine Weir* measure, described in the *Common Effects*
2567 section, would decrease delay of upstream migration, although higher spill could increase
2568 fallback rates and delay. Adult exposure to TDG would be higher than the No Action Alternative.
2569 The summer water temperatures in the river during the upstream migration would be similar to
2570 the No Action Alternative, with thermal issues continuing to reduce adult survival in the
2571 warmest years. Based on Upper Columbia River spring Chinook juvenile migration, powerhouse
2572 encounter rates would be reduced, and this could result in increased adult returns.

2573 **Upper Columbia River Summer/Fall-Run Chinook Salmon (Non ESA-listed)**

2574 ***Summary of Key Effects***

2575 Juvenile Upper Columbia summer/fall-run Chinook salmon would be similar to the No Action
2576 Alternative, with potential increases in juvenile survival due to lower predation in the John Day
2577 Reservoir.

2578 ***Larval Development/Juvenile Rearing in Mainstem Habitats***

2579 None of the measures of the Preferred Alternative would change the substrate sizes or
2580 distribution in the spawning areas or expand suitable spawning areas; therefore, this
2581 alternative is expected to have the same larval development and juvenile rearing habitat
2582 conditions as the No Action Alternative. The same is true for river depths in the spawning areas;
2583 no change is anticipated for eggs incubating in the gravel. No change is anticipated in McNary
2584 and John Day Dam reservoir plankton communities or shoreline habitats under the Preferred
2585 Alternative, relative to the No Action Alternative. Likewise, juvenile rearing habitat below
2586 Bonneville Dam is not expected to change relative to the No Action Alternative.

2587 ***Juvenile Fish Migration/Survival***

2588 Juvenile summer/fall Chinook salmon are susceptible to predation in the Columbia River. Water
2589 temperatures would be the same as the No Action Alternative, and therefore, there would be
2590 no change in temperature-related predation rates in this reach. Downstream migration of
2591 juveniles would be similar to the No Action Alternative.

2592 ***Adult Fish Migration/Survival***

2593 The number of days water temperatures in the McNary Dam tailrace exceed 20°C would not
2594 change relative to the No Action Alternative, so no change in migration delay, fallback, or
2595 susceptibility to disease are anticipated due to overall warmer mainstem water temperatures at
2596 the lower Columbia River Dams.

2597 Specific to Okanogan upper Columbia summer/fall Chinook salmon, there would be no change
2598 in the number of days the mainstem would be 20°C or higher at the confluence of the
2599 Okanogan River, relative to the No Action Alternative. This means that there would be no

2600 change anticipated in the ability of the Okanogan fish to wait (hold) in the mainstem until water
2601 temperatures in the Okanogan River are cool enough for adults to move up from the mainstem.
2602 This allows these salmon to migrate without having to experience water temperatures typically
2603 considered lethal for salmon and steelhead (Ashbrook et al. 2009).

2604 The frequency of meeting the Vernita Bar Agreement to protect the prolific fall Chinook salmon
2605 spawning in and around the Hanford Reach of the Columbia River in Washington is not
2606 expected to change under the Preferred Alternative relative to the No Action Alternative. Other
2607 operational changes under the Preferred Alternative are likewise not anticipated to affect
2608 upper Columbia summer/fall Chinook salmon spawning from the tailrace of Chief Joseph Dam
2609 to Bonneville Dam in terms of changes in flows or water temperatures. There could be
2610 increased TDG exposure from McNary to below Bonneville Dam.

2611 **Middle Columbia River Spring-Run Chinook Salmon**

2612 See Upper Columbia spring Chinook analysis as a surrogate for Middle Columbia Spring Chinook
2613 Salmon.

2614 ***Summary of Key Effects***

2615 Changes to Middle Columbia spring Chinook salmon would be similar to estimated changes for
2616 upper Columbia spring Chinook: survival rates from McNary Dam to Bonneville Dam would
2617 increase, travel times would be reduced, and predator disruption operations would further
2618 increase juvenile survival. Structural improvements would increase adult migration success, but
2619 higher spill may cause additional fallback and delay compared to the No Action Alternative.
2620 Exposure to higher levels of TDG would increase for both adult and juvenile fish as they migrate
2621 through the CRS.

2622 ***Juvenile Fish Migration/Survival***

2623 Using the surrogate species of upper Columbia spring Chinook salmon, and based on COMPASS
2624 model results, the Preferred Alternative may result in nearly a 1 percent increase in Middle
2625 Columbia spring Chinook salmon average juvenile survival from the McNary Dam to the
2626 Bonneville Dam tailrace. This would be an 8 percent decrease in average travel time, and a 10
2627 percent decrease in the average number of powerhouse passage events. Middle Columbia
2628 juvenile salmon would typically experience higher absolute survival than Upper Columbia spring
2629 Chinook salmon because they do not experience the additional mortality associated with the
2630 Columbia River from Chief Joseph Dam downstream through up to five non-federal dams.
2631 However, the surrogate metric used for Upper Columbia spring- Chinook salmon is survival
2632 from McNary to Bonneville Dam and would be similar for Middle Columbia spring Chinook
2633 salmon that pass the same CRS projects.

2634 **Adult Fish Migration/Survival**

2635 The *Modify Bonneville Ladder Serpentine Weir* measure, described in the *Common Effects*
2636 section, would decrease delay of upstream migration, although higher spill could increase
2637 fallback rates. Adult exposure to TDG would be higher than the No Action Alternative. Based on
2638 Upper Columbia spring Chinook juvenile migration, powerhouse encounter rates would be
2639 reduced, and this could result in increased adult returns.

2640 **Middle Columbia River Steelhead**

2641 **Summary of Key Effects**

2642 Changes in effects to Middle Columbia steelhead juvenile and adult migration and returns
2643 under the Preferred Alternative would be similar to the No Action Alternative. Certain
2644 structural measures and higher spill levels should result in higher survival rates for adult
2645 steelhead falling back through the dams and kelts migrating downstream.

2646 **Juvenile Fish Migration/Survival**

2647 Populations of Middle Columbia steelhead are distributed in the lower Columbia River between
2648 the confluences of the Deschutes and Walla Walla rivers. These steelhead pass between two to
2649 four CRS dams on their downstream outmigration to the ocean. No quantitative model exists
2650 for Middle Columbia steelhead, so COMPASS estimates from juvenile survival of Upper
2651 Columbia steelhead were used as a surrogate. CSS models do not exist for this population.
2652 COMPASS modeling predicts that the Preferred Alternative would decrease in average juvenile
2653 survival for Upper Columbia steelhead by 0.1 percent, cause no change in travel time, and
2654 decrease powerhouse passage events by 5 percent for fish passing all four lower Columbia River
2655 dams. Predator disruption operations, also described in *Common Effects*, would further
2656 increase juvenile survival by reducing predation on out-migrating smolts. Higher levels of TDG
2657 exposure would be higher than in the No Action Alternative. Outflows and temperatures would
2658 be similar to the No Action Alternative. Predator disruption operations, as described in the
2659 *Common Effects* section, would reduce predation on out-migrating Middle Columbia steelhead
2660 smolts. In general, the survival and outmigration of Middle Columbia steelhead would be very
2661 similar to the No Action Alternative.

2662 **Adult Fish Migration/Survival**

2663 Structural measures such as modifying the upper ladder serpentine sections at Bonneville Dam
2664 are expected to reduce delay associated with upstream passage. Higher spill levels during April
2665 periods should result in higher survival rates or for adult steelhead falling back through dams
2666 and kelts migrating downstream, as fewer adults use powerhouse passage routes when a spill
2667 or surface passage route is available (Normandeau et al. 2014; Richins and Skalski 2018). Based
2668 on Upper Columbia steelhead juvenile migration, powerhouse encounter rates would be
2669 reduced, and this could result in increased adult returns.

2670 **Snake River Salmon and Steelhead**

2671 ***Snake River Spring/Summer-Run Chinook Salmon***

2672 Summary of Key Effects

2673 Depending on the model used and assumptions regarding latent mortality, CSS and LCM modeling
2674 indicate that the Preferred Alternative would result in lower (7 percent) to substantially higher (35
2675 percent) SARs for Snake River spring/summer Chinook salmon. Juvenile survival would be very similar to
2676 the No Action Alternative (about 0.6 percent higher). Adults could see benefits to upriver migration with
2677 some structural measures. The Compass and CSS models both predicted substantial reductions in the
2678 proportion of fish transported. Unless otherwise noted, quantitative results from COMPASS, CSS, and
2679 the LCM are based on a combination of hatchery and natural origin fish. This applies for both juvenile
2680 and adult results.

2681 Juvenile Fish Migration/Survival

2682 This population migrates through the Snake and Columbia rivers downstream past the eight
2683 lower CRS projects. Structural and operational measures in the *Common Effects* section
2684 describe changes at all of these dams and would apply to these fish. The combination of several
2685 measures would decrease travel time and powerhouse encounters and overall, increase
2686 juvenile outmigration survival. For Snake River spring/summer Chinook salmon, the COMPASS
2687 and CSS cohort models estimate that the Preferred Alternative would increase juvenile survival
2688 from Lower Granite Dam to Bonneville Dam by up to 3 percent, and travel time would decrease
2689 by about 7 percent relative to the No Action Alternative. The increase in *Juvenile Fish Passage*
2690 *Spill* is expected to decrease powerhouse encounters substantially, with the models predicting
2691 a decrease of about 48 to 54 percent. Predator disruption operations, also described in
2692 *Common Effects*, would further increase juvenile survival by reducing predation on out-
2693 migrating smolts. TDG exposure would be 2.9 percent higher than the No Action Alternative,
2694 with a reach average exposure of 118.0 percent TDG. See Table 7-24 for a list of model outputs
2695 related to juvenile migration and survival.

2696 **Table 7-24. Preferred Alternative Juvenile Model Metrics for Snake River Spring/Summer**
2697 **Chinook Salmon**

Metric (Model)	No Action Alternative	Preferred Alternative	Change from No Action Alternative	% Change
Juvenile Survival (COMPASS)	50.4%	51.0%	+0.6%	1%
Juvenile Survival (CSS)	57.6%	60.5%	+2.9%	5%
Juvenile Travel Time (COMPASS)	17.7 days	16.5 days	-1.2 days	-7%
Juvenile Travel Time (CSS)	15.8 days	14.7 days	-1.1 days	-7%
% Transported (COMPASS)	38.5%	19.0%	-19.5%	-51%
% Transported (CSS)	19.2%	10.2%	-9.0%	47%
Transport: In-River Benefit Ratio (CSS)	0.86	0.62	-0.24	-27%

Metric (Model)	No Action Alternative	Preferred Alternative	Change from No Action Alternative	% Change
Powerhouse Passages (COMPASS)	2.3	1.2	-1.1	-48%
Powerhouse Passages (CSS)	2.15	0.98	-1.17	-54%
TDG Average Exposure (TDG Tool)	115.1% TDG	118.0% TDG	+2.9% TDG	2.5%

2698 Several measures in the Preferred Alternative would affect juvenile Snake River spring/summer
2699 Chinook salmon transportation rates. Both the LCM and CSS models predicted that the
2700 proportion of fish transported would be about half that of the No Action Alternative. CSS also
2701 predicts a decrease in the benefit to survival for transported smolts, likely due to improved in-
2702 river conditions that are driven by shorter juvenile fish travel times and decreased powerhouse
2703 passage.

2704 Smolts may be collected for transportation at the three Snake River projects starting as early as
2705 April 15, which is earlier than the No Action Alternative start date of April 25. The intent of this
2706 measure is to increase the region’s understanding of early season transport effects and benefits
2707 to early migrating Snake River steelhead. However, for Snake River Chinook, the earlier start to
2708 juvenile fish transport would have a neutral effect on the Transport In-River Benefit Ratio (TIR),
2709 though hatchery-origin Chinook salmon smolts have a greater benefit of transportation during
2710 this timeframe than natural-origin smolts (Transport COP, Gosselin et al. 2018). Without a clear
2711 benefit for the early period, earlier transport may slightly decrease Snake River spring/summer
2712 Chinook salmon adult returns.

2713 Increased spill would also increase the number of juveniles passing via spillways. This means
2714 they would not be collected in the juvenile fish bypasses for transportation. LCM results reflect
2715 that reducing transport rates, especially in May and June, would be expected to reduce SARs
2716 because transported fish typically return at higher rates than those of in-river migrants during
2717 this period. Overall across the entire spring migration season in both the No Action Alternative
2718 and the Preferred Alternative, the CSS cohort model predicted that natural-origin fish
2719 transported as juveniles returned at a lower rate than fish that migrated in-river as juveniles,
2720 partially due to modeled improvements to in-river survival rates. Both models reflect the
2721 relative benefits of juvenile transport in the Preferred Alternative could be less than the No
2722 Action Alternative because transportation rates would be reduced.

2723 Adult Fish Migration/Survival

2724 Several structural measures in the Preferred Alternative are anticipated to benefit adult Snake
2725 River spring/summer Chinook salmon upstream passage, including modifying the adult trap and
2726 bypass loop at Lower Granite Dam and modifying the upper ladder serpentine sections at
2727 Bonneville Dam (reducing delay). However, the Preferred Alternative has higher spring spill, and
2728 fallback rates of Snake River spring/summer Chinook salmon may increase since fallback for this
2729 population has been associated with higher flow and higher spill levels at many dams (Boggs et
2730 al. 2004; Keefer et al. 2005). Higher spill levels can also result in hydraulic patterns that mask
2731 adult fish ladder attraction flow at some dams, and this can cause delay the migration of adult
2732 salmon. In recent years, adult passage delays have been observed at Little Goose Dam with spill

2733 over 30 to 35 percent. It is important to note that regional managers use in-season adaptive
2734 management to identify and remedy any excessive fallback and delay, which would likely
2735 mitigate for this increase in spill. Spill reduction starting August 15 may reduce fallback for the
2736 few summer migrating adults that may still be passing CRS dams in August.

2737 Increasing the operating range by 6 inches at the lower Snake River Dams (MOP 1.5-foot range)
2738 and at John Day Dam (MIP 2-foot range) would have little effect on flow, and thus is not
2739 expected to affect adult migration timing or survival rates (NMFS 2019). Similarly, holding
2740 contingency reserves within juvenile fish passage spill is likely to have little effect, if any, on
2741 adult migration.

2742 Table 7-25 displays the median model outputs for adult metrics from both NMFS LCM and CSS.
2743 NMFS LCM results include different scenarios of latent mortality in the ocean survival phase,
2744 including decreased mortality of 0 percent, 10 percent, 25 percent, and 50 percent (scenario
2745 indicated in parentheses).

2746 **Table 7-25. Preferred Alternative Adult Model Metrics for Snake River Spring/Summer**
2747 **Chinook Salmon**

Metric (Model)	No Action Alternative	Preferred Alternative	Change from No Action Alternative	% Change
Lower Granite to Bonneville (LGR-BON) SARs ^{1/} (NMFS LCM) (Percent)	0.88%	0.81% (0%)	-0.07% (0%)	-7.5% (0%)
		0.88% (10%)	0% (10%)	0% (10%)
		0.97% (25%)	+0.09% (25%)	+10% (25%)
		1.12% (50%)	+0.24% (50%)	+28% (50%)
SARs LGR-BON (CSS)	2.0%	2.7%	+0.7%	+35%
Abundance of Middle Fork, South Fork and upper Salmon River representative populations (Number of adults; NMFS LCM) ^{2/}	2,351	1,790 (0%)	-561 (0%)	-24% (0%)
		2,149 (10%)	-202 (10%)	-9% (10%)
		2,645 (25%)	+294 (25%)	+13% (25%)
		3,600 (50%)	+1,249 (50%)	+53% (50%)
Abundance of Grande Ronde/Imnaha representative populations (CSS) ^{3/}	6,114	9,632	+3,518	+58%

2748 1/ NMFS LCM does not factor latent mortality due to the System into the SARs or abundance outputs. For
2749 discussion purposes, potential decreases in latent mortality of 10 percent, 25 percent, and 50 percent are shown.
2750 The value for 0 percent is the actual model output, the 10 percent, 25 percent, and 50 percent values represent
2751 scenarios of what SARs or abundance hypothetically could be under the increased ocean survival scenario if
2752 changes in the alternative were to decrease latent mortality by that much.

2753 2/ NMFS LCM provided results for 16 populations in the upper Salmon River, South Fork Salmon River, and Middle
2754 Fork Salmon River major population groups. The absolute values include these populations only, the percent
2755 change is considered indicative of the Snake River population for the purpose of comparing between MOs.

2756 3/ CSS provided results for six populations in the Grande Ronde/Imnaha major population group. The absolute
2757 values represent those populations only; the percent change is considered indicative of the Snake River population
2758 for the purpose of comparing between MOs.

2759 The LCM estimates SARs and abundance of the Upper Salmon River, South Fork Salmon River,
2760 and Middle Fork Salmon River Major Population Groups (MPGs). CSS estimates the abundance
2761 of Grande Ronde/Imnaha MPG. Both models use a combination of hatchery and natural-origin
2762 fish. For comparison purposes, the percent change from the No Action Alternative is considered

2763 indicative of the effects of Preferred Alternative on the Snake River spring Chinook salmon
2764 population.

2765 The LCM predicts the Preferred Alternative would result in reducing SARs (Lower Granite to
2766 Bonneville) by 7.5 percent with no latent mortality reduction to increasing adult returns by 28.0
2767 percent with a 50 percent latent mortality reduction. The CSS model predicts a 35 percent
2768 increase in the SARs (Lower Granite Dam to Bonneville Dam) for Snake River spring/summer
2769 Chinook salmon.

2770 With increases in juvenile survival both in the freshwater migration and in the ocean to
2771 adulthood, increases in abundance of fish to the spawning grounds would be expected. The
2772 NMFS model, looking at the Middle Fork Salmon, South Fork Salmon, and Upper Salmon
2773 populations, showed an average decrease in abundance of about 24 percent without factoring
2774 in any change to latent mortality and an increase of 53 percent assuming a 50 percent
2775 reduction in latent mortality. The CSS models, using the Grande Ronde/Imnaha MPG, indicated
2776 a 58 percent increase in abundance.

2777 ***Snake River Steelhead***

2778 Summary of Key Effects

2779 Depending on the model, juvenile survival is similar or increases. COMPASS and CSS both
2780 predict that juvenile travel time is similar to the No Action Alternative. TDG exposure would
2781 increase and powerhouse encounters would decrease substantially. The proportion of Snake
2782 River steelhead transported as juveniles would decrease under the Preferred Alternative.
2783 Predation is expected to decrease with the predator disruption measure in the John Day
2784 reservoir. Structural measures and higher spill may increase kelt survival. Based on the CSS
2785 model, SARs may increase by 28 percent.

2786 Juvenile Fish Migration/Survival

2787 This Distinct Population Segment (DPS) migrates through the Snake and Columbia rivers
2788 downstream past the eight lower CRS projects. Structural and operational measures described
2789 in the *Common Effects* section that describe changes at these dams would apply to these fish.
2790 The combination of several measures would decrease travel time and powerhouse encounters
2791 and increase survival. For Snake River steelhead, the COMPASS model predicts an increase in
2792 juvenile survival of 0.1 percent, and CSS cohort models estimate that Preferred Alternative
2793 would increase juvenile survival from Lower Granite Dam to Bonneville Dam by 7.4 percent.
2794 Both models agree that travel time would be similar and that powerhouse encounters would
2795 decrease 46 to 55 percent. Predator disruption operations, also described in *Common Effects*,
2796 would further increase juvenile survival by reducing predation on out-migrating smolts. TDG
2797 exposure would be higher than the No Action Alternative, with a reach average exposure of
2798 118.1 percent TDG compared to 115.1 percent under the No Action Alternative. See Table 7-26
2799 for a list of model outputs related to juvenile migration and survival.

2800 **Table 7-26. Juvenile Model Metrics for Snake River Steelhead under the Preferred Alternative**

Metric (Model)	No Action Alternative	Preferred Alternative	Change from No Action Alternative	% Change
Juvenile Survival (COMPASS)	42.7%	42.8%	+0.1%	NA
Juvenile Survival (CSS)	57.1%	64.5%	+7.4%	NA
Juvenile Travel Time (COMPASS)	16.4 days	16.5days	+0.1 days	+0.1%
Juvenile Travel Time (CSS)	16.2 days	15.8 days	-0.4 days	-2%
% Transported (COMPASS)	39.7%	20.9%	-18.8%	NA
% Transported (CSS)	Unknown			
Transport: In-River Benefit Ratio (CSS)	1.41	1.09	-0.32	-23%
Powerhouse Passages (COMPASS)	1.73	0.93	-0.80	-46%
Powerhouse Passages (CSS)	1.96	0.88	-1.08	-55%
TDG Average Exposure (TDG Tool)	115.1% TDG	118.1% TDG	+3.0% TDG	N/A

2801 Specific measures that would affect the change in transportation include potential earlier start
 2802 of transport (April 15) relative to the No Action Alternative (April 25). The earlier juvenile fish
 2803 transport start date would likely increase adult returns for hatchery-origin steelhead and would
 2804 have a neutral effect on natural-origin steelhead. Thus, the earlier transport date is likely not a
 2805 driver of the TIR response relative to the No Action Alternative because the effect should be
 2806 positive or neutral, not negative.

2807 Higher spill increases the number of juveniles passing via spillways and thus reduces collection
 2808 of juvenile fish for transportation. Reducing transport rates, especially in May and June, would
 2809 be expected to decrease total adult returns of steelhead. Higher in-river survival under the
 2810 Preferred Alternative compared to the No Action Alternative may also be a factor in the lower
 2811 season-wide TIR and is the most likely driver of the change in the Preferred Alternative relative
 2812 to the No Action Alternative.

2813 Additionally, the CSS cohort model estimates a 23 percent reduction in TIR (i.e., reduction in
 2814 transport benefit), relative to migration in-river compared the No Action Alternative. While a
 2815 Preferred Alternative TIR of 1.1 represents a reduction in TIR relative to the No Action
 2816 Alternative (TIR 1.4), the TIR still represents a season-wide benefit to transport relative to in-
 2817 river migration, measured in terms of relative SARs (DeHart CRSO-24/2019).

2818 Adult Fish Migration/Survival

2819 Several structural measures in the Preferred Alternative are anticipated to benefit adult
 2820 steelhead passage upstream, including modifying the adult trap at Lower Granite Dam and
 2821 modifying the upper ladder serpentine sections at Bonneville Dam (reducing delay). Adult
 2822 exposure to higher levels of TDG would increase relative to the No Action Alternative.

2823 Higher spill levels during April periods should result in higher survival rates for adult steelhead
 2824 falling back through dams and kelts migrating downstream. This is because fewer adults would
 2825 use powerhouse passage routes when a spill route is available, and downstream passage rates
 2826 increase when surface passage is available (Normandeau et al. 2014; Keefer et al. 2016).

2827 For Snake River steelhead, the CSS cohort model estimates that SARs would increase from 1.8
2828 percent under the No Action Alternative to 2.3 percent under the Preferred Alternative which is
2829 a 28 percent increase from the No Action Alternative. Table 7-27 displays the CSS cohort model
2830 results for Snake River steelhead. There is no NMFS LCM model for Snake River steelhead.

2831 **Table 7-27. Preferred Alternative Adult Model Metrics for Snake River Steelhead**

Metric (Model)	No Action Alternative	Preferred Alternative	Change from No Action Alternative	% Change
SARs LGR-BON (CSS)	1.8%	2.3%	+0.5%	+28%

2832 ***Snake River Coho Salmon***

2833 See Snake River spring/summer Chinook as a surrogate for Snake River coho salmon.

2834 Summary of Key Effects

2835 Juvenile survival would be very similar to the No Action Alternative (about 0.6 percent higher).

2836 Adults could see benefits to upriver migration with some structural measures.

2837 Juvenile Fish Migration/Survival

2838 Juvenile survival of Snake River coho salmon is estimated using COMPASS and CSS juvenile
2839 modeling results for Snake River spring Chinook salmon as a surrogate. Structural and
2840 operational measures described in the *Common Effects* section that describe changes at these
2841 dams would apply to these fish. The combination of several measures would decrease travel
2842 time and powerhouse encounters and overall increase juvenile outmigration survival. The
2843 COMPASS and CSS cohort models estimate that the Preferred Alternative would increase
2844 juvenile survival from Lower Granite Dam to Bonneville Dam by less than 1 percent, and travel
2845 time would decrease by about 7 percent. The increase in juvenile fish spill would be expected to
2846 decrease powerhouse encounters substantially, with the models predicting a decrease of about
2847 48 to 54 percent. TDG exposure would be 2.9 percent higher than the No Action Alternative,
2848 with a reach average exposure of 118.0 percent TDG.

2849 Adult Fish Migration/Survival

2850 Spill levels during the Snake River adult coho salmon migration would be similar to the No
2851 Action alternative; however, the duration may change with early spill reduction in the Preferred
2852 Alternative. Zero nighttime generation on the Snake River may delay later migrating Snake River
2853 coho salmon, but shaping this operation to occur only at night is expected to minimize this
2854 effect (Liscom et al. 1985). There would be no change to water temperatures, sediment
2855 concentrations or Dissolved Oxygen levels from any measures in the Preferred Alternative
2856 during the Snake River adult coho salmon migration period.

2857 **Snake River Sockeye Salmon**

2858 Summary of Key Effects

2859 Juvenile survival would be very similar to the No Action Alternative (about 0.6 percent higher).
2860 Travel time would be faster and powerhouse encounters substantially fewer. Fewer juvenile
2861 Snake River sockeye would be transported. Adults could see benefits to upriver migration with
2862 some structural measures, but may experience potentially higher fallback. Both adults and
2863 juveniles would be exposed to higher levels of TDG.

2864 Juvenile Fish Migration/Survival

2865 Juvenile survival of Snake River sockeye salmon is estimated using COMPASS and CSS juvenile
2866 modeling results for Snake River spring Chinook salmon as a surrogate, which indicates an
2867 increase in juvenile survival from Lower Granite Dam to Bonneville Dam by less than 1 percent,
2868 and a travel time decrease by about 7 percent. The increase in juvenile fish spill would be
2869 expected to decrease powerhouse encounters substantially, with the models predicting a
2870 decrease of about 48 to 54 percent. Predator disruption operations, also described in *Common*
2871 *Effects*, would further increase juvenile survival by reducing predation on out-migrating smolts.
2872 TDG exposure would be 2.9 percent higher than the No Action Alternative, with a reach average
2873 exposure of 118.0 percent TDG. See Table 7-27 for a list of model outputs related to juvenile
2874 migration and survival.

2875 Transportation of juvenile Snake River sockeye salmon could change due to spill and
2876 transportation measures in the Preferred Alternative. The outmigration window is more
2877 compressed, with the bulk of the smolts passing April through the end of May. However,
2878 starting transport in early April could increase transportation of juvenile Snake River sockeye
2879 salmon.

2880 Adult Fish Migration/Survival

2881 Several structural measures in the Preferred Alternative are anticipated to increase adult Snake
2882 River sockeye salmon passage success, including modifying the adult trap at Lower Granite Dam
2883 and modifying the upper ladder serpentine sections at Bonneville Dam.

2884 Transport of juvenile Snake River sockeye salmon is expected to decrease under the Preferred
2885 Alternative. Juvenile sockeye transported in the Snake River are more likely to fall back as
2886 adults than in-river migrating adult sockeye (Crozier et al. 2015). Transportation of juveniles
2887 appears to impair adult homing ability (i.e., ability to return back to their natal streams), which
2888 results in migration delay, increased fallback, and straying. This impaired homing ability may
2889 contribute to higher incidental harvest rates in the lower Columbia River than Middle Columbia
2890 sockeye salmon, which are the targets of the fishery. This impaired homing ability can be lethal
2891 during warm water years such as 2015.

2892 **Snake River Fall-Run Chinook Salmon**

2893 Summary of Key Effects

2894 Overall, no change or minimal change is anticipated for Snake River fall Chinook salmon,
2895 relative to the No Action Alternative. Juvenile survival and travel time would be similar to the
2896 No Action Alternative. Adult migration and survival would be similar to the No Action
2897 Alternative. Predator disruption operations, also described in *Common Effects*, would increase
2898 juvenile survival by reducing predation on out-migrating smolts. Improvements to the Lower
2899 Granite Dam adult fish trap, and Bonneville Adult fish ladders could reduce adult migration
2900 delay.

2901 Larval Development/Juvenile Rearing

2902 None of the measures of the Preferred Alternative would change the substrate sizes or
2903 distribution in the spawning areas or expand suitable spawning areas; therefore, this
2904 alternative is expected to have the same larval development and juvenile rearing habitat
2905 conditions as the No Action Alternative. The same is true for river depths in the spawning areas;
2906 no change is anticipated for eggs incubating in the gravel.

2907 Juvenile Fish Migration/Survival

2908 In-river survival would be expected to be similar to the No Action Alternative because summer
2909 spill levels would be the same. When spill levels are reduced in August under the Preferred
2910 Alternative, lower numbers of fish are actively migrating through the Snake River. Because
2911 transportation typically benefits Snake River juvenile fall Chinook in August, any decreases in
2912 dam passage survival due to reduced spill would likely be offset by increased returns from
2913 smolts that were transported downstream. Bird predation risk would decrease slightly due to
2914 changing operations at John Day Dam to reduce availability of Caspian tern nesting habitat prior
2915 to nesting season. Effects would be more noticeable for species like spring Chinook salmon and
2916 steelhead that migrate earlier, but would still be effective for Snake River fall Chinook salmon.
2917 None of the measures in the Preferred Alternative would affect turbidity during the juvenile
2918 outmigration months of May through July; therefore, their visual cover from predation would
2919 not change.

2920 Adult Fish Migration/Survival

2921 Several structural measures in the Preferred Alternative are anticipated to benefit adult Snake
2922 River fall Chinook salmon passage upstream, including modifying the adult trap at Lower
2923 Granite Dam and modifying the upper ladder serpentine sections at Bonneville Dam. Spill
2924 reduction starting August 15 may reduce fallback over the spillway, while still maintaining a
2925 non-powerhouse fallback route for adult fish that fallback. Zero generation operation could
2926 delay Snake River fall Chinook migrating in the Lower Snake River after October 15 (Liscom et
2927 al. 1985) but shaping this operation to occur only at night during the adult migration period is
2928 expected to minimize this effect. There would be no change to water temperatures, sediment

2929 concentrations or Dissolved Oxygen levels from any measures in Preferred Alternative during
2930 the Snake River fall Chinook adult migration period.

2931 **Lower Columbia River Salmon and Steelhead**

2932 ***Lower Columbia River Chinook Salmon***

2933 Summary of Key Effects

2934 Lower Columbia River Juvenile Chinook salmon survival and travel time would be similar to the
2935 No Action Alternative. Adult migration and survival would be similar to the No Action
2936 Alternative, with potentially higher fallback during the higher spill periods for the spring fish.

2937 Juvenile Fish Migration/Survival

2938 Five of the 32 sub-populations of Lower Columbia River Chinook salmon pass Bonneville Dam
2939 on their downstream outmigration to the ocean. There is no quantitative model for Lower
2940 Columbia River Chinook salmon; therefore, juvenile survival of Snake River spring/summer
2941 Chinook salmon at Bonneville Dam were used as a surrogate of juvenile survival. COMPASS
2942 modeling predicts a juvenile survival of 88.9 percent through the Bonneville Project, including
2943 the reservoir and the dam, which is similar to the No Action Alternative.

2944 Outflows can influence juvenile outmigration if changes in flows are enough to noticeably affect
2945 travel time and therefore survival. Hydrology modeling predicts Lower Columbia River Chinook
2946 spring and late-fall fish would experience outflows within 1 percent of the No Action Alternative
2947 with the exception of October, which is estimated to have 2 percent higher flows. The slight
2948 changes to river flow in the lower river would result in negligible changes to travel time and
2949 survival of Lower Columbia River Chinook. Likewise, water quality modeling indicated there
2950 would not be a perceptible change in temperature in the lower river due to the Preferred
2951 Alternative operations. Juvenile fish exposure to higher levels of TDG is expected to increase in
2952 the Preferred Alternative.

2953 Adult Fish Migration/Survival

2954 Structural measures such as modifying the upper ladder serpentine sections at Bonneville Dam
2955 could reduce delay associated with upstream passage for the five populations in the Lower
2956 Columbia River Chinook Salmon ESU that spawn upstream of Bonneville Dam. Fallback rates for
2957 spring-run Chinook may increase slightly with higher spill in April under the Preferred
2958 Alternative as fallback is associated with higher spill levels (Boggs et al. 2004; Keefer et al.
2959 2005). Hydrology and water quality modeling predicts increased exposure to higher levels of
2960 TDG that could affect Lower Columbia River Chinook salmon adult migration and survival.

2961 **Lower Columbia River Steelhead**

2962 Summary of Key Effects

2963 Lower Columbia River Juvenile steelhead survival and travel time would be similar to the No
2964 Action Alternative, with similar modeled dam survival, and hydrology. Exposure to higher levels
2965 of TDG would increase under the Preferred Alternative for both juvenile and adult steelhead.
2966 Adult migration and survival would be similar to the No Action Alternative, with potentially
2967 higher fallback during the higher spill for the spring-run steelhead populations that spawn
2968 upstream of Bonneville Dam.

2969 Juvenile Fish Migration/Survival

2970 Four of the 23 populations of Lower Columbia River steelhead pass Bonneville Dam on their
2971 downstream outmigration to the ocean. There is no quantitative model available for Lower
2972 Columbia River steelhead. Hydrology modeling predicts spring-run and late-fall-run steelhead
2973 would experience outflows within 1 percent of the No Action Alternative with the exception of
2974 October, which is estimated to have 2 percent higher flows. The slight changes to river flow in
2975 the lower river would result in negligible changes to travel time and survival of Lower Columbia
2976 River steelhead. Likewise, water quality modeling indicated there would not be a perceptible
2977 change in temperature in the lower river under the Preferred Alternative operations. Juvenile
2978 fish exposure to higher levels of TDG is expected to increase in the Preferred Alternative.

2979 Adult Fish Migration/Survival

2980 Modifying the upper ladder serpentine sections at Bonneville Dam could reduce adult steelhead
2981 delay associated with upstream passage for the populations that spawn upstream of Bonneville
2982 Dam. Spill for juvenile spring migrants at Bonneville Dam would be higher than the No Action
2983 Alternative and could result in slightly higher survival rates for adult steelhead falling back
2984 through dams and kelts migrating downstream. This is because fewer adults use powerhouse
2985 passage routes when a spill route is available and downstream passage rates increase when
2986 surface passage is available (Normandeau et al. 2014). Kelts that pass via surface passage at
2987 Bonneville Dam experience 100 percent survival (Rayamajhi et al. 2012). Hydrology and water
2988 quality models predict flows, and temperatures would be similar to the No Action Alternative.
2989 Higher TDG exposure could affect adult survival.

2990 **Lower Columbia River Coho Salmon**

2991 Summary of Key Effects

2992 Overall, no change or minimal change is anticipated for Lower Columbia River coho salmon
2993 relative to the No Action Alternative. Lower Columbia River coho juvenile salmon survival and
2994 travel time would be similar to the No Action Alternative. Adult Lower Columbia River coho
2995 salmon migration and survival would be similar to the No Action Alternative. Improvements to

2996 the Bonneville Dam adult fish ladders could reduce delay of adult coho for populations that
2997 spawn above Bonneville Dam.

2998 Juvenile Fish Migration/Survival

2999 Hydrology modeling predicts spring-run fish would experience outflows within 1 percent of the
3000 No Action Alternative with the exception of October, which is estimated to have 2 percent
3001 higher flows. The slight changes to river flow in the lower river would result in negligible
3002 changes to travel time and survival of Lower Columbia River coho salmon. Likewise, water
3003 quality modeling indicated there would be a negligible change in temperature in the lower river
3004 under the Preferred Alternative. Lower Columbia River coho juvenile salmon exposure to higher
3005 TDG is expected to increase under the Preferred Alternative.

3006 Adult Fish Migration/Survival

3007 Modifying the upper ladder serpentine sections at Bonneville Dam could reduce delay
3008 associated with upstream passage of Lower Columbia River coho salmon and this would benefit
3009 the populations in this ESU that spawn upstream of Bonneville Dam. Hydrology and water
3010 quality models predict flows and temperatures would be similar to the No Action Alternative
3011 during the adult coho salmon migration period.

3012 ***Columbia River Chum Salmon***

3013 Summary of Key Effects

3014 Effects under the Preferred Alternative would be similar to the No Action Alternative for chum
3015 salmon. The ability to meet flow targets and TDG exposure threshold (105 percent) during
3016 spawning and incubation would be similar to the No Action alternative. Adult and juvenile chum
3017 salmon migration and survival would be similar to the No Action Alternative.

3018 Larval Development/Juvenile Rearing

3019 Under the Preferred Alternative, chum flows would be similar to No Action Alternative and
3020 expected to be met in more than 90 percent of all years. TDG is also expected to be similar,
3021 exceeding 105 percent TDG in 5 out of 80 years.

3022 Juvenile Fish Migration/Survival

3023 Chum salmon encounter only one CRS project, Bonneville Dam, so none of the structural
3024 measures described in *Common Effects* for juvenile salmon and steelhead would apply to these
3025 fish, and only a small proportion of spawning occurs above Bonneville.

3026 Adult Fish Migration/Survival

3027 The structural measure to modify the Bonneville Dam serpentine weir ladder would improve
3028 passage for the small portion of Columbia River chum salmon that pass this project, but most

3029 chum spawn downstream of Bonneville Dam. Migration of adult chum into the Columbia River
3030 is in October and November. Bonneville Dam average monthly outflows would be about 2
3031 percent higher in October and the same as the No Action Alternative in November.

3032 **OTHER ANADROMOUS FISH**

3033 **Pacific Eulachon**

3034 ***Summary of Key Effects***

3035 Effects in the Preferred Alternative would be similar to the No Action Alternative for juvenile
3036 Pacific eulachon migration and survival.

3037 Compared to the No Action Alternative, the Preferred Alternative would have no change in the
3038 time between the peak spawning runs, egg development, and larval emergence for Pacific
3039 eulachon. The spring freshet that disperses larvae to adequate food sources would continue to
3040 be highly variable, with an average of 168 days between spawning temperature triggers and
3041 peak flows (158 days in high-flow years, and 156 days in low-flow years).

3042 Spring flow rates would be expected to be within 1 percent of the No Action Alternative during
3043 outmigration, so any changes affecting Pacific eulachon feeding would be negligible.

3044 Pacific eulachon would continue to migrate into the Columbia River from November through
3045 March, with specific dates of migration and spawning based on a variety of environmental
3046 factors, including temperature, high tides, and ocean conditions (NMFS 2017). Modeled data
3047 for the Preferred Alternative (based on the period of record for Bonneville Dam tailwater
3048 temperatures) indicate that temperatures would not be substantially different than the No
3049 Action Alternative. Spawning locations and substrate conditions would not be expected to
3050 differ from the No Action Alternative.

3051 Bird predation risk can be influenced by flow rates. Higher flows are linked to higher predation
3052 rates on Pacific eulachon, whereas at lower flows, birds tend to switch to marine prey. Under
3053 the Preferred Alternative, there would be negligible change in flows (0 to 2 percent) in all
3054 months and water year types.

3055 **Green Sturgeon**

3056 ***Summary of Key Effects***

3057 Green sturgeon use the Columbia River primarily for foraging habitat for adults and subadults.
3058 Key effects of the Preferred Alternative are focused on how flows and temperatures influence
3059 the cues for entering the Columbia River from the Pacific Ocean as well as the availability and
3060 distribution of food sources. Overall, the lower Columbia River would continue to provide good
3061 foraging and rearing habitat for green sturgeon. There would be negligible changes to foraging
3062 habitat from flows (within 1 percent) compared to the No Action Alternative in all months but
3063 October, which would have 2 percent higher flow in the Lower Columbia River on average.

3064 **Pacific Lamprey**

3065 ***Summary of Key Effects***

3066 The Preferred Alternative has measures intended to increase upstream passage success and
3067 reduce injury and mortality for Pacific lamprey. These measures are proposed structural
3068 improvements that include converting extended-length submersible bar screen material to
3069 screen material that would not impinge or entangle juvenile lamprey, expanding the network of
3070 lamprey passage structures to bypass impediments in fish ladders, changing the design for
3071 turbine cooling water strainers, and replacing turbines for safer fish passage.

3072 As described for the No Action Alternative, upstream and downstream passage at the lower
3073 Columbia River and Snake River Dams has influenced population decline and reduced
3074 distribution of Pacific lamprey. The most substantial benefit of the Preferred Alternative would
3075 be the improvements to get lamprey to enter and pass the fish ladders; this would occur
3076 through expanding the network of lamprey passage structures and modifying fish ladders to
3077 incorporate lamprey passage criteria into the structural modifications.

3078 ***Larval Development/Juvenile Rearing***

3079 The Preferred Alternative includes manipulation of the John Day Reservoir for predator
3080 disruption. Water levels would be increased prior to Caspian tern nesting season and then
3081 dropped back down to the normal operating pool in June. Depending on dewatering rates,
3082 larval lamprey could become stranded if they are rearing in the shallows when the pool level
3083 would be dropped. Otherwise, ramping rates and dewatering issues would be the same in the
3084 Preferred Alternative as for the No Action Alternative.

3085 ***Juvenile Fish Migration/Survival***

3086 Several measures would improve conditions and reduce injuries and losses of juvenile lamprey
3087 that migrate past lower Snake and Columbia River dams.

3088 Proposed actions include the following:

- 3089 • Replace the extended-length submersible bar screen material with screen material that
3090 would not impinge and entangle juvenile lamprey. Because turbine routes are generally
3091 associated with lower survival of migrating juvenile salmon and steelhead, turbine intakes
3092 are equipped with screens that help bypass these fish to higher survival routes. Some of
3093 these screens are made of closely spaced bars. These screens are effective at safely
3094 diverting juvenile salmon and steelhead, but juvenile lamprey are often so small they
3095 become impinged between these bars. The modification or replacement of these screens
3096 with woven mesh or more tightly spaced bar material would reduce lamprey mortality.
- 3097 • Turbine cooling water intakes within the turbine scroll case are equipped with a strainer
3098 that prevents debris from entering the cooling water system. However, these strainers do
3099 not prevent the entrainment of juvenile lamprey and some juvenile salmon and steelhead.

3100 The retrofitting of these intakes with hoods that allow water flow but prevent debris and
3101 juvenile fish entry would reduce lamprey losses in the cooling water intake system.

- 3102 • Replacing turbines at the John Day Project (also defined in the *Common Effects to Salmon*
3103 *and Steelhead* section) with a newer design of turbine could improve conditions for fish
3104 passage and reduce the injury rate for lamprey.

3105 Because of the high degree of uncertainty surrounding how many juvenile lamprey are injured
3106 on their downstream migration, and the relative effects to juvenile lamprey due to passage via
3107 surface routes or turbine routes, it is difficult to quantify the improvement represented by all of
3108 the measures. For fish that encounter multiple dams on their migration downstream, reducing
3109 the total number of hazards would increase their probability for survival to the adult life stage.

3110 **Adult Migration/Survival**

3111 Key structural measures in the Preferred Alternative that are intended to provide
3112 improvements to adult lamprey passage and survival include:

- 3113 • Expand network of lamprey passage structures at Bonneville, The Dalles, and John Day
3114 Dams: Fish ladders at most of the projects were designed primarily for salmon and
3115 steelhead passage. More recent work has shown some parts of the structures create
3116 migration delays and even barriers for lamprey.
- 3117 • Modify the upper ladder serpentine flow control ladder sections at Bonneville Dam. At
3118 Bonneville Dam's Bradford Island and Washington Shore ladder flow control sections, the
3119 baffles that help slow velocities and control flows do not allow for direct line movement of
3120 fish passing the dam, but requires fish to weave through the baffles. This construction
3121 reduces fish passage efficiency and increases migration delays. The modification of these
3122 baffles would include replacing baffles allow for direct faster movement through the ladder
3123 baffles from this section of the ladders and replace them with baffles that have in-line
3124 vertical slots and orifices. This measure has the potential to increase adult salmon and
3125 steelhead survival by reducing upstream travel times and higher conversion rates. A similar
3126 modification at John Day Dam, the only other CRS dam to use this type of ladder, resulted in
3127 substantial reduced passage time for salmon and steelhead. Similar improvements are
3128 expected for Bonneville Dam. In addition, these improvements would reduce migration
3129 delays and barriers for Pacific lamprey.
- 3130 • Installing closeable gates on Bonneville Powerhouse 2 floating orifice gates would reduce
3131 incidences of lamprey falling out of the Washington Shore Fish Ladder. Closeable gates
3132 would allow seasonal closure during the lamprey passage season (June to September).
3133 Lamprey passage studies have shown that a large portion of the adult lamprey run enters
3134 the main south shore fishway entrance at Powerhouse 2. However, the passage success
3135 rate for these fish is low because many fall back out of the fishway through the floating
3136 orifice gates as they traverse the collection channel that crosses the powerhouse and
3137 connects the south entrance to the fish ladder. Closing the floating orifice gates would
3138 eliminate this problem, and increase the success rate of adult lamprey passing Bonneville

3139 Dam. The floating orifice gates would be re-opened outside the adult lamprey passage
3140 season to allow additional entrances to the ladder system for salmon and steelhead, in
3141 particular, when sea lions are present in the spring. This measure is expected to increase
3142 adult lamprey upstream passage success by keeping adult lamprey from failing out of the
3143 ladder once they enter it.

3144 The overall expected improvements in lamprey passage efficiency should decrease
3145 susceptibility to physical stress and mortality, and shorter holding time, which is beneficial to
3146 the fish. Increasing passage success at each dam, starting lower in the system, puts more adults
3147 further upstream. Therefore, these structural measures for lamprey are expected to provide a
3148 benefit to the spatial distribution of Pacific lamprey in the Columbia Basin. All of the structural
3149 measures to reduce losses would also have benefits to the population and recruitment in the
3150 next generation. Pacific Lamprey do not exhibit strong homing tendencies to their river of natal
3151 origin, hence, improved survival rates from adult return to juvenile outmigration would benefit
3152 the north Pacific population rather than only the Columbia Basin.

3153 **American Shad**

3154 **Summary of Key Effects**

3155 No change is anticipated to juvenile American shad because plankton communities and
3156 shoreline habitat are not changing in the Preferred Alternative. The proportion of adult shad
3157 counted at Bonneville Dam that migrate upstream past McNary Dam is expected to remain
3158 similar relative to the No Action Alternative.

3159 **7.7.5 Resident Fish**

3160 **7.7.5.1 Region A**

3161 **KOOTENAI RIVER BASIN**

3162 **Summary of Key Effects**

3163 Under the Preferred Alternative, the *Modified Draft at Libby* and *Sliding Scale at Libby and*
3164 *Hungry Horse* measures would have a direct effect on Libby Dam operations and reservoir
3165 elevations. The key effects of the Preferred Alternative would be the continued effects
3166 described under the No Action Alternative, many of which limit important biological processes,
3167 with a mix of effects from the measures in the Preferred Alternative. The Preferred Alternative
3168 includes operational measures that would have minor to moderate adverse and beneficial
3169 effects to resident fish compared to the No Action Alternative. The relationships that affect
3170 food webs in Lake Kootenai would have moderate beneficial effects. Below Libby Dam, there
3171 would be minor adverse effects to riparian function in median years, but minor beneficial
3172 effects to riparian habitat function, fish growth, and food production in wet years. Riparian
3173 processes for cottonwood generation would be similar or slightly better than under the No
3174 Action Alternative, with minor adverse effects to riparian habitat functionality and minor

3175 beneficial effects to rates of flow recession during the riparian recruitment period. Riparian
3176 function and cottonwood recruitment would benefit from mitigation measures to increase
3177 riparian vegetation. Additional mitigation measures included in the Preferred Alternative are
3178 *Plant Cottonwood Trees (up to 100 acres) on the Kootenai River below Libby Dam* and *Plant*
3179 *native wetland and riparian vegetation (up to 100 acres) on the Kootenai River downstream of*
3180 *Libby*. Conditions for Kootenai River white sturgeon and burbot would be variable, but overall
3181 minor beneficial effects to ecosystem productivity would be realized compared to the No
3182 Action Alternative, especially in wet years. Effects to other native fish below Libby Dam would
3183 be either negligible or minor beneficial effects.

3184 **Habitat Effects Common to All Fish**

3185 The Preferred Alternative would have slightly lower flows during the early spring freshet than
3186 the No Action Alternative, which would translate to a greater delay in growth and development
3187 of resident fish and their food sources compared to the No Action Alternative. Conversely, in
3188 wet years, there would be a beneficial effect because the flows in early spring would be higher
3189 than the No Action Alternative; the higher flows would increase productivity in the river
3190 because more river margins and floodplain areas would be inundated, allowing these habitats
3191 to become warmer and more productive sooner than in the No Action Alternative. For further
3192 description and graphic representation of the hydrograph in wet, dry, and average year types
3193 see Section 7.7.1 for Region A.

3194 The Preferred Alternative measures would result in similar potential timeframes for
3195 cottonwood and willow seeding and recruitment compared to the No Action Alternative; on
3196 average, about half of the time winter flows would exceed a stage of 1,753 feet at Bonners
3197 Ferry (considered representative of the previous summer's seeding elevation), leading to
3198 mortality of seedlings recruited the previous spring. The potential riparian habitat area
3199 provided for seeding and recruitment would decrease by about 30 percent under the Preferred
3200 Alternative, which provides about 0.7-foot band of potential vegetation, compared to a 1.0-foot
3201 band in the No Action Alternative. However, mitigation measures would provide up to 100
3202 acres of riparian (cottonwood) plantings large enough to withstand inundation by winter flows.
3203 Additionally, the rate of recession would be slower after flows have reached their highest point
3204 in the spring. This would allow for greater riparian recruitment because the slower rate of
3205 recession is closer to the optimum rate for the roots of seedlings to maintain contact with the
3206 water table as it recedes. However, the slower rate is more prevalent in dry years, leading to
3207 riparian recruitment in lower elevations that are more susceptible to inundation the following
3208 winter. In wet and average years, the rate of hydrograph recession would be similar to the No
3209 Action Alternative. Considering all of these factors, the Preferred Alternative, coupled with the
3210 additional mitigation for cottonwoods discussed previously, would provide a minor beneficial
3211 effect to riparian recruitment.

3212 **Bull Trout**

3213 The metrics for food productivity under the Preferred Alternative varies for different food
3214 sources, but overall the Preferred Alternative would provide moderate beneficial effects for bull

3215 trout in the reservoir. Lake Koocanusa would be above elevation 2,450 feet for 60 days,
3216 compared to only 44 in the No Action Alternative on average during the summer when
3217 productivity is critical. The increased volume of productive water would be a moderate
3218 beneficial effect to food source productivity.

3219 The average minimum annual pool elevation of Lake Koocanusa under the Preferred Alternative
3220 would be approximately 3 feet lower in dry and average years than under the No Action
3221 Alternative. The expected result would be more area during these year types subject to annual
3222 dewatering and decreased benthic insect production. In wet years, the minimum pool elevation
3223 would be the same as the No Action Alternative. There would be a minor decrease in bull trout
3224 growth or survival (or both), particularly for juveniles as they out-migrate from tributaries, but
3225 before they switch to fish for prey, during dry and average years. However, the annual
3226 maximum elevation of Lake Koocanusa under the Preferred Alternative would be about 2 feet
3227 higher than under the No Action Alternative and would result in higher terrestrial insect
3228 availability under this alternative. This, coupled with the higher volume of the productive
3229 euphotic (surface and near surface) water, would result in a moderate benefit to the food web
3230 for bull trout.

3231 Under the Preferred Alternative, Libby Dam would provide discharge of 20 kcfs or greater for 11
3232 days, on average, during the spring freshet, which is 2 days less than the mean for the No
3233 Action Alternative. The mean flow rate from May 15 to June 15 under the Preferred Alternative
3234 would be slightly less than under the No Action Alternative. Similar to the No Action
3235 Alternative, this would be insufficient to mobilize or reshape tributary deltas that could prevent
3236 bull trout access during low flows in the fall spawning season. Improvements to riparian
3237 function from mitigation measures described previously on the Kootenai River would provide a
3238 minor benefit for bull trout habitat below Libby Dam.

3239 The mean summer discharge from Libby Dam would be slightly lower under the Preferred
3240 Alternative than the No Action Alternative; these reduced flows would provide slightly more
3241 usable habitat and would be in the optimum range for bull trout food availability and off-
3242 channel inundation and connectivity.

3243 **Kootenai River White Sturgeon**

3244 The Preferred Alternative would have a negligible change to peak sturgeon flows in most water
3245 year types, but a minor beneficial increase in wet years related to the increased rate of flow in
3246 the spring. The rate of which flows decrease after reaching the highest point in the spring
3247 would be similar to the No Action Alternative, and there would be one day less floodplain
3248 connectivity for larval rearing. River temperature would be similar to the No Action Alternative.
3249 Effects of the Preferred Alternative to Kootenai River White Sturgeon would be negligible
3250 compared to those of the No Action Alternative in most water year types and minor beneficial
3251 in wet years, when the sturgeon have the best chance of recruitment.

3252 **Other Fish**

3253 As described for bull trout, there would be a moderate beneficial effect to the food web that
3254 would also benefit westslope cutthroat trout and kokanee in Lake Kooconusa. The euphotic
3255 zone would see moderate beneficial effects. Regarding benthic insect production, the minimum
3256 annual pool elevation of Lake Kooconusa under the Preferred Alternative would be
3257 approximately 3 feet lower in average years for minor adverse effects, 2 feet higher in dry years
3258 for beneficial effects, and similar to the No Action Alternative in wet years. This would result in
3259 overall negligible to minor effects to benthic insect larvae production for resident fish species.
3260 The annual maximum elevation of Lake Kooconusa under the Preferred Alternative would be
3261 about 2 feet higher than under the No Action, and would result in slightly higher terrestrial
3262 insect availability. Entrainment of kokanee would be similar to the No Action Alternative.

3263 The Kootenai River below Libby Dam would have slightly lower discharges for the period May
3264 15 to September 30 than the No Action Alternative, and would provide a negligible increase in
3265 usable habitat for juvenile and adult rainbow trout (less than 2 percent) than the No Action
3266 Alternative. Entrainment of kokanee would be similar to the No Action Alternative. For burbot
3267 in the reservoir, entrainment risk would be slightly lower. For burbot in the Kootenai River, the
3268 spring freshet flow increase in most years would be less than No Action Alternative for a minor
3269 adverse effect, but higher and a minor beneficial effect in wet years. The change in days of
3270 floodplain connectivity would be negligible. High and variable flows could interrupt burbot
3271 spawning migrations, while low (4 kcfs) and stable winter flows enhance the likelihood of
3272 successful burbot spawning. Median flows under the Preferred Alternative would be slightly
3273 higher than No Action Alternative, but flow variability would be similar. Burbot recruitment
3274 would be similar to the No Action Alternative. Improvements to riparian function and floodplain
3275 connectivity would provide a minor to moderate beneficial effect due to additional rearing
3276 habitat for many of these species.

3277 **HUNGRY HORSE/FLATHEAD/CLARK FORK FISH COMMUNITIES**

3278 **Summary of Key Effects**

3279 The key effects under the Preferred Alternative would be very similar to the No Action
3280 Alternative, with exceptions due to the *Sliding Scale at Libby and Hungry Horse* measure. Higher
3281 reservoir elevations in the summer and into the fall months in drier years, as well as reduced
3282 summer outflows, would have minor to moderate beneficial effects to food supply, habitat
3283 suitability, and spawning fish access into tributaries, especially in dry years.

3284 **Habitat Effects Common to All Fish**

3285 In most years, the deepest draft of the reservoir would be similar to the No Action Alternative,
3286 and in dry years this lowest point of the year would be several feet higher than the No Action
3287 Alternative. Maintaining a higher elevation provides a larger pool of water. In wet and average
3288 water years the hydrograph would be similar to No Action Alternative; the reservoir would still
3289 reach near full pool (elevation 3,560 feet) by early July and be allowed to drain until the end of

3290 September to about 3,550 feet elevation. In dry years the reservoir would approach full pool
3291 similar to No Action Alternative but would have water withdrawn, or drafted, more slowly until
3292 the end of September, ending about 6 feet higher than the No Action Alternative. Similarly,
3293 through the fall and winter months the Preferred Alternative elevations would be similar to No
3294 Action Alternative in wet and average years, and the median elevation of dry years would be
3295 about 4 feet higher than No Action Alternative. Note, in the driest years the project would be
3296 operated to meet minimum flows for resident fish downstream of the project resulting in
3297 similar drafts to the No Action Alternative.

3298 Lake elevation in the warm summer months determines the volume of reservoir that would be
3299 available to produce plankton (euphotic zone). With higher summer elevations in dry years the
3300 euphotic zone in August and September would be 2 percent and 3 percent higher, respectively.
3301 In other months, and in all months of wet and average years the zone would be similar to the
3302 No Action Alternative volume, with less than 1 percent change. See Appendix E for a table of
3303 the calculated euphotic zone predictions of the Preferred Alternative.

3304 Reservoir drawdowns at any time during the year affect the production of insects that live on
3305 the bottom of the reservoir. Aquatic insects are the primary food supply for fish during spring
3306 and early summer and remain important fish prey through late fall. The Preferred Alternative
3307 would draft at a lower rate than the No Action Alternative in the summer and the surface of the
3308 reservoir would remain at a higher elevation through the following fall and winter in dry years.
3309 This would result in slightly more area for benthic insect (those that live on, under, or near the
3310 reservoir floor/lake bottom) production than the No Action Alternative, particularly in the large,
3311 shallow lobes of the upper reservoir where a small change in elevation can result in a
3312 proportionally larger change in inundated/submerged lake bottom. Some of the larger aquatic
3313 insects have long life cycles that require overwintering where they are deposited; higher winter
3314 elevations would improve the survival of these important insects. Surface area can be used as
3315 an index for change in benthic area. By this measure, the Preferred Alternative surface area
3316 would be 1 to 3 percent higher than the No Action Alternative in the summer months of dry
3317 years, and similar to No Action Alternative in other years.

3318 Finally, the reservoir surface elevation determines the surface area available for terrestrial
3319 insects to land on the water, where they become available as fish food during summer and fall.
3320 The reservoir elevation also influences the proximity of the water's edge to terrestrial
3321 vegetation and therefore, the amount of the poorly flying insects that become available to fish
3322 by passively landing on the water. In the summer months of dry years, the surface area would
3323 still decrease as the reservoir drafts, but at a lower rate than the No Action Alternative. By mid-
3324 summer there would be about 1 percent more surface area than the No Action Alternative and
3325 by late September there would be up to about 3 percent, or about 600 acres, more. See
3326 Appendix E for a table of the calculated surface area predictions of the Preferred Alternative.

3327 Zooplankton would continue to be entrained into the South Fork Flathead River from Hungry
3328 Horse reservoir. In the long-term, repairs to the slide gates of the selective withdrawal
3329 structure, as described in the No Action Alternative measure *Hungry Horse Project Power Plant*

3330 *Modernization* (and carried forward in the Preferred Alternative), would reduce the
3331 entrainment of zooplankton by allowing adjustments to take water from the zones in the
3332 reservoir that are not heavily populated with zooplankton to reach target water temperatures.
3333 Outflows, and therefore zooplankton entrainment, under the Preferred Alternative would be
3334 slightly (up to 1 percent) higher than the No Action Alternative in October through June in all
3335 year types, and 1 percent to 5 percent lower in July through September. This would provide a
3336 minor beneficial effect to reservoir food supply in the summer by reducing entrainment
3337 compared to the No Action Alternative.

3338 Outflow patterns from Hungry Horse Reservoir can also affect how fish are entrained into the
3339 South Fork Flathead River, and the habitat conditions, such as river elevation (stage), velocities,
3340 and temperatures in the river. Slightly lower outflows in late summer would reduce
3341 entrainment of fish. The temperature control structure would still operate in the summer
3342 months as in the No Action Alternative so changes in outflows in this timeframe would not
3343 affect summer temperatures downstream.

3344 In the Flathead River down to Flathead Lake, habitat suitability under the No Action Alternative
3345 is a key issue due to high flows during the summer and winter. Under the Preferred Alternative,
3346 summer flows would be 1 to 5 percent lower and provide a minor benefit to habitat suitability
3347 by mimicking a natural hydrograph more closely, reducing velocities compared to the No Action
3348 Alternative. Spring peak flows and winter base flows would be the same or slightly higher than
3349 the No Action Alternative. These spring flows would continue to occasionally provide flushing of
3350 sediments from gravels to maintain habitat; effects from slight flow increases in the winter
3351 would be a negligible effect to fish habitat. The winter water temperature warming influence
3352 from the contribution of the South Fork Flathead would be similar to the No Action Alternative,
3353 as would the total dissolved gas levels in the river.

3354 The influence of Preferred Alternative changes to Flathead Lake levels and Seli's Ksanka Qlispe'
3355 Dam operations would be minimal compared to the No Action Alternative, and habitat
3356 conditions in these areas would be similar to those described under the No Action Alternative.

3357 **Bull Trout**

3358 Summer production of zooplankton would slightly increase under the Preferred Alternative as
3359 well as surface insect landing and feeding area, and annual benthic insect populations that
3360 support the bull trout food web. Juvenile bull trout moving into the reservoir in the spring rely
3361 on eating benthic and terrestrial insects until they transition to eating fish so this would be a
3362 moderate beneficial effect to bull trout, especially in dry years. The prey items that adult bull
3363 trout eat also consume benthic insects and may be in better condition or more plentiful. This
3364 could result in slightly improved bull trout condition/health.

3365 Higher reservoir elevations in the fall would decrease the risk and exposure to predation and
3366 angling pressure for upstream migrating bull trout. The difference between the Preferred
3367 Alternative and the No Action Alternative would be more pronounced in dry years when these
3368 issues tend to occur. The sedimentation of tributary deltas currently is unknown, but there

3369 could potentially be access to some tributaries in some years where fish would have been
3370 blocked under the No Action Alternative.

3371 Bull trout entrainment through the dam would likely decrease under the Preferred Alternative
3372 due to slightly lower late summer outflows. Withdrawals in August and September are
3373 generally selected from fairly deep in the water column to release the target temperature, and
3374 bull trout have been documented in these strata at this time of year. Entrainment under the No
3375 Action Alternative is likely minimal, but would be expected to decrease up to about 5 percent
3376 under the Preferred Alternative as modeled.

3377 In the South Fork Flathead River, below Hungry Horse Dam, zooplankton inputs from the
3378 reservoir may decrease slightly in summer with lower outflows, but benthic production would
3379 remain stable. Decreased late summer flows would more closely mimic a normalized
3380 hydrograph and lower velocities would result in more suitable habitat for bull trout. Overall
3381 there are few bull trout that use the South Fork Flathead River and impacts to these species
3382 would be negligible and habitat effects are minor.

3383 Summer flows in the mainstem Flathead River would continue to meet minimum flow
3384 requirements, but are projected to be slightly lower than the No Action Alternative in some
3385 years, for a minor improvement in habitat suitability. Muhlfeld et al. (2011) found even
3386 moderate increases in summer flows resulted in substantial decreases in suitable area for bull
3387 trout, and that nighttime habitat for subadult bull trout was most sensitive. The 2 to 5 percent
3388 decrease due to Preferred Alternative operations would be a minor beneficial effect to bull
3389 trout habitat, especially for subadults. The mainstem Flathead River would be similar to the No
3390 Action Alternative in winter, with barely perceptible changes (slightly higher) from the No
3391 Action Alternative.

3392 Operations of Seli's Ksanka Qlispe' Dam (Flathead Lake) would be similar to the No Action
3393 Alternative, and the bull trout habitat use and life history functions in Flathead Lake, the Lower
3394 Flathead River, and Clark Fork River would be similar to the No Action Alternative.

3395 **Other Fish**

3396 Hungry Horse Reservoir favors a native fish dominated community. Juvenile bull trout and adult
3397 whitefish, northern pikeminnow, sculpins, and westslope cutthroat trout feed on zooplankton,
3398 aquatic insects, and terrestrial insects; adult bull trout prey on mountain whitefish, suckers,
3399 minnows, etc. The food web effects described above would also apply to all of these species of
3400 fish in Hungry Horse Reservoir. Slight increases in zooplankton, benthic insects, and increased
3401 summertime feeding of terrestrial insects could improve food supply, especially in dry years.

3402 Westslope cutthroat trout and other native fish spawn in the spring (April through June), so
3403 effects on adults migrating into tributaries to spawn would differ from bull trout. Spring
3404 spawning fish migrate when reservoir levels are lower and tend to experience longer varial
3405 zones, or areas where the tributaries pass through the upper parts of the reservoirs that are
3406 only seasonally inundated during high water periods and, as such, are typically void of

3407 vegetation and of insufficient depth to provide cover. This subjects them to increased exposure
3408 to predation and angling pressure. Under Preferred Alternative operations the April and May
3409 elevations would be either the same or slightly higher than in No Action Alternative. Spring
3410 spawning fish such as westslope cutthroat trout would experience slightly fewer varial zone
3411 effects (predation and angling pressure) and access issues to spawning tributaries under the
3412 Preferred Alternative. Juveniles typically out-migrate in June when the effects would also be
3413 similar to the No Action Alternative.

3414 Entrainment from the reservoir would also continue at unquantified levels and could decrease
3415 slightly in the summer months with lower outflows. Northern pike minnow and bull trout have
3416 been documented at the depths of late summer withdrawal and would be most susceptible to
3417 entrainment, and therefore be benefitted most by this minor effect of the Preferred
3418 Alternative. Entrainment would be expected to decrease 1 to 5 percent in the summer months
3419 and change in winter would be negligible.

3420 Habitat suitability described for bull trout would be similar for other native fish in the mainstem
3421 Flathead River (Muhlfeld et al. 2011), with lower summer flows in the Preferred Alternative
3422 resulting in a minor increase in suitable habitat for these native fish in the summer.

3423 Effects to fish in Flathead Lake, the lower Flathead River, and Clark Fork River would be the
3424 same as described under the No Action Alternative.

3425 **LAKE PEND OREILLE (ALBENI FALLS RESERVOIR)/PEND OREILLE RIVER**

3426 **Summary of Key Effects**

3427 Hydrology modeling showed that Lake Pend Oreille elevations, inflows, and outflows would be
3428 similar to those found in the No Action Alternative. Biological relationships were dependent on
3429 these parameters, so the key effects of the Preferred Alternative for bull trout, fish habitat, and
3430 other fish species in the Pend Oreille basin would be the same as those described under the No
3431 Action Alternative. The key effects of the Preferred Alternative would be the continued effects
3432 of the No Action Alternative, many of which limit important biological processes, with a mix of
3433 effects from the measures in the Preferred Alternative. The Preferred Alternative includes
3434 operational measures that would have minor to moderate adverse and beneficial effects to
3435 resident fish compared to the No Action Alternative. The various mechanisms that affect food
3436 webs in Lake Kootenai would realize a moderate benefit. Below Libby Dam, there would be
3437 minor adverse effects to riparian function in median years, but minor beneficial effects to
3438 riparian habitat function, fish growth, and food production in wet years. Riparian processes for
3439 cottonwood generation would be similar or slightly better than the No Action Alternative, with
3440 minor adverse effects to riparian habitat functionality and minor beneficial effects to rates of
3441 flow recession during the riparian recruitment period. Riparian function and cottonwood
3442 recruitment would benefit from mitigation measures to increase riparian vegetation.
3443 Conditions for Kootenai River white sturgeon and burbot would be variable, but overall minor
3444 beneficial effects to ecosystem productivity would be realized compared to the No Action
3445 Alternative, especially in wet years. Effects to other native fish below Libby Dam would be

3446 either negligible or minor beneficial effects. Under the Preferred Alternative, the *Modified Draft*
3447 *at Libby* and *Sliding Scale at Libby and Hungry Horse* would have a direct effect on Libby Dam
3448 operations and reservoir elevations. Mitigation measures included in the Preferred Alternative
3449 are *Plant Cottonwood Trees (up to 100 acres) on the Kootenai River below Libby Dam* and *Plant*
3450 *native wetland and riparian vegetation (up to 100 acres) on the Kootenai River downstream of*
3451 *Libby*.

3452 **Habitat Effects Common to All Fish**

3453 The Preferred Alternative would have slightly lower flows during the early spring freshet than
3454 the No Action Alternative, which would translate to a greater delay in growth and development
3455 of resident fish and their food sources compared to the No Action Alternative. Conversely, in
3456 wet years, there would be a beneficial effect because the flows in early spring would be higher
3457 than the No Action Alternative; the higher flows would increase productivity in the river
3458 because more river margins and floodplain areas would be inundated, allowing these habitats
3459 to become warmer and more productive sooner than in the No Action Alternative. For further
3460 description and graphic representation of the hydrograph in wet, dry, and average year types
3461 see Section 7.7.1 for Region A.

3462 The Preferred Alternative measures would result in similar potential timeframes for
3463 cottonwood and willow seeding and recruitment compared to the No Action Alternative; on
3464 average, about half of the time winter flows would exceed a stage of 1,753 feet at Bonners
3465 Ferry (considered representative of the previous summer's seeding elevation), leading to
3466 mortality of seedlings recruited the previous spring. The potential riparian habitat area
3467 provided for seeding and recruitment would decrease by about 30 percent under the Preferred
3468 Alternative, which provides about 0.7-foot band of potential vegetation, compared to a 1.0-foot
3469 band in the No Action Alternative. However, mitigation measures would provide up to 100
3470 acres of riparian (cottonwood) plantings large enough to withstand inundation by winter flows.
3471 Additionally, the rate of recession after the spring peak would be 60 percent slower, and would
3472 allow for greater riparian recruitment because the slower rate of recession is closer to the
3473 optimum rate for the roots of seedlings to maintain contact with the water table as it recedes.
3474 However, the slower rate is more prevalent in dry years, leading to riparian recruitment in
3475 lower elevations that are more susceptible to inundation the following winter. In wet and
3476 average years, the rate of hydrograph recession would be similar to the No Action Alternative.
3477 Considering all of these factors, the Preferred Alternative would provide a minor beneficial
3478 effect to riparian recruitment.

3479 **Bull Trout**

3480 The metrics for food productivity under the Preferred Alternative varies for different food
3481 sources, but overall the Preferred Alternative would provide moderate beneficial effects for bull
3482 trout in the reservoir. Lake Koocanusa would be above elevation 2,450 feet for 60 days,
3483 compared to only 44 in the No Action Alternative on average during the summer when
3484 productivity is critical. The increased volume of productive water would be a moderate
3485 beneficial effect to food source productivity.

3486 The average minimum annual pool elevation of Lake Koocanusa under the Preferred Alternative
3487 would be approximately 3 feet lower in dry and average years than under the No Action
3488 Alternative. The expected result would be more area during these year types subject to annual
3489 dewatering and decreased benthic insect production. In wet years, the minimum pool elevation
3490 would be the same as the No Action Alternative. There would be a minor decrease in bull trout
3491 growth and/or survival, particularly for juveniles as they out-migrate from tributaries but
3492 before they switch to fish for prey, during dry and average years. However, the annual
3493 maximum elevation of Lake Koocanusa under the Preferred Alternative would be about 2 feet
3494 higher than under the No Action Alternative and would result in higher terrestrial insect
3495 availability under this alternative. This, coupled with the higher volume of the productive
3496 euphotic (surface and near surface) water, would result in a moderate benefit to the food web
3497 for bull trout.

3498 Under the Preferred Alternative, Libby Dam would provide discharge of 20 kcfs or greater for 11
3499 days, on average, during the spring freshet, which is 2 days less than the mean for the No
3500 Action Alternative. The mean flow rate from May 15 to June 15 under the Preferred Alternative
3501 would be slightly less than under the No Action Alternative, and, similar to the No Action
3502 Alternative, would be insufficient to mobilize or reshape tributary deltas that can prevent bull
3503 trout access during low flows in the fall spawning season. Improvements to riparian function
3504 from mitigation measures would provide a minor benefit to bull trout habitat in the Kootenai
3505 River.

3506 The mean summer discharge from Libby Dam would be slightly lower under the Preferred
3507 Alternative than the No Action Alternative; these reduced flows would provide slightly more
3508 usable habitat and would be in the optimum range for bull trout food availability and off-
3509 channel inundation and connectivity.

3510 **Kootenai River White Sturgeon**

3511 The Preferred Alternative would have a negligible change to peak sturgeon flows in most water
3512 year types, but a minor beneficial increase in wet years related to the increased rate of flow on
3513 the ascending limb of the hydrograph. There would be a negligible decrease in the duration of
3514 receding limb of the hydrograph, and one day less floodplain connectivity for larval rearing.
3515 River temperature would be similar to the No Action Alternative. Effects of the Preferred
3516 Alternative to Kootenai River white sturgeon would be negligible compared to those of the No
3517 Action Alternative in most water year types and minor beneficial in wet years, when the
3518 sturgeon have the best chance of recruitment.

3519 **Other Fish**

3520 As described for bull trout, there would be a moderate beneficial effect to the food web that
3521 could benefit westslope cutthroat trout and kokanee in Lake Koocanusa. The euphotic zone
3522 would see moderate beneficial effects. Regarding benthic insect production, the minimum
3523 annual pool elevation of Lake Koocanusa under the Preferred Alternative would be
3524 approximately 3 feet lower in average years for minor adverse effects, 2 feet higher in dry years

3525 for beneficial effects, and similar to No Action Alternative in wet years. This would result in
3526 overall negligible to minor effects to benthic insect larvae production for resident fish species.
3527 The annual maximum elevation of Lake Koochanusa under the Preferred Alternative would be
3528 about 2 feet higher than under the No Action, and would result in slightly higher terrestrial
3529 insect availability. Entrainment of kokanee would be similar to the No Action Alternative.

3530 The Kootenai River below Libby Dam would have slightly lower discharges for the period May
3531 15 to September 30 than the No Action Alternative, and would provide negligible increase in
3532 usable habitat for juvenile and adult rainbow trout (less than 2 percent) than the No Action
3533 Alternative. Entrainment of kokanee would be similar to No Action Alternative. For burbot in
3534 the reservoir, entrainment risk would be slightly lower. For burbot in the Kootenai River, spring
3535 freshet flow increase in most years would be less than No Action Alternative for a minor
3536 adverse effect, but higher and a minor beneficial effect in wet years. The change in days of
3537 floodplain connectivity would be negligible. High and variable flows can interrupt burbot
3538 spawning migrations, while low (4 kcfs) and stable winter flows enhance the likelihood of
3539 successful burbot spawning. Median flows under the Preferred Alternative would be slightly
3540 higher than No Action Alternative, but flow variability would be similar. Burbot recruitment
3541 would be similar to the No Action Alternative overall. Improvements to riparian function and
3542 floodplain connectivity would provide a minor to moderate beneficial effect due to additional
3543 rearing habitat for many of these species.

3544 **HUNGRY HORSE/FLATHEAD/CLARK FORK FISH COMMUNITIES**

3545 **Summary of Key Effects**

3546 The key effects under the Preferred Alternative would be very similar to the No Action
3547 Alternative, with exceptions due to the *Sliding Scale at Libby and Hungry Horse* measure. Higher
3548 reservoir elevations in the summer and into the fall months in drier years, as well as reduced
3549 summer outflows, would have minor to moderate beneficial effects to food supply, habitat
3550 suitability, and spawning fish access into tributaries, especially in dry years.

3551 **Habitat Effects Common to All Fish**

3552 In most years the deepest draft of the reservoir would be similar to the No Action Alternative,
3553 and in dry years this lowest point of the year would be several feet higher than the No Action
3554 Alternative. Maintaining a higher elevation provides a larger pool of water. In wet and average
3555 water years the hydrograph would be similar to No Action Alternative; the reservoir would still
3556 reach near full pool (elevation 3,560 feet) by early July and be allowed to drain until the end of
3557 September to about 3,550 feet elevation. In dry years, the reservoir would approach full pool
3558 similar to No Action Alternative but would have water withdrawn, or drafted, more slowly until
3559 the end of September, ending approximately 6 feet higher than the No Action Alternative.
3560 Similarly, through the fall and winter months the Preferred Alternative elevations would be
3561 similar to No Action Alternative in wet and average years, and the median elevation of dry
3562 years would be about 4 feet higher than No Action Alternative. Note, in the driest years the

3563 project would be operated to meet minimum flows for resident fish downstream of the project
3564 resulting in similar drafts to No Action Alternative.

3565 Lake elevation in the warm summer months determines the volume of reservoir that would be
3566 available to produce plankton (euphotic zone). With higher summer elevations in dry years the
3567 euphotic zone in August and September would be 2 percent and 3 percent higher, respectively.
3568 In other months, and in all months of wet and average years, the zone would be similar to the
3569 No Action Alternative volume, with less than 1 percent change. See Appendix E for a table of
3570 the calculated euphotic zone predictions of the Preferred Alternative.

3571 Reservoir drawdowns at any time during the year affect the production of insects that live on
3572 the bottom of the reservoir. Aquatic insects are the primary food supply for fish during spring
3573 and early summer and remain important fish prey through late fall. The Preferred Alternative
3574 would draft at a lower rate than the No Action Alternative in the summer and the surface of the
3575 reservoir would remain at a higher elevation through the following fall and winter in dry years.
3576 This would result in slightly more area for benthic insects (those that live on, under, or near the
3577 reservoir floor/lake bottom) production than the No Action Alternative, particularly in the large,
3578 shallow lobes of the upper reservoir where a small change in elevation can result in a
3579 proportionally larger change in inundated/submerged lake bottom. Some of the larger aquatic
3580 insects have long life cycles that require overwintering where they are deposited; higher winter
3581 elevations would improve the survival of these important insects. Surface area can be used as
3582 an index for change in benthic area. By surface area measurement, the Preferred Alternative
3583 area would be 1 to 3 percent higher than the No Action Alternative in summer months of dry
3584 years, and similar to No Action Alternative in other years.

3585 Finally, the reservoir surface elevation determines the surface area available for terrestrial
3586 insects to land on the water, where they become available as fish food during summer and fall,
3587 as well as influencing the proximity of the water's edge to terrestrial vegetation and therefore
3588 the amount of the poorly-flying insects that become available to fish by passively landing in the
3589 water. In summer months of dry years, the surface area would still decrease through the
3590 summer as the reservoir drafts, but at a lower rate than the No Action Alternative. By mid-
3591 summer there would be about 1 percent more surface area than the No Action Alternative and
3592 by late September there would be up to about 3 percent, or about 600 acres, more. See
3593 Appendix E for a table of the calculated surface area predictions of the Preferred Alternative.

3594 Zooplankton would continue to be entrained into the South Fork Flathead River from Hungry
3595 Horse reservoir. In the long-term, operations of the slide gates of the selective withdrawal
3596 structure, as described in the No Action Alternative measure *Hungry Horse Project Power Plant
3597 Modernization* (and carried forward in the Preferred Alternative), would reduce the
3598 entrainment of zooplankton by allowing adjustment to take water from the zones in the
3599 reservoir that are not heavily populated with zooplankton to reach target temperatures.
3600 Outflows, and therefore zooplankton entrainment, under the Preferred Alternative would be
3601 slightly (up to 1 percent) higher than the No Action Alternative in October through June in all
3602 year types, and 1 to 5 percent lower in July through September. This would provide a minor

3603 beneficial effect to reservoir food supply in the summer by reducing entrainment compared to
3604 the No Action Alternative.

3605 Outflow patterns from Hungry Horse Reservoir can also affect how fish are entrained into the
3606 South Fork Flathead River, and the habitat conditions, such as river elevation (stage), velocities,
3607 and temperatures in the river. Slightly lower outflows in late summer would reduce
3608 entrainment of fish. The temperature control structure would still operate in the summer
3609 months as in the No Action Alternative so changes in outflows in this timeframe would not
3610 affect summer temperatures downstream.

3611 In the Flathead River down to Flathead Lake, habitat suitability under the No Action Alternative
3612 is a key issue due to unnaturally high flows during the summer and winter. Under the Preferred
3613 Alternative, summer flows would be 1 to 5 percent lower and provide a minor benefit to
3614 habitat suitability by mimicking a natural hydrograph more closely, reducing velocities
3615 compared to the No Action Alternative. Spring peak flows and winter base flows would be the
3616 same or slightly higher than No Action Alternative. These spring flows would continue to
3617 occasionally provide flushing of sediments from gravels to maintain habitat; effects from slight
3618 flow increases in the winter would be a negligible effect to fish habitat. The winter water
3619 temperature warming influence from the contribution of the South Fork Flathead would be
3620 similar to No Action Alternative, as would the TDG in the river.

3621 The influence of Preferred Alternative changes to Flathead Lake levels and Seli's Ksanka Qlispe'
3622 Dam operations would be minimal compared to the No Action Alternative, and habitat
3623 conditions in these areas would be similar to those described under the No Action Alternative.

3624 **Bull Trout**

3625 Higher reservoir elevations in the summer and into the fall months in drier years, as well as
3626 reduced summer outflows, under the Preferred Alternative would slightly increase the summer
3627 production of zooplankton, surface insect landing and feeding area, and annual benthic insect
3628 populations that support the bull trout food web. Juvenile bull trout moving into the reservoir
3629 in the spring rely on eating benthic and terrestrial insects until they transition to eating fish so
3630 this would be a moderate beneficial effect to bull trout, especially in dry years. Adult bull trout
3631 prey also consume benthic insects and the prey may be in better condition or more plentiful.
3632 This could result in slightly improved bull trout condition/health.

3633 Higher reservoir elevations in the fall would decrease the risk and exposure to predation and
3634 angling pressure for upstream migrating bull trout. The difference between the Preferred
3635 Alternative and No Action Alternative would be more pronounced in dry years when these
3636 issues tend to occur. The sedimentation of tributary deltas is not known, but there could
3637 potentially be access to some tributaries in some years where fish would have been blocked
3638 under the No Action Alternative.

3639 Bull trout entrainment through the dam would likely decrease in the Preferred Alternative due
3640 to slightly lower late summer outflows. Withdrawals in August and September are generally

3641 selected from fairly deep in the water column to release the target water temperature, and bull
3642 trout have been documented in these strata at this time of year. Entrainment under the No
3643 Action Alternative is likely minimal but would be expected to decrease up to about 5 percent
3644 under the Preferred Alternative as modeled.

3645 In the South Fork Flathead River, below Hungry Horse Dam, zooplankton inputs from the
3646 reservoir may decrease slightly in summer with lower outflows, but benthic production would
3647 remain stable. Decreased late summer flows would more closely mimic a naturalized
3648 hydrograph and lower velocities would result in more suitable habitat for bull trout. Overall
3649 changes in the South Fork Flathead River would be negligible for bull trout; the habitat effects
3650 are minor, and few bull trout use this area.

3651 Summer flows in the mainstem Flathead River would continue to meet minimum flow
3652 requirements but are projected to be slightly lower than the No Action Alternative in some
3653 years, for a minor improvement in habitat suitability. Muhlfeld et al. (2011) found even
3654 moderate increases in summer flows resulted in substantial decreases in suitable area for bull
3655 trout, and that nighttime habitat for subadult bull trout was most sensitive. The 2 to 5 percent
3656 decrease due to Preferred Alternative operations would be a minor beneficial effect to bull
3657 trout habitat, especially for subadults. The mainstem Flathead River would be similar to the No
3658 Action Alternative in winter, with barely perceptible changes (slightly higher) from the No
3659 Action Alternative.

3660 Operations of Seli's Ksanka Qlispe' Dam (Flathead Lake) would be similar to the No Action
3661 Alternative, and the bull trout habitat use and life history functions in Flathead Lake, the Lower
3662 Flathead River, and Clark Fork River would be similar to the No Action Alternative.

3663 **Other Fish**

3664 Hungry Horse Reservoir favors a native fish dominated community. Juvenile bull trout and adult
3665 whitefish, northern pikeminnow, sculpins, and westslope cutthroat trout feed on zooplankton,
3666 aquatic insects, and terrestrial insects; adult bull trout prey on mountain whitefish, suckers,
3667 minnows, etc. The food web effects described above would also apply to all of these species of
3668 fish in Hungry Horse Reservoir. Slight increases in zooplankton, benthic insects, and increased
3669 summertime feeding of terrestrial insects could improve food supply, especially in dry years.

3670 Westslope cutthroat trout and other native fish spawn in the spring (April through June), so
3671 effects on adults migrating into tributaries to spawn would differ from bull trout. Spring
3672 spawning fish migrate when reservoir levels are lower and tend to experience longer varial
3673 zones, or areas where the tributaries pass through the upper parts of the reservoirs that are
3674 only seasonally inundated during high water periods and, as such, are typically void of
3675 vegetation and of insufficient depth to provide cover. This subjects them to increased exposure
3676 to predation and angling pressure. Under Preferred Alternative operations the April and May
3677 elevations would be either the same or slightly higher than in No Action Alternative. Spring
3678 spawning fish such as westslope cutthroat trout would experience slightly less varial zone
3679 effects (predation and angling pressure) and access issues to spawning tributaries under the

3680 Preferred Alternative. Juveniles typically out-migrate in June when the effects would also be
3681 similar to the No Action Alternative.

3682 Entrainment from the reservoir would also continue at unquantified levels and could decrease
3683 slightly in the summer months with lower outflows. Northern pikeminnow and bull trout have
3684 been documented at the depths of late summer withdrawal and would be most susceptible to
3685 entrainment and therefore be benefitted most by this minor effect of the Preferred Alternative.
3686 Entrainment would be expected to decrease 1 to 5 percent in the summer months and change
3687 in winter would be negligible.

3688 Habitat suitability described for bull trout would be similar for other native fish in the mainstem
3689 Flathead River (Muhlfeld et al. 2011), with lower summer flows in the Preferred Alternative
3690 resulting in a minor increase in suitable habitat for these native fish in the summer.

3691 Effects to fish in Flathead Lake, the lower Flathead River, and Clark Fork Rivers would be the
3692 same as described under the No Action Alternative.

3693 **LAKE PEND OREILLE (ALBENI FALLS RESERVOIR)/PEND OREILLE RIVER**

3694 **Summary of Key Effects**

3695 Hydrology modeling showed that Lake Pend Oreille elevations, inflows, and outflows would be
3696 similar to those found in the No Action Alternative. Biological relationships were dependent on
3697 these parameters, so the key effects of the Preferred Alternative for bull trout, fish habitat, and
3698 other fish species in the Pend Oreille basin would be the same as those described under the No
3699 Action Alternative.

3700 **7.7.5.2 Region B**

3701 **LAKE ROOSEVELT/COLUMBIA RIVER FROM U.S.-CANADA BORDER TO CHIEF JOSEPH DAM**

3702 **Summary of Key Effects**

3703 The most notable effect from the Preferred Alternative would be habitat and spawning success
3704 effects from the earlier draft of Lake Roosevelt in above average water years. There would be
3705 minor to moderate effects from increased stranding of kokanee and burbot eggs, and potential
3706 increased spawning habitat access issues for redband rainbow trout. Mitigation measures
3707 would provide a minor beneficial effect to these fish. The Preferred Alternative would have a
3708 negligible effect to white sturgeon in this reach. Minor increases or decreases in retention time
3709 in various months and year-types would result in minor adverse or beneficial effects to fish in
3710 Lake Roosevelt due to entrainment risk and food source reductions, depending on year type
3711 and time of year. The Preferred Alternative would continue to support both wild and hatchery-
3712 raised kokanee, redband rainbow trout and hatchery rainbow trout as well as non-native
3713 warmwater game species such as walleye, smallmouth bass, and northern pike. Northern pike
3714 would likely continue to increase and invade downstream, and the lake elevations could result
3715 in a minor decrease in the ability for boat-based Northern pike suppression efforts in above

3716 average water years. Rufus Woods Lake would continue to provide habitat for fish entrained
3717 from Lake Roosevelt and from limited production of shoreline spawning by some species. Fish
3718 entrainment could increase in winter and decrease in the summer months in some years. TDG
3719 would be similar or less than the No Action Alternative in most years, but maintenance
3720 operations would increase TDG in some years in the short term with long term benefits due to
3721 increased reliability. The operational measures that could impact fish include the *Update*
3722 *System FRM Calculation, Planned Draft Rate at Grand Coulee, Fall Operational Flexibility for*
3723 *Hydropower (Grand Coulee), and Lake Roosevelt Additional Water Supply, as well as the Grand*
3724 *Coulee Maintenance Operations* measure carried forward from the No Action Alternative, fish
3725 and wildlife mitigation measures carried forward, and new mitigation for *Spawning Habitat*
3726 *Augmentation at Lake Roosevelt*. Additionally, the *Modified Draft at Libby and Sliding Scale at*
3727 *Libby and Hungry Horse* measures in the Preferred Alternative affect inflows to Lake Roosevelt.

3728 **Habitat Effects Common to All Fish**

3729 Inflows to Lake Roosevelt would be within 1 percent of the No Action Alternative, with
3730 negligible increases in winter months and decreases in spring and summer. The most notable
3731 habitat effects come from reservoir elevation changes in Lake Roosevelt. Earlier drafts (when
3732 water is drained from the reservoir) in wet years would result in the median wet year elevation
3733 at the end of February about 5 feet lower than the No Action Alternative. In addition, fall
3734 operations would differ such that completing refill to 1,283 feet (as outflows are reduced to
3735 allow the reservoir to fill) could be delayed from the end of September to the end of October,
3736 resulting in elevations about a half a foot lower through these 2 months. Mid-May through
3737 August, and December through January elevations would be the same as No Action Alternative.
3738 In the No Action Alternative the project is refilled to 1,283 feet NGDV29 by the end of
3739 September in most years (modeling assumption shows that this occurs in all years); for the
3740 Preferred Alternative the elevation at the end of September would be below 1,283 feet in 40
3741 percent of years.

3742 Median peak outflows under the Preferred Alternative would follow the same pattern as the No
3743 Action Alternative with minor changes, including increases in January and February (0 to 1
3744 percent), reductions in spring and summer (up to 2 percent in April and August).

3745 The duration that water stays in the reservoir (i.e., retention time) is a driving metric for the
3746 food web in Lake Roosevelt and influences the populations of several fish species. Under the
3747 Preferred Alternative, monthly average retention time would be within 1 percent of the No
3748 Action Alternative in most months of all water year types, with a few exceptions. In average
3749 years, it would decrease 2 percent in September and increase 2 percent in October. In dry
3750 years, it would be 2 percent higher than the No Action Alternative in October and 4 percent
3751 higher in May. In wet years, it would be 2 percent higher in October but 4 percent and 3
3752 percent lower in February and May, respectively. Retention time is lowest in wet years because
3753 more water is moving through the system, and therefore more critical to fish effects.

3754 Temperature in the reservoirs would be similar to the No Action Alternative. Generally
3755 speaking, water quality modeling showed the sum of operational measures would result in

3756 lower TDG than the No Action Alternative, although operations to support maintenance
3757 measures would likely increase TDG from April to July during maintenance, but may result in
3758 slight reductions in spill long-term. The *Grand Coulee Maintenance Operation* measure reduces
3759 the hydraulic capacity through the power plant in the near term; this has the potential to
3760 increase spill in some years. This impact is partially offset in wet years by the *Planned Draft*
3761 *Rate at Grand Coulee*. Spill and resulting TDG levels are expected to be similar to the No Action
3762 Alternative; with the potential of TDG in the reservoir and tailwater in excess of 125 percent
3763 TDG. TDG in the Grand Coulee tailwater is also a concern for fish in Rufus Woods Lake.

3764 **Bull Trout**

3765 Under the Preferred Alternative, bull trout in Lake Roosevelt could continue to move to cooler
3766 locations in the reservoir and these refuges would remain similar to the No Action Alternative.
3767 Retention time of a reservoir can influence the productivity, growth, and distribution of
3768 zooplankton which, in turn, affects fish growth, distribution, and entrainment risk. Minor
3769 changes in inflows and outflows (all less than 2 percent difference from the No Action
3770 Alternative) would be negligible for bull trout flushing and entrainment. The bull trout prey
3771 base would continue to fluctuate as the fish they eat are sensitive to changes in productivity
3772 and location of zooplankton in Lake Roosevelt that is influenced by the retention time of water
3773 in the reservoir. In dry and average years these would be negligible or minor beneficial effects
3774 with slightly higher water retention time allowing zooplankton to develop longer in the
3775 reservoir. In wet years there would be minor decreases in retention time during February and
3776 May, which would be a minor adverse effect because zooplankton would have less time to
3777 develop. Bull trout are also sensitive to contaminants that are found in this region and would
3778 continue to bioaccumulate contaminants as a top predator. Water fluctuation events that
3779 mobilize mercury would be the same as the No Action Alternative. Overall effects to bull trout
3780 would be negligible because of the small magnitude of changes and the scarcity of bull trout in
3781 Lake Roosevelt.

3782 **Other Fish**

3783 White sturgeon recruitment would be dependent on flows exceeding 200 kcfs and appropriate
3784 temperatures in late June/early July. The Preferred Alternative flows at the Canadian border in
3785 June and July would be similar to the No Action Alternative, exceeding 200 kcfs about 28
3786 percent of the time and 9 percent, respectively, in mid-June and July. In high flow years, the
3787 Lake Roosevelt reservoir elevations would be the same as the No Action Alternative in these
3788 months. Under the Preferred Alternative, recruitment of white sturgeon would continue to be a
3789 rare event supplemented by hatchery propagation and rearing, similar to the No Action
3790 Alternative.

3791 Wild production of native fish such as burbot, kokanee and redband rainbow trout would
3792 continue to provide valuable resources in Lake Roosevelt. As described in the common habitat
3793 effects, these fish are the most sensitive to the effects of changing retention times. Under the
3794 No Action Alternative an estimated average of over 400,000 fish annually would be entrained,
3795 with 30 to 50 percent of them being kokanee, primarily of wild origin and rainbow trout the

3796 second most entrained species. Under Preferred Alternative operations, retention time would
3797 decrease 4 percent and 3 percent, respectively, in February and May of wet years for a minor
3798 adverse effect. Changes in other months and year types would be either negligible or minor
3799 beneficial effects to fish entrainment, zooplankton entrainment, and food webs.

3800 For tributary spawning species such as redband rainbow trout and a portion of the wild
3801 production of kokanee, tributary access at the right time of year is important. Reservoir
3802 drawdown in the spring creates barren tributary reaches through the varial zone (upper region
3803 of the reservoir that is only seasonally inundated, resulting in areas devoid of vegetation cover),
3804 which directly and indirectly impedes migration to and from tributaries and the reservoir.
3805 Redband rainbow trout need access to tributaries in the spring. Under the Preferred
3806 Alternative, reservoir elevations would be 2 to 3 feet lower than the No Action Alternative
3807 levels in the critical spawning migration time of April to May in wet years. Specific access issues
3808 are unknown, but redband rainbow trout spawn in Sanpoil River, Blue Creek, Alder, Hall Creek,
3809 Nez Perce Creek, Onion Creek, Big Sheep Creek, and Deep Creek. These tributaries higher in the
3810 basin are more susceptible to elevation changes because a smaller change in vertical lake
3811 elevation would result in a larger area of varial zone exposure than tributaries closer to the
3812 dam, due to the shallow slope of the reservoir. Migratory impacts, although not well
3813 documented, could be minor to moderate given the timing and extent of the drawdowns in the
3814 Preferred Alternative. Additionally, minor increases in exposure during migrations to these
3815 tributaries would increase the varial zone effects where migrating fish are more exposed to
3816 predation and angling due to lack of cover. The portion of kokanee that spawn in tributaries
3817 access these habitats in the fall. In some years the reservoir elevation would be slightly lower
3818 than the No Action Alternative, but would still be above the elevation of 1,283 feet that
3819 provides access for kokanee spawning under the No Action Alternative.

3820 Species such as kokanee and burbot that spawn on shorelines in Lake Roosevelt are susceptible
3821 to eggs drying out if reservoir levels drop while eggs are still in the gravel. Kokanee spawn on
3822 shoreline gravels September 15 to October 15 and eggs incubate through February. Burbot
3823 tend to spawn successfully in depths provided by the No Action Alternative in the Columbia
3824 River and in Lake Roosevelt on shorelines near the Colville River in winter with eggs incubating
3825 through the end of March (Bonar et al. 2000). In the Preferred Alternative, the dry and average
3826 years would be similar to No Action Alternative. In wet years, however, the earlier drafting of
3827 the reservoir would strand or dewater more burbot and kokanee eggs because the reservoir
3828 elevation would be similar to No Action Alternative when eggs are deposited, but drop up to 5
3829 feet deeper in the wet years before fry emerge. The portion of kokanee that spawn in the
3830 shallower 5 feet of elevation could have eggs desiccated when these drops occur. Due to earlier
3831 drafts, more eggs deposited in fall would also become dewatered before enough time elapses
3832 for emergence. Fry sometimes also stay in the gravels and could become stranded as well. The
3833 earlier drafts of Lake Roosevelt would be a moderate adverse effect to kokanee and redband
3834 rainbow trout. Mitigation measures to study if these operations affect these species, determine
3835 specific spawning locations, and augment spawning habitat to increase spawning at levels
3836 where eggs would be safer would be a minor beneficial effect to kokanee and burbot. Burbot
3837 spawn later in the winter, but would also be affected by the deeper draft in the reservoir. Lake

3838 elevations influence river stage up to the U.S.-Canada border but the water level changes are
3839 smaller than in the reservoir. Thus, burbot that spawn in the rivers would experience the same
3840 patterns of dewatering, but to a lesser degree.

3841 Kokanee are very sensitive to water temperature, and during summer are found at depths
3842 below 120 m to find suitably cool water. Under the No Action Alternative, Lake Roosevelt is
3843 very weakly stratified but does have suitably cool water at this depth along with suitable levels
3844 of dissolved oxygen. Lake whitefish and mountain whitefish also likely use this cool water in the
3845 summer. Reservoir water temperatures and thermal stratification in the summer in the
3846 Preferred Alternative would be similar to the No Action Alternative.

3847 Non-native warmwater gamefish, such as walleye, northern pike, smallmouth bass, sunfish,
3848 crappie, and others, as well as the prey fish that they eat (such as shiners, dace, and sculpins) all
3849 tolerate a wide range of environmental conditions and would continue to contribute to the
3850 fishery community under the Preferred Alternative, and continue to negatively impact native
3851 species via predation. The invasion downstream by northern pike is of concern. The Lake
3852 Roosevelt co-managers, such as the Confederated Tribes of the Colville Reservation, The
3853 Spokane Tribe of Indians and Washington Department of Fish and Wildlife, co-managers would
3854 continue to actively suppress pike populations using gillnets. The co-managers set the gillnets
3855 by boats as soon as they can get on the water in the spring until the boat ramp becomes
3856 unusable at an elevation of 1,235 feet. Under the No Action Alternative this occurs on April 15
3857 in wet years and would not occur at all in dry and average years. Under the Preferred
3858 Alternative in wet years this would occur up to about a week sooner and preclude the ability for
3859 the pike suppression efforts for that time period. For estimation purposes, one crew typically
3860 removes about 100 pike per week and they would operate three crews (Colville Tribe
3861 unpublished data), so losing up to a week under the Preferred Alternative could result in an
3862 estimated 300 pike not removed. It should be noted that this analysis focuses on one boat
3863 ramp, but the middle of Lake Roosevelt becomes inaccessible earlier, at lake elevation of 1,245
3864 feet. Additionally, outflows and retention time would continue to influence the entrainment
3865 and downstream invasion of non-native gamefish below Chief Joseph Dam where ESA-listed
3866 anadromous salmonids would be susceptible to predation by them. During the time when pike
3867 juveniles would be most susceptible to entrainment (May to August), retention time under the
3868 Preferred Alternative would be similar or slightly higher so entrainment risk for pike would be
3869 similar to the No Action Alternative or slightly lower. Adult pike would continue to move further
3870 downstream (similar to No Action Alternative), so minor increases in entrainment in February
3871 and May due to retention time changes would be a minor adverse effect to native fish due to
3872 minor increased risk of pike entrainment.

3873 Once released, the net pen fish that supplement the rainbow trout fishery in Lake Roosevelt
3874 would experience similar effects as their native counterparts except for spawning and early
3875 rearing effects. In addition, the net pen locations are situated where the water quality can be
3876 affected by changes in reservoir elevations; these fish are sensitive to temperature and TDG
3877 levels. Their eventual recruitment to the fishery can be affected by retention time coupled with
3878 reservoir elevation at the time of their release (McLellan et al. 2008), which is typically in May.

3879 Under the Preferred Alternative, the water quality at these locations would be similar to the No
3880 Action Alternative. In average and dry years, reservoir levels and retention time would be
3881 similar to No Action Alternative or slightly beneficial. In wet years, the reservoir would be
3882 slightly lower than No Action Alternative, and the water retention time in May would be 3
3883 percent lower; this would be a minor adverse effect to entrainment risk for these fish. The
3884 operators strive to release these fish to coincide with the initiation of reservoir refill to reduce
3885 entrainment risk, which under Preferred Alternative would be the same as the No Action
3886 Alternative, so these fish would continue to be released when water quality conditions would
3887 be suitable.

3888 The fish in Rufus Woods Lake would continue to be supplemented by entrained fish out of Lake
3889 Roosevelt to a large extent, with fish mostly entrained during the spring freshet and winter
3890 drawdown periods. Slightly higher flows in the winter drawdown in the Preferred Alternative
3891 may increase entrainment slightly and boost populations in Rufus Woods Lake. Minor decreases
3892 in spring freshet outflows likely would decrease entrainment during this period, but, as
3893 described in the previous paragraph, there could be slightly higher entrainment in May due to
3894 lower retention times. This lake has more riverine characteristics with steep gradients and
3895 narrow canyon walls, making it more like a river than a reservoir, with short water retention
3896 time and low productivity. High flows during late spring and early summer would continue to
3897 flush eggs and larvae from protected rearing areas similar to the No Action Alternative, but at a
3898 slightly lower magnitude.

3899 TDG in the Grand Coulee tailwater is a concern for fish in Rufus Woods Lake as it sometimes
3900 exceeds 125 percent TDG under the No Action Alternative. Water quality modeling showed TDG
3901 under the Preferred Alternative would be similar to the No Action Alternative except for slight
3902 decreases in spring months of average years. However, maintenance operations would likely
3903 increase TDG from April to July in some years due to a reduction in the number of turbines
3904 available to pass water. On the other hand, the *Planned Draft Rate at Grand Coulee* measure
3905 could decrease potential spill during this same time and partially offset any increased TDG. As
3906 this maintenance is completed, the hydraulic capacity through the power plant and reliability
3907 should increase, which would result in decreases in forced outages and spill. This would
3908 eventually reduce TDG in comparison to the No Action Alternative. Overall, effects under the
3909 Preferred Alternative would be minor adverse to fish in Lake Rufus Woods.

3910 **7.7.5.3 Region C**

3911 **SNAKE RIVER BASIN**

3912 **Summary of Key Effects**

3913 Key effects from the Preferred Alternative that differ from those found under the No Action
3914 Alternative include moderate increases in spill and TDG in April through mid-June from the
3915 *Juvenile Fish Passage Spill* measure and increases in entrainment at Dworshak Reservoir in
3916 January from the *Slightly Deeper Draft for Hydropower (Dworshak)* measure. These effects
3917 would have minor adverse effects to resident fish species in Region C.

3918 **Habitat Effects Common to All Fish**

3919 Common habitat effects of the Preferred Alternative are similar to those identified for the No
3920 Action Alternative with the exception of the increased spill, elevated TDG, and increased
3921 entrainment discussed in the section above.

3922 **Bull Trout**

3923 Effects of the Preferred Alternative to bull trout within the Snake River Basin that differ from
3924 the No Action Alternative include increases in spill and TDG from April to mid-June, as well as
3925 an increase in entrainment risk at Dworshak Reservoir in January. Increased spill during the
3926 spring spill season would cause moderate increases in TDG that would likely result in minor
3927 adverse effects to bull trout using the mainstem Snake River as a migratory corridor during
3928 spring. In addition, during spring high spill bull trout are generally migrating out of the Snake
3929 River back to cooler tributary habitats. These fish may experience minor adverse effects in
3930 delay at projects while searching for fish ladder entrances. Increased spill at Dworshak in wet
3931 years would have minor adverse effects to bull trout in the form of increased risk of
3932 entrainment.

3933 **Other Fish**

3934 Effects to white sturgeon under the Preferred Alternative that differ from the No Action
3935 Alternative would include moderate increases in TDG in the lower Snake River. Water Quality
3936 data shows increases in exposure to high TDG from April through mid-June when compared
3937 with the No Action Alternative. These increases would have minor adverse effects to white
3938 sturgeon larvae and fry, particularly in a drifting life stage that occurs near the water surface.

3939 Key effects of the Preferred Alternative relative the No Action Alternative for additional fish
3940 resources would include moderate increases in TDG from April through mid-June. Increases in
3941 spill under this alternative would increase TDG by approximately 5 percent during spring spill
3942 operations. High TDG would have minor adverse effects to early life stages of resident fish that
3943 are not able to avoid high TDG by changing depth. Other effects would be similar to the No
3944 Action Alternative.

3945 **7.7.5.4 Region D**

3946 **MAINSTEM COLUMBIA RIVER FROM MCNARY DAM TO THE LOWER COLUMBIA RIVER**
3947 **ESTUARY**

3948 **Summary of Key Effects**

3949 The key effects under the Preferred Alternative would be due to changes in TDG in the river
3950 from *Juvenile Fish Passage Spill Operations*, and changes in the John Day Reservoir operations
3951 from certain measures including *Predator Disruption Operations* and *Increased Forebay Range*
3952 *Flexibility*. Bull trout, white sturgeon, and other resident fish would experience intermittently

3953 higher or lower TDG levels, and the drop in the John Day reservoir could result in a minor effect
3954 of potential stranding sturgeon larvae.

3955 **Habitat Effects Common to All Fish**

3956 Outflows from McNary Reservoir influence some of the fish relationships described in this
3957 section. Peak spring flows affect habitat maintenance for some species. Modeled monthly
3958 median outflows for the Preferred Alternative would be within 2 percent of the No Action
3959 Alternative. Other flow parameters referred to in this section refer to outflows of McNary Dam,
3960 which are indicative of flows downstream through the other projects. The median outflows at
3961 McNary Dam in spring months (with change from No Action Alternative in parentheses) would
3962 be:

- 3963 • April: 192 kcfs (-1 percent)
- 3964 • May: 260 kcfs (0 percent)
- 3965 • June: 285 kcfs (0 percent)
- 3966 • July: 198 kcfs (-1 percent)

3967 Operations changes at John Day reservoir would result in October median monthly average
3968 outflows being 2 percent higher than the No Action Alternative in October, 1 percent higher in
3969 January, February, and June; and 1 percent lower in March to May and July to September.

3970 Water quality in Region D would experience an overall negligible change from the No Action
3971 Alternative, though there could be increases or decreases in TDG during certain times of the
3972 year due to increased spill during the spring spill season.

3973 **Bull Trout**

3974 Bull trout are known to use the mainstem Columbia River to move between tributaries and
3975 have been observed at Bonneville Dam and McNary Dam in the spring and summer (Barrows et
3976 al. 2016). Water temperature is the most important habitat factor for bull trout in the
3977 mainstem Columbia; temperature would not change under the Preferred Alternative. TDG
3978 levels in the winter, when most bull trout would be using the river, would also be similar to the
3979 No Action Alternative.

3980 Adult bull trout move downstream during fall and overwinter in reservoirs (October to
3981 February) (Barrows et al. 2016). Although bull trout successfully move between areas on the
3982 mainstem, their migration can be delayed at the dams.

3983 Passage through turbines can cause injury or mortality, as well as migration delays. Blade strike
3984 incidence increases with increased blade size. The Preferred Alternative includes the *Improved*
3985 *Fish Passage Turbines at John Day* measure, which would improve survival (Deng et al. 2019). At
3986 John Day, turbine replacement would provide safer passage for any bull trout that move
3987 through the dam.

3988 The Preferred Alternative includes *Predator Disruption Operations* that could reduce predation
3989 on bull trout and other native resident fish species, which would be a beneficial effect
3990 compared to the No Action Alternative.

3991 **Other Fish**

3992 Under the Preferred Alternative, white sturgeon spawning and recruitment would be similar to
3993 the No Action Alternative with negligible differences in the number of days with suitable flow
3994 conditions and suitable temperatures for embryo incubation. In years of low flow conditions,
3995 water temperatures could increase beyond the suitable range by early June, resulting in little or
3996 no recruitment (similar to the No Action Alternative).

3997 White sturgeon spawning generally occurs in areas with fast-flowing waters over coarse
3998 substrates (Parsley et al. 1993). Minor changes in outflow under the Preferred Alternative
3999 would not be large enough to cause discernable velocity changes that would affect sturgeon
4000 spawning habitat.

4001 Lack of upstream white sturgeon (juvenile and adult) passage decreases the connectivity of the
4002 population (Parsley et al. 2007). This would not change under the Preferred Alternative
4003 compared to the No Action Alternative.

4004 As described previously, the Preferred Alternative includes the *Improved Fish Passage Turbines*
4005 *at John Day* measure, which would reduce injuries and mortality of juvenile sturgeon (Deng et
4006 al. 2019).

4007 White sturgeon larvae are negatively affected by TDG. Studies have shown high rates of altered
4008 buoyancy at 118 percent TDG, and 50 percent mortality at 131 percent TDG (Counihan et al.
4009 1998). Under the Preferred Alternative, there would be negligible increases in TDG overall, with
4010 periods of time where it could be increased due to increased spill. During these times, there
4011 would be minor adverse effects to juveniles and larvae, depending on their ability to move to
4012 deeper depths. Adults are more able to compensate for increased TDG by moving to lower
4013 depths, but larvae in shallow water are not able to compensate and would be more affected.

4014 Under the Preferred Alternative, lower flows at Bonneville during dry years in May and August
4015 could potentially increase pinniped predation rates, but it is also likely that sturgeon are
4016 avoiding the tailrace due to predation pressure.

4017 Resident fish such as sculpin, walleye, and smallmouth bass are predators of embryo and age-0
4018 white sturgeon. Under the Preferred Alternative, predation would continue to affect early life
4019 stages of white sturgeon.

4020 Reservoirs in the lower Columbia may be in maturation (meaning that as reservoirs get older
4021 they trap sediments, become shallower, and changes to biological process may occur). This
4022 could lead to sedimentation and invasive aquatic plants reducing habitat value for sturgeon
4023 through changes in predation, food availability, and suitability for invasive species. Under the

4024 Preferred Alternative, river mechanics would be the same as the No Action Alternative, except
4025 in the John Day Reservoir, where there is the potential for a minor amount of bed sediment to
4026 become finer due to changes in operations. This would be a negligible effect to white sturgeon
4027 in the timeframe of this EIS.

4028 Under the Preferred Alternative, no changes to resident fish communities would be expected.
4029 As shown above, outflow rates below McNary Dam would be very similar to the No Action
4030 Alternative. Water quality and food availability would also be similar to the No Action
4031 Alternative. Increased TDG would likely affect some species of resident fish.

4032 Conditions that promote lower water temperatures and higher spring flows tend to lower the
4033 survival rates of warmwater game fish, potentially lowering populations of predators on salmon
4034 and steelhead. The Preferred Alternative would be expected to continue supporting
4035 warmwater game fish at levels similar to the No Action Alternative.

4036 **7.7.6 Macroinvertebrates**

4037 Below is a discussion of the macroinvertebrates in Regions A, B, C, and D under the Preferred
4038 Alternative. For more detailed information on the effects of the Preferred Alternative on
4039 aquatic invertebrates and implications on food web interactions see the Habitat Effects section
4040 of the respective resident fish community analyses previously described under the applicable
4041 region.

4042 **7.7.6.1 Region A**

4043 Project operations under the Preferred Alternative would affect the following aquatic
4044 environments: Hungry Horse Reservoir, South Fork Flathead River, Flathead River, Flathead
4045 Lake, lower Flathead River, Clark Fork River, Lake Pend Oreille, Pend Oreille River, Lake
4046 Kooncanusa, and the Kootenai River. Specifically, these measures include the *Sliding Scale at*
4047 *Libby and Hungry Horse* and the *Modified Draft at Libby*.

4048 At Hungry Horse reservoir, *Sliding Scale at Libby and Hungry Horse* is the only new measure in
4049 the Preferred Alternative that would affect operations and therefore, invertebrates. Higher
4050 elevations in the summer and into the fall months, as well as reduced summer outflows, would
4051 have minor to moderate beneficial effects to macroinvertebrates. With higher summer
4052 elevations in dry years the euphotic zone in August and September would be 2 percent and 3
4053 percent higher, respectively, for a minor benefit to zooplankton production, which fuels the
4054 food web for aquatic macroinvertebrates, in these months during dry years. In other months
4055 (and in all months of wet and average years), the euphotic zone would be similar to the No
4056 Action Alternative, with less than 1 percent change. Zooplankton entrainment would be slightly
4057 lower than the No Action Alternative in summer months in drier years due to slightly decreased
4058 outflows. In the long term, rehabilitation of the selective withdrawal system (as part of the
4059 *Hungry Horse Project Power Plant Modernization* measure, carried forward from the No Action
4060 Alternative) would also reduce entrainment as gates could be operated to draw water from
4061 strata in the reservoir that are not densely occupied by zooplankton. The Preferred Alternative

4062 would draft at a lower rate than the No Action Alternative in the summer and would remain at
4063 a higher elevation through the following fall and winter in dry years. Using surface area as an
4064 index for benthic area, the surface area under the Preferred Alternative would be 1 to 3
4065 percent higher than the No Action Alternative in summer months during dry years, and similar
4066 to the No Action Alternative in other years. This would result in minor to moderate beneficial
4067 effects to benthic macroinvertebrates compared to the No Action Alternative, particularly in
4068 the large, shallow lobes of the upper reservoir. In these aquatic habitats, a small change in
4069 elevation can result in a proportionally larger change in inundated lake bottom. Some of the
4070 larger aquatic insects have long life cycles that require overwintering where they were
4071 deposited; higher winter elevations would improve the survival of these species.

4072 In the South Fork Flathead and mainstem Flathead Rivers, slight decreases in summer flows in
4073 the Preferred Alternative would cause a slight decrease in habitat for macroinvertebrate
4074 production, although minimum flows would continue to protect these habitats, and lower
4075 summer flows than the No Action alternative are closer to normalized flow regimes. The
4076 Preferred Alternative would result in negligible changes to invertebrate communities in
4077 Flathead Lake, the lower Flathead River, and the Clark Fork River.

4078 The operations of Albeni Falls Project would be similar to the No Action Alternative operations
4079 and would result in negligible effects to Lake Pend Oreille or the Pend Oreille River. Negligible
4080 effects are expected to the macroinvertebrate communities in those habitats.

4081 In the Kootenai basin, Lake Koocanusa would be held above an elevation of 2,450 feet more
4082 than twice as many days as the No Action Alternative, which would increase the overall
4083 productivity of zooplankton and macroinvertebrates in the system and be a moderate benefit
4084 to macroinvertebrates. Regarding benthic insect production, the minimum annual pool
4085 elevation of Lake Koocanusa under the Preferred Alternative would be approximately 3 feet
4086 lower in average years for minor adverse effects, 2 feet higher in dry years for beneficial
4087 effects, and similar to No Action Alternative in wet years. This would result in overall negligible
4088 effects to benthic invertebrate production. Below Libby Dam, outflows would be slightly lower
4089 than the No Action Alternative in summer months causing a minor reduction in habitat for
4090 invertebrates, but flow variability would be similar to the No Action Alternative so survival of
4091 these organisms would not change.

4092 **7.7.6.2 Region B**

4093 The Columbia River from Canada to Lake Roosevelt would continue to produce benthic aquatic
4094 insects such as stonefly, caddisfly and mayfly larvae, with negligible to minor adverse effects
4095 from the Preferred Alternative. The operational measures in the Preferred Alternative that
4096 could affect macroinvertebrates include the *Update System FRM Calculation, Planned Draft*
4097 *Rate at Grand Coulee, Fall Operational Flexibility for Hydropower (Grand Coulee), and Lake*
4098 *Roosevelt Additional Water Supply*, as well as the *Grand Coulee Maintenance Operations*
4099 carried forward from the No Action Alternative. There would also be fish and wildlife mitigation
4100 measures carried forward from the No Action Alternative, and new mitigation for *Spawning*
4101 *Habitat Augmentation at Lake Roosevelt*.

4102 Operations under the Preferred Alternative would result in minor changes in river elevations at
4103 the U.S.-Canada border in the months September and October, as the fall operation of the
4104 reservoir would result in median river stage (elevation) of about 2 feet lower than the No
4105 Action Alternative by the end of September, with minor decreases in macroinvertebrate
4106 habitat. Otherwise the Preferred Alternative would have a similar stage as the No Action
4107 Alternative in the Columbia River near the international border. Further downstream, as
4108 reservoir influences are more noticeable, the Preferred Alternative would have this same fall
4109 pattern of minor reductions in stage. There would also be minor decreases in river stage from
4110 earlier drafts of the reservoir (resulting in lower elevations compared to the No Action
4111 Alternative) in January and February of wet years. This would reduce habitat, as well as increase
4112 the risk of dewatering macroinvertebrates in the winter. In these months, the reservoir would
4113 be up to 5 feet lower than the No Action Alternative by the end of February, and the decreased
4114 levels would continue until refill would begin in early May. This change in elevation represents
4115 the vertical feet, actual habitat dewatered, and proportion of macroinvertebrates affected,
4116 which would vary depending on habitat used and the slope of the riverbanks at various
4117 locations throughout the reservoir. The subsequent reduction in habitat and additional
4118 dewatering would be a minor to moderate effect, depending on year type. *Spawning Habitat*
4119 *Augmentation at Lake Roosevelt* would provide up to 100 acres of additional gravel substrate in
4120 areas more protected from dewatering events that would provide minor beneficial effects to
4121 macroinvertebrate production and survival.

4122 In Lake Roosevelt, the production, distribution and persistence of zooplankton is highly variable
4123 and sensitive to retention time of water in the reservoir, which is a function of inflows,
4124 reservoir volume, and outflows. Under the Preferred Alternative, monthly average retention
4125 time would be within 1 percent of the No Action Alternative in most months of all water year
4126 types, with a few minor exceptions. In average years, it would decrease 2 percent in September
4127 and increase 2 percent in October. In dry years, it would be 2 percent higher than the No Action
4128 Alternative in October and 4 percent higher in May. In wet years, it would be 2 percent higher
4129 in October but 4 percent and 3 percent lower in February and May, respectively. During wet
4130 years, retention time is lowest because more water is moving through the system. With lower
4131 retention times under the Preferred Alternative in these 2 months, when retention times are
4132 already fairly low, there would be increased entrainment of zooplankton out of Lake Roosevelt.

4133 Downstream of Grand Coulee Dam, Rufus Woods Lake has more riverine characteristics with
4134 steep gradients and narrow canyon walls, making it more like a river than a reservoir, with short
4135 water retention time and low productivity. Aquatic insect production and survival in Lake Rufus
4136 Woods would be similar to the No Action Alternative, but there would be minor increases in
4137 zooplankton inputs in February and May of wet years, as described above. There would be
4138 negligible change to these communities. In some years in the short-term, *Grand Coulee*
4139 *Maintenance Operations* may result in increased TDG exposure as maintenance activities
4140 reduce turbines available and spill may increase. In the long term, TDG would be decreased as
4141 the units become more reliable. This would be a minor effect to invertebrate populations that
4142 are generally more resistant than fish to effects from elevated TDG (Ryan et al. 2002), and it

4143 would occur infrequently. Effects due to TDG under the Preferred Alternative to
4144 macroinvertebrates would be negligible.

4145 **7.7.6.3 Region C**

4146 Effects of the Preferred Alternative to macroinvertebrates in Region C that differ from the No
4147 Action Alternative would include effects from the *Slightly Deeper Draft for Hydropower at*
4148 *Dworshak*, which would result in increased entrainment in Dworshak Reservoir during January
4149 of wet years. This would also lead to faster refill at Dworshak on dry years, as well as elevated
4150 TDG downstream of Lower Granite Dam on the Snake River due to *Juvenile Fish Passage Spill*. In
4151 addition, increased entrainment during the winter months would have minor adverse effects to
4152 zooplankton populations in Dworshak Reservoir as portions of these populations would be
4153 entrained from the reservoir and into the Clearwater River. Conversely, on wet years the
4154 reservoir would refill earlier and would stay near full pool for a longer period of time, providing
4155 a minor beneficial effect to invertebrate populations that colonize these substrates.

4156 Under the Preferred Alternative TDG would increase by approximately 5 percent from April
4157 through mid-June. This increase in TDG would have minor effects to invertebrate populations
4158 that are generally more resistant to effects from elevated TDG (Ryan et al. 2002).

4159 The macroinvertebrate community of the lower Snake reservoirs and river would continue
4160 similar to the No Action Alternative. Siberian prawns and opossum shrimp would continue to
4161 increase in the reservoir environments. The reservoirs would continue to provide habitat for
4162 clams, mussels, and other invertebrates, as in the No Action Alternative, and crayfish would
4163 continue to find suitable habitat in the rock and riprap of reservoirs.

4164 **7.7.6.4 Region D**

4165 The Preferred Alternative would not differ from the No Action Alternative in its effects to flows
4166 or water temperatures. Effects to invertebrates that differ from the No Action Alternative
4167 would include reservoir elevation manipulations at John Day Reservoir to dissuade nesting of
4168 Caspian Terns that consume juvenile salmon and steelhead as part of the *Predator Disruption*
4169 *Measure*.

4170 Under the Preferred Alternative, pool elevations would be about 1 foot higher in the John Day
4171 Reservoir from late March through early June, and then drop in early June by about 2 feet
4172 before returning to base elevations in September. During the period of March through early
4173 June, aquatic macroinvertebrates could colonize the additional benthic substrate and shallow
4174 water habitat afforded by the higher pool elevation, but could then be stranded or desiccated
4175 when levels drop in June. The other run of river dams would continue to be operated at stable
4176 elevations that would continue production of these aquatic macroinvertebrates.

4177 **7.7.7 Vegetation, Wildlife, Wetlands, and Floodplains**

4178 **7.7.7.1 Region A – Libby, Hungry Horse, and Albeni Falls Dams**

4179 There are two measures in the Preferred Alternative that would be implemented in Region A:
4180 the *Modified Draft at Libby* and the *Sliding Scale at Libby and Hungry Horse* that differ from the
4181 No Action Alternative. Under the Preferred Alternative, both these measures would directly
4182 affect operations and reservoir levels at Libby. The *Sliding Scale at Libby and Hungry Horse*
4183 measure would directly impact Hungry Horse outflows. The Preferred Alternative water
4184 management and operational measures in Region A would have negligible effects on Albeni
4185 Falls Dam outflow and Lake Pend Oreille elevation compared to the No Action Alternative.

4186 The *Modified Draft at Libby* causes the spring reservoir elevation at Lake Koochanusa to be lower
4187 than the No Action Alternative when the seasonal water supply forecast is less than 6.9 Maf.
4188 Deeper drafts would increase the barren zone width around Lake Koochanusa providing greater
4189 surface area of exposed soils for potential colonization by invasive species. The barren zone
4190 causes a hydrologic disconnect between the reservoir and tributary confluences, like the
4191 Tobacco River. The biologically rich transition zone between emergent herbaceous, and
4192 forested and scrub-shrub wetlands would shift having minor impacts on wildlife habitat.

4193 In average and high water years, reservoir elevations are up to 4 feet lower in winter and
4194 spring. By summer, reservoir elevations are up to 1 foot higher than No Action Alternative in
4195 average years, and up to 5 feet higher in wet years in May through October. In dry years,
4196 reservoir elevations are up to 12 feet lower in fall and slightly lower in summer by several feet.
4197 These reservoir elevation changes in Lake Koochanusa would cause minor shifts in transition
4198 zones between uplands and emergent and forested wetlands. In August and September, the
4199 reservoir elevation would be about 1-4 feet higher than the No Action Alternative due to
4200 *Modified Draft at Libby* and *Sliding Scale at Libby and Hungry Horse* measures.

4201 Libby Dam outflow under the Preferred Alternative is impacted by the *Modified Draft at Libby*
4202 *and Sliding Scale at Libby and Hungry Horse*. Monthly average outflow in average to dry years
4203 increases in January, February, and March, followed by a reduction in April and May as refill
4204 begins caused by the *Modified Draft at Libby*. In dry years, Libby releases higher flows in June,
4205 July, and August. Conversely, in wet years, Libby releases higher flows in late April, and lower
4206 flows in late June, July and August. In typical to wet years, reduced outflow starts in June
4207 through September resulting from the *Sliding Scale at Libby and Hungry Horse*.

4208 Under existing conditions, Libby Dam maintains higher flows to inundate the channel during the
4209 most biologically productive time of the year, May 15 through September 30. While operations
4210 at this location are primarily fish focused, wildlife habitats and wildlife populations would
4211 continue to benefit from increased water availability downstream. The small wetland fringe in
4212 areas where the reservoir converges with small tributaries would continue to be inundated and
4213 benefit from operations. Under the Preferred Alternative operations during wet years, would
4214 reduce outflows to the Kootenai River from June to September potentially reducing ecological
4215 productivity in the river. Regardless of the water year, the transition zone between wetlands

4216 and uplands in the Kootenai may be altered under the Preferred Alternative, resulting in the
4217 loss of wildlife habitat if not mitigated.

4218 Under the Preferred Alternative, the *Modified Draft at Libby* and *Sliding Scale at Libby and*
4219 *Hungry Horse* measures affect flows at Bonners Ferry to a smaller degree than outflows at Libby
4220 Dam due to dilution effects of major tributaries downstream. In wet years, flows are higher in
4221 October and April, and lower in August. In average years, flows are higher in January-March,
4222 and lower in April-September. In dry years, flows are lower in November and May, and higher
4223 in January, and June-August.

4224 Ongoing trends of reduced riparian vegetation establishment due to higher winter flows would
4225 be expected to continue. Winter flows can inundate and scour river banks, destroying tree and
4226 shrub saplings like cottonwoods and willows that have not yet developed sufficient root
4227 structures to withstand high winter flows or the spring freshet. The gradual loss of deciduous
4228 woody plant communities and conversion to coniferous uplands and forested and scrub-shrub
4229 wetlands could lead to a loss of biodiversity and degraded ecosystem function in the Libby Dam
4230 study area (Kootenai Tribe of Idaho [KTOI] 2013). At Libby Dam and downstream along the
4231 Kootenai River, because high winter releases scour seedlings, some riparian cottonwood
4232 communities could continue to decline in some locations due to altered hydrological conditions
4233 if not mitigated.

4234 Streambank erosion and bank sloughing would potentially increase in the Preferred Alternative
4235 due to higher winter outflows at Libby Dam. Shoreline erosion in Bonner's Ferry, Idaho, caused
4236 by frozen banks suddenly drawn down due to reduced flows, would continue to maintain the
4237 trend of wildlife habitat reduction relative to the No Action Alternative, if not mitigated.

4238 For Hungry Horse, the *Sliding Scale at Libby and Hungry Horse* would have direct effects on
4239 reservoir elevations and outflows during most years, with the largest differences from the No
4240 Action Alternative occurring in dry years. Winter water levels are slightly lower (typically less
4241 than a foot) than the No Action Alternative in most years but can be several feet lower in the
4242 driest years. Summer water levels can be several feet lower in the driest 25 percent of years.
4243 This change would have negligible effects to minor beneficial effects to vegetation surrounding
4244 the reservoir. The higher water elevation would increase soil moisture and reduce the extent of
4245 exposed barren zone in the fall. This would maintain vegetation communities around the
4246 reservoir. Wildlife would experience a smaller barren zone compared to the No Action
4247 Alternative. This would benefit smaller prey species, but the effects would be negligible.

4248 The *Sliding Scale at Libby and Hungry Horse* measures would also affect Hungry Horse Dam
4249 outflows, causing slight increases in the winter and early spring (up to 2 percent) and slight
4250 decreases July through September (3 percent typical). The decreases in summer flows can
4251 result in a decrease in water levels in the Flathead River of 0.1 feet. These changes in outflow
4252 and river elevation would have no effects to negligible effects on vegetation along the South
4253 Fork Flathead and Flathead rivers. The diversity, quantity, and quality of vegetation and wildlife
4254 habitat on the South Fork Flathead and Flathead rivers would not change as a result of the
4255 Preferred Alternative.

4256 The Preferred Alternative measures would not impact the annual peak reservoir levels in the
4257 Albeni Falls Dam reservoir, or impact timing of refill or drawdown. Results from modeling and
4258 analysis show that reservoir elevations in most water years would remain consistent with the
4259 No Action Alternative. The differences in monthly reservoir elevations during most water years
4260 and months is within the expected range of natural variability. Thus, negligible impacts to
4261 vegetation communities and wildlife habitat are expected from the implementation of this
4262 proposed measure. Undercutting of banks and erosion resulting from reservoir operations, boat
4263 wakes, and wind-wave erosion would be expected to continue under the Preferred Alternative.

4264 The Preferred Alternative would affect the monthly average outflow of Albeni Falls Dam. In
4265 higher flow years, the outflow in the summer months would be similar to No Action Alternative.
4266 In low water years, outflow would be several hundred cfs lower in August (-1 percent) and
4267 September (-2 percent). The Preferred Alternative measures would have negligible downstream
4268 impacts on vegetation communities and habitat. The Preferred Alternative measures are not
4269 anticipated to increase invasive species colonization in the Hungry Horse and Albeni Falls Dam
4270 study areas.

4271 Invasive species management within the Corps-managed lands would continue under the No
4272 Action Alternative. Invasive species in the affected environment include Russian olive, Canadian
4273 thistle, flowering rush, and false indigo bush. The *Modified Draft at Libby* causes the spring
4274 reservoir elevation at Libby Dam to be lower than the No Action Alternative. Deeper drafts
4275 would increase the barren zone width around Lake Kootenai providing greater surface area of
4276 exposed soils for potential colonization by invasive species. Invasive species spread in the Lake
4277 Kootenai drawdown zone may have downstream effects when plant seeds that enter the
4278 reservoir are washed downstream in the Kootenai.

4279 The seasonal wetlands within the Kootenai Wildlife Refuge are drained in spring and summer to
4280 promote emergent vegetation for waterfowl food sources. Under the No Action Alternative
4281 current operations of Libby Dam adversely affect wetland management capability, reducing
4282 availability of forested and scrub-shrub and emergent herbaceous wetlands (USFWS 2015).
4283 Under the Preferred Alternative, the Modified Draft at Libby would result in lower flows in late
4284 April and May, and higher flows in June, July, and August in dry years. Excess water in the
4285 summer would have a minor adverse effect on the wildlife refuge limiting the ability to modify
4286 water levels.

4287 Operational changes at Libby Dam under Preferred Alternative would cause water level
4288 fluctuations at the Kootenai Falls Wildlife Management Area. However, these fluctuations
4289 would not have measurable impacts on wildlife habitat.

4290 Similar to the No Action Alternative, the Pend Oreille Wildlife Management Area would be
4291 inundated for approximately 4 to 5 months each year. Habitat types range from exposed
4292 mudflats during winter reservoir drawdown to submerged lands with rooted aquatic plants and
4293 forested uplands. During the summer, the Wildlife Management Area contains emergent marsh
4294 habitat with an average water depth of 2 to 4 feet surrounded by a narrow zone of sedges,
4295 cottonwoods, and willows. In low water years, outflow would be several hundred cfs lower in

4296 August (-1 percent) and September (-2 percent). Therefore, the Preferred Alternative is
4297 anticipated to have no effect on the Pend Oreille Wildlife Management Area.

4298 The *Modified Draft at Libby* causes the spring reservoir elevation at Libby Dam to be lower than
4299 the No Action Alternative when the seasonal water supply forecast is less than 6.9 Maf. A larger
4300 transition zone devoid of vegetative cover would expose wildlife to increased rates of
4301 predation. For wildlife, the barren zone represents an area that smaller wildlife species, such as
4302 rodents or snakes, must navigate to reach water in the reservoir. Crossing wide barren zones
4303 with no cover poses a risk of predation for prey species, which is a detriment to them, while
4304 conversely providing a benefit to predators.

4305 Reservoir levels in July, August and September are higher in dry, average, and high water years.
4306 In August and September, the reservoir elevation would be about 1-4 feet higher than the No
4307 Action Alternative due to *Modified Draft at Libby* and *Sliding Scale at Libby and Hungry Horse*
4308 measures. Changes in reservoir elevation in Lake Kocanusa during summer may have minor
4309 impacts to nesting waterfowl.

4310 Libby Dam releases lower flows in late June, July and August in typical to wet years resulting
4311 from the *Sliding Scale at Libby and Hungry Horse*. Shallow backwater habitat may become
4312 intermittently dry as river elevations decrease, causing immotile amphibian eggs and tadpoles,
4313 like those of the western toad and northern leopard frog, to desiccate.

4314 Aquatic invertebrates, like caddisflies and stoneflies, would experience similar interruptions in
4315 life cycle, which could lead to changes in the food web and a corresponding decrease in food
4316 availability to wildlife such as swallows and flycatchers (See Section 3.5, *Aquatic Habitats,*
4317 *Aquatic Invertebrates, and Fish*). Western grebes are abundant on portions of the Pend Oreille
4318 Wildlife Management Area. Denton Slough is a shallow bay with a large quantity of submerged
4319 plants used by western grebe to construct their nests from May through September (Idaho
4320 Department of Fish and Game [IDFG] 1999). The Preferred Alternative is not expected to impact
4321 nesting birds in the Albeni Falls Dam study area.

4322 Operational changes at Libby Dam from the Preferred Alternative would also be evident in
4323 downstream reaches of the Columbia River, as discussed below.

4324 **7.7.7.2 Region B Grand Coulee and Chief Joseph**

4325 Under the Preferred Alternative, the *Update System FRM Calculation, Planned Draft Rate at*
4326 *Grand Coulee, Fall Operational Flexibility for Hydropower (Grand Coulee), and Lake Roosevelt*
4327 *Additional Water Supply* measures would directly affect outflows from Grand Coulee Dam. In
4328 addition, the *Modified Draft at Libby* and *Sliding Scale at Libby and Hungry Horse* measures
4329 from Region A upstream would affect inflows and outflows at Grand Coulee Dam. The outflows
4330 from Grand Coulee Dam would differ from the No Action Alternative depending on the time of
4331 year. In almost every month of the year, the outflow from Grand Coulee Dam under the
4332 Preferred Alternative would differ from the No Action Alternative due to various measures at
4333 Grand Coulee Dam and in Region A upstream. However, these changes are relatively small, with

4334 median monthly average flows typically within 1 percent of those under the No Action
4335 Alternative. The pattern of flow changes from Grand Coulee Dam outflow would continue
4336 through the middle Columbia River under the Preferred Alternative. The middle Columbia River
4337 monthly average flows for the Preferred Alternative (as change from No Action Alternative)
4338 shows minor changes in the median values of monthly average flows for Lake Roosevelt Inflow,
4339 Grand Coulee Dam outflow, and other dam outflow locations downstream in Region B of less
4340 than 1 to 2 percent throughout spring and summer.

4341 Collectively, these measures only slightly influence reservoir elevations in Lake Roosevelt and
4342 downstream reaches of the Columbia River through the run of river past Chief Joseph Dam,
4343 resulting in only potentially minor changes to the quantity, quality, and distribution of habitats
4344 in the study area. However, even minor changes to wildlife habitats could have a corresponding
4345 effect on wildlife populations in the study area. During the spring, the potential to have a minor
4346 decrease in water elevation, even only 1 to 2 percent, could affect the growth of emergent
4347 vegetation on the shoreline and cause a minor increase in the barren strip of land immediately
4348 adjacent to the water. The frequency and duration of drying conditions could slightly increase
4349 for areas with emergent herbaceous and forested and scrub-shrub wetlands, and these habitats
4350 could transition into upland habitats, or plant communities in these habitats would transition to
4351 predominantly species more tolerant of dry conditions. This could change plant composition
4352 and distribution, or reduce the overall quantity of wetland acreage. The amount of impacts,
4353 however, are very likely to be minor, given the small percentage of water elevation changes
4354 throughout an average year under the Preferred Alternative when compared to the No Action
4355 Alternative.

4356 **7.7.7.3 Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and ice**
4357 **Harbor Dams**

4358 Structural measures in the Preferred Alternative in Region C include the *Lower Granite Trap*
4359 *Modifications, Lamprey Passage Ladder Modifications, Fewer Fish Screens, and Turbine Strainer*
4360 *Lamprey Exclusion* measures. These measures would collectively improve conditions for ESA-
4361 listed fish and lamprey passage and survival. Structural measures would be limited to the
4362 immediate vicinity of the project dams on the lower Snake and Columbia Rivers and
4363 construction-related effects would not result in widespread effects to wildlife habitats or
4364 populations.

4365 Operational measures associated with the Preferred Alternative in Region C include the *Deeper*
4366 *Draft for Hydropower at Dworshak, Increased Forebay Range Flexibility, Juvenile Fish Passage*
4367 *Spill (Operations), Early Start Transport, Contingency Reserves in Fish Spill, Zero Generation*
4368 *Operations, Above 1% Turbine Operations, and Increased Forebay Range Flexibility* measures.
4369 Collectively, these measures could improve fish passage times and increase abundance of
4370 juvenile fish transported to the estuary, increase capacity and provide flexibility for hydropower
4371 generation, shape hydropower generation, and maintain grid reliability, and decrease avian
4372 predation of juvenile salmon and steelhead.

4373 Under the Preferred Alternative, the *Slightly Deeper Draft for Hydropower at Dworshak*
4374 measure would allow for additional hydropower generation and hydropower flexibility by
4375 drafting to reservoir elevations lower than what is required for FRM purposes. This measure
4376 would result in lower water levels than the No Action Alternative in larger forecast years in the
4377 months of January, February, and March, and then similar water levels for the rest of the year.
4378 By the end of February, only the wettest 10 percent of years would have deeper drafts than the
4379 No Action Alternative, but the difference could range from 2 to 35 feet. By the end of March,
4380 reservoir levels are effectively the same as the No Action Alternative, typically less than a foot
4381 lower.

4382 This measure would not result in changes to the quantity, quality, and distribution of habitats in
4383 the Dworshak Reservoir. Changes to wildlife habitats have a corresponding effect on wildlife
4384 populations in the study area. However, lower water levels in January, February, and March
4385 would have a minor adverse effect on elk migration patterns, when ice is present on the
4386 reservoir. When ice is present, elk may cross the reservoir to reach their south-facing winter
4387 range on the northern end of the reservoir. In winters when snow accumulates on thin ice, elk
4388 and deer may fall through the ice and die. Migration across the ice occurs frequently when ice
4389 and snow conditions permit. Drawdown of the reservoir effects ice thickness (Huokuna et al.
4390 2017).

4391 Downstream of Dworshak Reservoir, this measure would not result in changes to the quantity,
4392 quality, and distribution of habitats in the Clearwater River. Changes to wildlife habitats have a
4393 corresponding effect on wildlife populations in the study area. There would be no net loss or
4394 reduction in the quality and distribution of existing emergent herbaceous and forested and
4395 scrub-shrub wetlands under the Preferred Alternative, when compared to the No Action
4396 Alternative. Existing wetlands would continue to be productive habitats supporting breeding
4397 amphibians, reptiles, mammals, and birds during the spring and summer breeding season.

4398 Under the Preferred Alternative, operating reservoir elevation restrictions at the four lower
4399 Snake River dams would be changed to provide operating flexibility during the fish passage
4400 season April 3 through August 15 (August 15–31 becomes minimum spill operations) due to the
4401 *Increased Forebay Range Flexibility* measure. At all four projects, the seasonal MOP range is
4402 increased from a 1.0-foot range to a 1.5-foot range, each with a 0.5-foot increase in the upper
4403 end of the range. Any fluctuations in water elevations would be approximately 0.5 feet higher
4404 than the No Action Alternative and the range of natural variability for daily operations.
4405 Therefore, the Preferred Alternative may affect the quantity, quality, or distribution of existing
4406 habitat types by making them slightly wetter than the No Action Alternative. However, the
4407 overall effect would be negligible.

4408 Emergent herbaceous wetlands may become established in new areas where water depth and
4409 inundation patterns support establishment of wetland vegetation and soil conditions,
4410 increasing the overall quantity and quality of wetlands in the area. There would be no reduction
4411 in the quality and distribution of existing emergent herbaceous and forested and scrub-shrub
4412 wetlands under the Preferred Alternative, when compared to the No Action Alternative.

4413 Existing wetlands would continue to be productive habitats supporting breeding amphibians,
4414 reptiles, mammals, and birds during the spring and summer breeding season.

4415 The Preferred Alternative is not anticipated to result in new exposed soil. Therefore, invasive
4416 species colonization is unlikely to expand within Region C. Invasive species management efforts
4417 are anticipated to continue similar to the No Action Alternative.

4418 The *Early Start Transport* measure would reduce the quantity of juvenile salmonid and
4419 steelhead available to avian and mammalian predators similar to MO1, MO2, and MO4. There
4420 would be fewer juvenile salmonids in the system between collection points in the lower Snake
4421 and release points below Bonneville Dam between April 15 and October 31. Decreasing the
4422 number of juvenile salmonids above Bonneville Dam would decrease overall prey resources
4423 supporting a variety of wildlife populations at higher trophic levels above Bonneville Dam,
4424 specifically colonial nesting terns, gulls, and pelicans. These colonies prey heavily on juvenile
4425 salmonids and fewer fish would likely force birds to transition to other prey resources, delay
4426 nesting, or relocate breeding activities to other areas on the Columbia Plateau where prey
4427 resources are more widely available (Meyer et al. 2016). Consistent or long-term delays in nest
4428 initiation would decrease overall reproductive success for the colony, reducing the overall
4429 fecundity and potentially leading to a long-term reduction in regional populations.

4430 The changes proposed as part of the Preferred Alternative, specifically the *Early Start Transport*
4431 measure, would offset impacts to juvenile salmonids by transporting individuals through the
4432 lower Snake and Columbia Rivers. As a result, it is assumed that the abundance and condition
4433 of juvenile salmon and steelhead entering the estuary would similarly increase the prey base
4434 available to colonial nesting waterbirds in the estuary. An increase in the prey base would
4435 support reproductive success of these colonies, providing long-term benefits to regional
4436 populations.

4437 **7.7.7.4 Region D – McNary, John Day, The Dalles, and Bonneville Dams**

4438 Structural measures in the Preferred Alternative in Region D include the *Lamprey Passage*
4439 *Structures, Turbine Strainer Lamprey Exclusion, Modify Bonneville Ladder Serpentine Weir,*
4440 *Bypass Screen Modifications for Lamprey, Closable Gates, Improved Fish Passage Turbines at*
4441 *John Day Dam, Fewer Fish Screens, and Lamprey Passage Ladder Modifications* measures. These
4442 measures would collectively improve conditions for ESA-listed fish and lamprey passage and
4443 survival. Structural measure effects would be limited to the immediate vicinity of the project
4444 dams on the lower Snake and Columbia Rivers and construction-related effects would not result
4445 in widespread effects to wildlife habitats or populations.

4446 Operational measures associated with the Preferred Alternative in Region D include the *Juvenile*
4447 *Fish Passage Spill (Operations), Early Start Transport, Contingency Reserves in Fish Spill, Above*
4448 *1% Turbine Operations, Predator Disruption Operations, Increased Forebay Range Flexibility,*
4449 *and John Day Full Pool* measures. Collectively, these measures would improve fish passage
4450 times and increase abundance of juvenile fish transported to the estuary, increase capacity and

4451 provide flexibility for hydropower generation, shape hydropower generation, maintain grid
4452 reliability, and decrease avian predation of juvenile salmon and steelhead.

4453 Under the Preferred Alternative, there would be no changes to the reservoir elevations at
4454 McNary, The Dalles, or Bonneville Dam and river elevations would remain consistent with the
4455 No Action Alternative. Any fluctuations in water elevations would be within the normal
4456 operating range for daily operations. The Preferred Alternative is anticipated to have a similar
4457 level of effect to the quantity, quality, or distribution of existing habitat types and there would
4458 be no additional effects to vegetation communities or wildlife habitat at these projects.
4459 Similarly, wetland habitats downstream of Bonneville Dam, such as Franz Joseph, Pierce,
4460 Steigerwald, Ridgefield, Julia-Butler Hansen, and Lewis and Clark National Wildlife Refuges,
4461 would remain consistent with existing conditions despite minor changes in water surface
4462 elevations. Any changes in river elevations downstream of Bonneville Dam from implementing
4463 the Preferred Alternative would become progressively muted and would not result in
4464 measurable changes in effects to wildlife populations or their habitats downstream of
4465 Bonneville Dam.

4466 At John Day Dam, the *John Day Full Pool*, *Predator Disruption Operations*, and *Increased*
4467 *Forebay Range Flexibility* measures change reservoir operating ranges compared to the No
4468 Action Alternative. As described in Section 3.6.2, *Affected Environment*, and the No Action
4469 Alternative, there are regionally important forested and scrub-shrub and emergent herbaceous
4470 wetlands in the John Day Dam study area, including the extensive wetland complex at the
4471 Umatilla National Wildlife Refuge. The *John Day Full Pool* and *Increased Forebay Range*
4472 *Flexibility* measures of the Preferred Alternative would change operational limits on reservoir
4473 elevations, inundating wetland habitats between 0.5 to 2.5 feet vertically. Increasing the
4474 duration and extent of inundation could shift wetland species composition from facultative
4475 species to a greater dominance by obligate species. Despite the increased duration of
4476 inundation under the Preferred Alternative, the temporary nature of inundation is not expected
4477 to result in functional changes to wetland habitats in Lake Umatilla.

4478 Emergent herbaceous wetlands may become established in new areas where water depth and
4479 inundation patterns support establishment of wetland vegetation and soil conditions,
4480 increasing the overall quantity and quality of wetlands in the area. There would be no reduction
4481 in the quality and distribution of existing emergent herbaceous and forested and scrub-shrub
4482 wetlands under the Preferred Alternative, when compared to the No Action Alternative.
4483 Existing wetlands would continue to be productive habitats supporting breeding amphibians,
4484 reptiles, mammals, and birds during the spring and summer breeding season. These wetland
4485 habitats would continue to support regionally important migratory waterfowl overwintering in
4486 the Umatilla National Wildlife Refuge by providing forage opportunities and prey resources.

4487 The Preferred Alternative is not anticipated to result in new exposed soil. Therefore, invasive
4488 species colonization is unlikely to expand within Region D. Invasive species management efforts
4489 are anticipated to continue similar to the No Action Alternative.

4490 Habitat conditions in Lake Wallula, Lake Celilo, and Lake Bonneville are not expected to change
4491 under the Preferred Alternative. Consequently, there would be no measurable impacts to
4492 wildlife populations using these habitats under the Preferred Alternative. In locations where
4493 ODFW or WDFW manage wetland habitats for wildlife, operations and maintenance actions
4494 under the Preferred Alternative are assumed to continue similar to current practices under the
4495 No Action Alternative, including actions at Klickitat Wildlife Area and Sondino Ponds in
4496 Washington for western pond turtle. It is assumed that wildlife concentrations and use of
4497 habitats in the lower Columbia River estuary would not change under the Preferred Alternative
4498 from current conditions as described in the No Action Alternative.

4499 The *Early Start Transport* measure would reduce the quantity of juvenile salmonid and
4500 steelhead available to avian and mammalian predators under the Preferred Alternative, similar
4501 to MO1, MO2, and MO4. There would be fewer juvenile salmonids in the system between
4502 collection points in the lower Snake and release points below Bonneville Dam between April 15
4503 and October 31. Decreasing the number of juvenile salmonids above Bonneville Dam would
4504 decrease overall prey resources supporting a variety of wildlife populations at higher trophic
4505 levels above Bonneville Dam, specifically colonial nesting terns, gulls, and pelicans. These
4506 colonies prey heavily on juvenile salmonids and fewer fish would likely force birds to transition
4507 to other prey resources, delay nesting, or relocate breeding activities to other areas on the
4508 Columbia Plateau where prey resources are more widely available (Meyer et al. 2016).
4509 Consistent or long-term delays in nest initiation could decrease overall reproductive success for
4510 the colony, reducing the overall fecundity and potentially leading to a long-term reduction in
4511 regional populations.

4512 Avian populations would also experience additional impacts from changes in the availability of
4513 nesting habitat. Nesting habitat on Badger Island, Foundation Island, and Crescent Island would
4514 be similar to the No Action Alternative due to consistent reservoir elevations in Lake Wallula.
4515 However, less habitat would be available in Lake Umatilla as a result of the *Predator Disruption*
4516 *Operations* measure. As described for the No Action Alternative, several islands in Lake Umatilla
4517 are used by colonial nesting waterbirds, including the Blalock Islands, and these sites would be
4518 inundated during the breeding season under the Preferred Alternative. Because the *Predator*
4519 *Disruption Operations* measure could reduce the overall quantity and availability of habitat in
4520 Lake Umatilla prior to the breeding season, nesting waterbirds would likely delay nest initiation
4521 until late June and July, forego nesting, or relocate to other areas.

4522 Avian predators displaced from nesting habitat in Lake Umatilla under the Preferred Alternative
4523 would be expected to relocate to other islands and continue to forage within the Columbia
4524 River Basin. Alternatively, birds would move to alternate nesting locations in Lake Celilo (i.e.,
4525 Miller Rocks) or Lake Wallula (i.e., Badger or Foundation Island), where habitat availability
4526 would remain consistent with the area currently available under the No Action Alternative. As
4527 discussed in Section 3.6.3.2, Caspian terns are highly mobile during the breeding season and
4528 move between breeding colonies in a given year and between years, demonstrating a
4529 willingness to nest away from the Columbia River while still foraging on juvenile salmonids
4530 (Corps 2014, 2018, 2019). It is also possible that some birds would move outside of the

4531 Columbia River Basin in response to *Predator Disruption Operation* measure and nest in
4532 colonies in northern California, southern Oregon, or along the Oregon and Washington coasts.

4533 The changes proposed as part of the Preferred Alternative, specifically the *Early Start Transport*
4534 measure, would offset impacts to juvenile salmonids by transporting individuals through the
4535 lower Snake and Columbia Rivers. As a result, it is assumed that the abundance and condition
4536 of juvenile salmon and steelhead entering the estuary would similarly increase the prey base
4537 available to colonial nesting waterbirds in the estuary. An increase in the prey base would
4538 support reproductive success of these colonies, providing long-term benefits to regional
4539 populations.

4540 This measure would increase the survival and condition of juvenile fish entering the estuary. As
4541 described in Section 3.5, the expected impact in smolt-to-adult returns and overall abundances
4542 of adult salmon and steelhead would increase the prey base available to marine mammals
4543 foraging downstream of Bonneville Dam or offshore from the mouth of the Columbia River,
4544 such as seals, sea lions, and other predators. In addition, it is assumed that the abundance and
4545 condition of juvenile salmon and steelhead entering the estuary would similarly increase in the
4546 prey base available to nesting waterbirds, which would be a moderately beneficial impact to
4547 the size and reproductive success of these colonies.

4548 Management activities implemented at and immediately downstream of John Day Dam, The
4549 Dalles Dam, and Bonneville Dam to reduce avian predation on juvenile salmonids by gulls and
4550 terns under the No Action Alternative are expected to continue under the Preferred
4551 Alternative. These activities include the maintenance of avian wires spanning the river in an
4552 effort to minimize large concentrations of birds congregating at juvenile bypass outfalls, where
4553 they can more easily prey upon juveniles exiting the bypass systems. Similar to the No Action
4554 Alternative, no management actions would occur under the Preferred Alternative at Miller
4555 Island in Lake Celilo to limit or preclude nesting habitat for colonial nesting birds.

4556 **7.7.8 Special Status Species**

4557 This section discusses the potential effects of implementing Preferred Alternative on ESA-listed
4558 plant and animal species that may occur in the study area.

4559 Table 7-28 provides details about ESA-listed wildlife species that are known or likely to occur in
4560 the study area and the potential effects to these species or their critical habitats in response to
4561 Preferred Alternative implementation. Similar to the No Action Alternative, it is assumed that
4562 those species Federally-listed and present in the study area will remain listed, and existing
4563 regulatory and best management practices would reduce the likelihood that populations would
4564 continue declining or become extinct. It is assumed that neither grizzly bear critical habitat nor
4565 whitebark pine would be listed, and their presence and population in, or in the vicinity of, the
4566 study area would remain relatively stable.

4567 The impacts to wildlife from adult salmon and steelhead returning to the Columbia River
4568 estuary is described in Section 3.5. The CSS model is indicating a major increase of smolt-to-

4569 adult returns and the overall abundance of adult salmon and steelhead returning to the estuary
4570 increases. However, the NMFS LCM model is indicating a negligible decrease in smolt-to-adult
4571 returns. This represents a negligible adverse decrease to moderate increase in Chinook salmon
4572 populations that would return to the Columbia and Snake rivers. Therefore, the prey base
4573 available to marine mammals foraging downstream of Bonneville Dam and offshore from the
4574 mouth of the Columbia River, such as seals and sea lions, may be negligibly lower to moderately
4575 higher and the Preferred Alternative, which could have long-term, beneficial impacts on wildlife
4576 downstream of Bonneville Dam. Alternatively, fish populations could decrease negligibly and
4577 the overall abundance of salmon and steelhead returning to the Columbia River estuary could
4578 decrease. This would have negligible effects to marine mammal populations.

4579 An increase in Chinook salmon returns could cause an increase in sea lions around the
4580 Bonneville and The Dalles dam. Hazing would continue and may increase around these dams. In
4581 addition, the southern resident killer whales may have a slight increase in available food around
4582 the mouth of the Columbia River. However, this increase in food availability would have a
4583 negligible effect on killer whales, given that the Snake River and Columbia Chinook populations
4584 constitute a small portion of their overall diet. Fish hatchery production would continue at
4585 similar rates to the No Action Alternative into the future and the change in Chinook salmon
4586 abundance influenced by the Preferred Alternative would be negligible.

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4588 Table 7-28. Sensitive Species Effects for Preferred Alternative

Common Name	Scientific Name	Status of Species and Critical habitat	Projects Where Species Occurs	Effects of Preferred Alternative
Mammals				
Grizzly bear	<i>Ursus arctos horribilis</i>	ESA status: T CH: Proposed	Libby Hungry Horse	Construction of structures on the dams: No effect. Hydrology: Negligible effect on habitat. Hydrograph would not be beneficial to establishment of cottonwood seedling or a benefit to riparian species. Conclusion: Negligible effect. Preferred Alternative would have a negligible benefit to the grizzly bear from No Action Alternative conditions. Riparian mitigation is proposed in the form of cottonwood plantings. The Preferred Alternative is not likely to adversely affect grizzly bears.
Columbian white-tailed deer	<i>Odocoileus virginianus leucurus</i>	ESA status: T CH: None	Downstream of Bonneville Dam	Construction of structures on the dams: No effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected. Hydrology: Negligible effect. Virtually no change in river elevation within range of Columbian white-tailed deer. No change is suitable habitat or probability of flooding individuals. Conclusion: Negligible effect to Columbian white-tailed deer from Preferred Alternative. The Preferred Alternative is not likely to adversely affect Columbian white tailed deer.
California sea lion	<i>Zalophus californianus</i>	ESA status: None CH: None Marine Mammal Protection Act	Downstream of Bonneville Dam, occasionally seen at The Dalles Dam	Construction of structures on dams: Negligible, temporary effect. Minimal visual and noise disturbance, potentially resulting in avoidance of the area. Prey availability: Negligible Effect. Smolt-to-adult survivorship varies between the two models. These models predict a negligible decrease to major increase in Chinook salmon returns. This would be a minor change in prey availability in comparison from No Action Alternative conditions. Conclusion: Negligible effect. Numbers of California sea lions could increase under Preferred Alternative and may be slightly higher based on increases of the available fish. Hazing would continue under the Preferred Alternative. California sea lion populations would remain stable.
Steller sea lion	<i>Eumetopias jubatus</i>	ESA status: None CH: None Marine Mammal Protection Act	Downstream of Bonneville Dam	Construction of structures on dams: Temporary. Negligible effect. Minimal visual and noise disturbance, potentially resulting in avoidance of the area. Prey availability: Negligible Effect. Smolt-to-Adult survivorship varies between the two fish models. These models predict a negligible decrease to major increase in Chinook salmon returns. This would result in a minor change in prey availability in comparison from No Action Alternative conditions. Conclusion: Negligible effect. Numbers of Steller sea lions could increase under the Preferred Alternative and may be slightly higher based on increases of the available fish. Hazing would continue under the Preferred Alternative. Steller sea lion populations would remain stable.
Southern Resident killer whale Distinct Population Segment	<i>Orcinus orca</i>	ESA status: E CH: None	None	Construction of structures on the dams: No effect. Disturbance would not extend to suitable habitat for Southern Resident killer whale, no individuals or habitat affected. Prey Availability: Negligible effect. Smolt-to-Adult survivorship varies between the two fish models. These models predict a negligible decrease to major increase in Chinook salmon returns. This would result in a minor change in prey availability in comparison from No Action Alternative conditions. Conclusion: Negligible effect. The southern resident killer whale population would remain similar to the No Action Alternative based on the fact that the Columbia and Snake River chinook salmon are a small percentage of the overall diet for the population. Some prey may be more available or there may be a slight decrease in available fish. The fish hatchery production will continue at similar rates into the future. The Preferred Alternative is not likely to adversely affect the southern resident killer whale population.
Birds				
Yellow-billed cuckoo	<i>Coccyzus americanus</i>	ESA status: T CH: Proposed	Study area is within the range of yellow-billed cuckoo.	Construction of structures on the dams: No effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected. Hydrology: Negligible effect. Preferred Alternative is unlikely to have any impact on yellow-billed cuckoo due to infrequent sightings of the birds near the study area. Long-term effects of decreased riparian vegetation along the Kootenai River (Plant Cottonwood Trees [up to 100 acres] near Bonners Ferry and Plant Native Wetland and riparian vegetation [up to 100 acres] on the Kootenai River downstream of Libby) may equate to decreased acreages of suitable habitat for the western yellow-billed cuckoo. Mitigation efforts may offset these impacts. Conclusion: Negligible effect. There would be some continued loss of habitat at the Libby area for cottonwood recruitment, similar to the No Action Alternative. Overall, cottonwoods may continue to decline in areas where they are established. The Preferred Alternative is not likely to adversely affect the yellow-billed cuckoo.
Bald eagle and golden eagle	<i>Haliaeetus leucocephalus</i> <i>Aquila chrysaetos</i>	Bald and Golden Eagle Protection Act	Throughout the study area.	Construction of structures on the dams: No effect. Hydrology: Negligible effect. Preferred Alternative operations would continue trends in reducing riparian habitat along the Kootenai River. Mitigation efforts may offset these impacts. Conclusion: Negligible effect. Forested areas should remain forested along the riparian system. Riparian plantings are proposed under the Preferred Alternative. Therefore, the impact to bald and golden eagles should be negligible in compared to No Action Alternative.
Streaked horned lark	<i>Eremophila alpestris strigata</i>	ESA status: T CH: Designated	Downstream of Bonneville Dam	Construction of structures on the dams: No effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected. Hydrology: No Effect. Virtually no change in river elevation below RM 123. Not likely to convert suitable habitat or flood individuals. Conclusion: The Preferred Alternative is not likely to adversely effect to the streaked horned lark.

Common Name	Scientific Name	Status of Species and Critical habitat	Projects Where Species Occurs	Effects of Preferred Alternative
Plants				
Ute ladies'-tresses	<i>Spiranthes diluvialis</i>	ESA status: T CH: None	Grand Coulee Chief Joseph	<p>Construction of structures on the dams: No effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected.</p> <p>Hydrology: Negligible Effect. Changes in reservoir elevations could alter regions along the water margins where the plant occurs. The general trend toward lower reservoir elevations throughout most of the year due to the large deviation at Grand Coulee would have a negative impact on the plant, if the plant were to grow along the banks and margins of Lake Roosevelt.</p> <p>Conclusion: Negligible effect. There would be low impact to this species if the plant were to grow along the banks and margins of Lake Roosevelt. The Preferred Alternative is not likely to adversely affect the Ute Ladies' Tresses.</p>

4590 Effects to floodplains were also evaluated. For the Preferred Alternative, changes in flood
4591 elevations are expected to be similar to those predicted for MO 1 and 2. Flood elevation
4592 changes would typically be negligible (absolute value less than 0.3 feet) with minor reductions
4593 (absolute value less than 1 foot) in flood elevations predicted in Region D for the Columbia
4594 River below Bonneville Dam for floods with moderate to low frequencies (Annual Exceedance
4595 Probability values from 15 to 2 percent). The annual average probability of inundation under
4596 the Preferred Alternative would remain unchanged from current conditions in most of the
4597 basin, with minor reductions in inundation frequency below Bonneville Dam.

4598 **7.7.9 Power Generation and Transmission**

4599 This section evaluates effects on hydropower under the Preferred Alternative. Overall,
4600 hydropower would decrease relative to the No Action Alternative under the Preferred
4601 Alternative. However, because of the shape of the remaining hydropower generation in the
4602 Preferred Alternative, the LOLP was essentially the same as that of the No Action Alternative;
4603 therefore, potential replacement resources that would maintain LOLP at No Action Alternative
4604 levels were not evaluated. Absent offsetting cost reductions, the effects of decreased
4605 hydropower generation would result in upward pressure on electricity rates under the
4606 Preferred Alternative relative to No Action Alternative. Over the past 2 years, Bonneville and its
4607 partners have taken steps to offset the costs of reduced hydropower generation resulting from
4608 the flexible spill agreement. The co-lead agencies expect that the conditions that drive the
4609 flexible spill operation value for power would evolve with changes in energy markets and the
4610 resource mix. For example, as coal plants are retired and likely replaced with renewable
4611 resources, the price of electricity may fluctuate more over the day than it does today. This
4612 could improve the value of the increased-power-generation periods within flex spill if there are
4613 greater spreads in power prices throughout the day. Similarly, increased access to different
4614 markets and the evolution of the power markets may increase Bonneville's ability to take
4615 advantage of price values through power trading with adjacent regions (e.g., California). The
4616 spill operations contained in the Preferred Alternative are intended to test the potential
4617 biological benefits of significantly increased spill while maintaining cost neutrality for regional
4618 electricity ratepayers relative to the 2018 spill injunction.

4619 **7.7.9.1 Changes in Power Generation**

4620 Table 7-29 and Figure 7-20 present the generation for the No Action Alternative and Preferred
4621 Alternative and their differences by month. Overall, generation from the CRS projects would
4622 drop from 8,300 aMW under the No Action Alternative, on average, over all water years, to
4623 8,140 aMW under the Preferred Alternative. This represents a decrease of 160 aMW, which is
4624 about a 2 percent decrease in generation on average. (The decrease in generation from all
4625 Northwest U.S. projects including the non-Federal projects that are affected by changes in the
4626 CRS projects is 160 aMW.) The reduction in critical water generation from the Preferred
4627 Alternative is even greater. The critical water year generation of the CRS projects would
4628 decrease by about 5 percent (300 aMW) thus decreasing the amount of firm power used to
4629 supply Bonneville's long-term contracts.

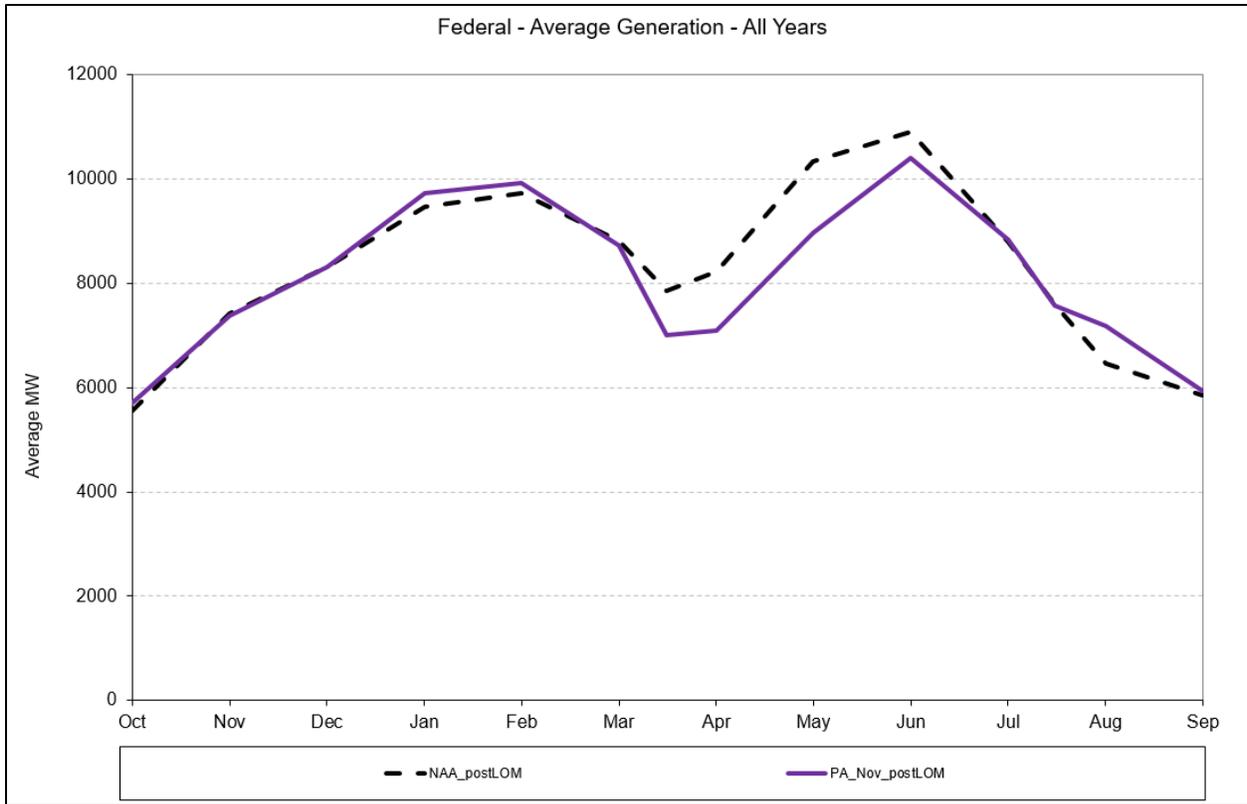
4630 **Table 7-29. Monthly Electricity Generation at the Columbia River System Projects under**
4631 **Preferred Alternative (aMW)**

Month	No Action Alternative	Preferred Alternative Generation Difference	Preferred Alternative % Difference
October	5,500	153	2.8%
November	7,400	-47	-0.6%
December	8,300	16	0.2%
January	9,500	278	2.9%
February	9,700	190	2.0%
March	8,800	-96	-1.1%
April I ^{1/}	7,800	-845	-10.8%
April II ^{1/}	8,200	-1,100	-13.9%
May	10,000	-1,400	-13.3%
June	11,000	-490	-4.5%
July	8,800	31	0.3%
August I ^{1/}	7,600	-19	-0.3%
August II ^{1/}	6,500	731	11.3%
September	5,800	90	1.5%
Annual Average	8,300	-160	-1.9%

4632 1/ HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these
4633 months tend to have significant natural flow differences between their first and second halves. Estimates are
4634 rounded to two significant digits and may not sum to the totals reported due to rounding.
4635 Source: HYDSIM results (November 2019)

4636 The measure that appears to have the largest impact on generation is *the Juvenile Fish Passage*
4637 *Spill Operations* measure that reduces generation in the spring. There would be slight increases
4638 in generation in the winter, primarily from the *Slightly Deeper Draft for Hydropower at*
4639 *Dworshak* measure and in the second half of August from the summer spill timing in the
4640 *Juvenile Fish Passage Spill Operations* measure. For generation in the critical water year, the
4641 largest impact would be from the *Juvenile Fish Passage Spill Operations* measure. Additionally,
4642 the *Sliding Scale at Libby and Hungry Horse* measure contributes to reductions in summer
4643 generation. The generation at Grand Coulee would be reduced in January.

4644 While there would be a decrease in generation, the largest decrease would be in the spring
4645 when the region often has surplus power. With the 1937 water year baseline comparison, there
4646 would be a decrease in July and early August. However, the slight increase in generation in the
4647 winter and late August compared to the No Action Alternative would offset the impact on
4648 power system reliability from the spring and summer generation loss. The result would be an
4649 LOLP for the Preferred Alternative that is essentially the same as the No Action Alternative (6.5
4650 percent for the Preferred Alternative compared to 6.6 percent for the No Action alternative).



4651
4652 **Figure 7-20. Monthly Hydropower Generation at the CRS Projects, No Action and Preferred**
4653 **Alternative, in aMW, for the Base Case without Additional Coal Plant Retirements**

4654 The ability of CRS projects to meet peak-periods would decrease by 1.2 percent, relative to the
4655 No Action Alternative. Based on a qualitative assessment of the alternative, the Preferred
4656 Alternative has some measures that would increase the flexibility of operating the CRS projects
4657 while the *Juvenile Fish Passage Spill Operations* measure would decrease the flexibility of the
4658 hydrosystem. Thus, the Preferred Alternative might increase the ability to integrate other
4659 renewable resources into the power grid in some seasons while decreasing this capability in the
4660 spring.

4661 Other non-Federal regional hydropower projects that are located downstream of CRS projects
4662 (such as the Mid-Columbia hydropower projects) would experience similar trends as the CRS
4663 projects in the winter from flow changes upstream of these projects. However, the non-Federal
4664 projects would not be affected by the changes in fish passage spill in the Preferred Alternative
4665 or flow changes at Dworshak. The regional generation including these non-Federal projects
4666 would generate on average 13,200 aMW, which is a decrease of approximately 1 percent
4667 (approximately 200 aMW) relative to the No Action Alternative (at 13,400 aMW). The CRS
4668 projects account for almost all of the hydropower generation decrease under the Preferred
4669 Alternative.

4670 **EFFECTS ON POWER SYSTEM RELIABILITY**

4671 Despite the reduction in annual average hydropower generation under the Preferred
4672 Alternative, the LOLP would be 6.5 percent, which would be 0.1 percentage points lower than
4673 the LOLP in the No Action Alternative, which has a LOLP of 6.6 percent. This difference is not
4674 statistically significant. The slight reduction in LOLP occurs even with the loss of generation
4675 because of the shape of the remaining generation in the Preferred Alternative. The largest
4676 reductions in annual average hydropower generation occur in periods when the system is
4677 generally surplus (spring) and loads are easier to meet, while smaller reductions would also
4678 occur in July and the first half of August. The Preferred Alternative increases generation in late
4679 August and in the winter, which generally offsets these reductions, returning LOLP to essentially
4680 the same level of the No Action Alternative.

4681 As described in Chapter 3.7, these LOLP estimates rely on the assumption that 4,246 MW of
4682 coal generating capacity would continue to serve regional loads (primarily investor-owned
4683 utility loads, not public utility loads) over the study period. In future scenarios with limited and
4684 no coal capacity, the LOLP under the Preferred Alternative would decrease by 3 percentage
4685 points and 4 percentage points, respectively, compared to the No Action Alternative. This
4686 would result in absolute LOLP percentage values of 24 percent in a limited coal capacity
4687 scenario (whereas the No Action Alternative is 27 percent), and 59 percent without any regional
4688 coal capacity (whereas the No Action Alternative is 63 percent). The LOLP for No Action (6.6
4689 percent) without the additional coal retirements is already above the Northwest Power and
4690 Conservation Council target of 5 percent, and the Preferred Alternative is essentially the same
4691 at 6.5 percent. However, the difference between the two alternatives does become more
4692 significant with additional coal plant closures, largely due to the Preferred Alternative having
4693 slightly more generation than the No Action Alternative in the winter and late-August.

4694 **POTENTIAL REPLACEMENT RESOURCES AND ASSOCIATED COSTS**

4695 Because the Draft Preferred Alternative has essentially the same power supply adequacy and
4696 system reliability as the No Action Alternative, the analysis did not identify a need for
4697 replacement resources (as was the case with MO1, MO3, and MO4). In contrast, MO1, MO3,
4698 and MO4 decreased the regional power system reliability (and required replacement resources
4699 to maintain system reliability), and MO2 increased system reliability compared to No Action
4700 (and did not require replacement resources).

4701 The LOLP for the No Action Alternative (6.6 percent) without the additional coal retirements is
4702 already above the NW Council target of 5 percent, indicating a need for the region to add new
4703 resources to meet the NW Council target.

4704 For the scenario with limited or no coal capacity, the No Action Alternative has a significantly
4705 higher LOLP, and new resources will be needed to maintain the current level of reliability
4706 (Table 7-30). In these scenarios, for the Preferred Alternative no additional zero-carbon
4707 resources would be needed to restore the regional LOLP to the No Action Alternative level. That
4708 is, if the Preferred Alternative is adopted, and either the Limited Coal Capacity scenario

4709 occurred or the No Coal scenario occurred, the region would not need to acquire any more
4710 resources for the Preferred Alternative than it would have otherwise acquired under the No
4711 Action Alternative.

4712 In fact, the Draft Preferred Alternative would reduce the need for new resources to replace
4713 retired coal capacity. In scenarios with limited coal generation capacity and assuming no new
4714 gas plants are built, restoring LOLP to 6.6 percent would require 200 MW fewer zero-carbon
4715 replacement resources under the Preferred Alternative, relative to the No Action Alternative, as
4716 summarized in Table 7-30. Under a no-coal future, the Draft Preferred Alternative would
4717 require 1,000 MW fewer zero-carbon replacement resources than the No Action Alternative.
4718 The reason for this change is related to the seasonality of the LOLP. In the base case without
4719 additional coal retirements, the Preferred Alternative has about the same LOLP as the No
4720 Action Alternative measured annually. However, The No Action Alternative has a higher LOLP in
4721 January and February, while the Preferred Alternative has a higher LOLP June through August.
4722 As coal plants are retired, the replacement resources may consist of large quantities of new
4723 solar power. Because solar is more effective in the summer, it takes slightly less solar power for
4724 a limited or no coal scenario for the Preferred Alternative with a larger summer LOLP than for
4725 the No Action Alternative with a larger winter LOLP.

4726

4727 **Table 7-30. Coal Capacity Assumptions Zero-Carbon Replacement Resources**

Alternative	Base Case Coal Capacity Assumption in EIS (4,246 MW)			More Limited Coal Capacity (1,741 MW)			No Coal Capacity (0 MW)		
	Pre-Resource Build LOLP	Zero-Carbon Resource Build (MW)	Change from No Action (MW)	Pre-Resource Build LOLP	Zero-Carbon Resource Build (MW)	Incremental Resource Build for Preferred Alternative as Impacted by Additional Coal Retirements (MW)	Pre-Resource Build LOLP	Zero-Carbon Resource Build (MW)	Incremental Resource Build for Preferred Alternative as Impacted by Additional Coal Retirements (MW)
No Action	6.6%	0	0	27%	8,800	N/A	63%	28,000	N/A
Draft Proposed Action	6.5%	0	0	24%	8,600	0	59%	27,000	0

4728 Note: The replacement resources for the No Action Alternative include demand-response, wind, and solar.

4729 **EFFECTS ON TRANSMISSION FLOWS, CONGESTION, AND THE NEED FOR INFRASTRUCTURE**

4730 **Bonneville interconnections**

4731 Under the Preferred Alternative, no new transmission interconnections or reinforcements
4732 would be required.

4733 **Bonneville transmission reliability and operations**

4734 Under the Preferred Alternative, Bonneville would continue to meet its transmission system
4735 reliability requirements. There could be an increase in generation from the Lower Snake and
4736 Lower Columbia projects during the last half of August relative to the No Action Alternative.
4737 This generation would provide additional flexibility that could provide operational benefits for
4738 the transmission system. As a result, no additional reinforcements have been identified beyond
4739 those that are a part of Bonneville's regular system assessments.

4740 **Regional transmission system congestion effects**

4741 Under any runoff condition, small changes in the number of congestion hours relative to the No
4742 Action Alternative would occur on the majority of north to south paths. The Pacific DC Intertie
4743 (PDCI) and the South of Custer interfaces would experience increases of 40 and 38 hours
4744 relative to the No Action Alternative under low runoff conditions and smaller changes under
4745 other runoff conditions. Other north to south paths would see changes of 30 congestion hours
4746 or less.

4747 In high runoff conditions, some west to east paths would experience a higher number of
4748 congested hours as additional hydro generation is exported. The largest increases would be on
4749 the Hemingway to Summer Lake⁹ path (61 hours) and the Idaho to Northwest path (52 hours).
4750 Under median runoff there would be a reduction of approximately 54 congestion hours relative
4751 to the No Action Alternative for the Hemingway to Summer Lake path and about 107
4752 congestion hours for the Idaho to Northwest path. See Appendix H, *Power and Transmission*,
4753 for more detailed congestion graphs.

4754 Changes in the patterns of CRS generation under the Preferred Alternative would have a minor
4755 impact on congestion for Pacific Northwest transmission paths.

⁹ The Hemingway – Summer Lake transmission line component of both the Hemingway – Summer Lake and Idaho to Northwest transmission paths.

4756 **CHANGES IN ELECTRICITY RATES**

4757 **Bonneville Wholesale Power Rates**

4758 ***Overview***

4759 This section describes the effects of the Preferred Alternative on Bonneville’s wholesale power
4760 rate pressure. The methodology used in this section is the same methodology used to evaluate
4761 the wholesale power rate effects of the MOs, which is described in detail in Chapter 3.7.3.1 of
4762 this DEIS. In summary, the power rate pressure effects analysis for the Preferred Alternative is
4763 comprised of four components: (1) a Base Case Analysis; (2) a Rate Sensitivity Analysis; (3) a
4764 summary of the total effects on Bonneville wholesale power rate pressures of the Preferred
4765 Alternative (i.e., Base Case Analysis plus Rate Sensitivity Analysis); and (4) an Other Regional
4766 Cost Pressure analysis. A table identifying each element of this analysis is provided below
4767 followed by a brief description of each component in Table 7-31.

4768 To the extent that the Preferred Alternative increases the cost of power generation and
4769 transmission (e.g., if Bonneville or other entities need to acquire new sources of power or
4770 construct transmission infrastructure), the increased costs would place upward pressure on
4771 wholesale and retail electricity rates. The term “upward rate pressure” indicates the potential
4772 for increases in rates resulting from the added costs of generating and transmitting power;
4773 upward rate pressure could lead to increased rates absent the ability of Bonneville or other
4774 entities to balance out the added costs. Likewise, “downward rate pressure” indicates the
4775 potential for reductions in rates resulting from decreased costs of generating and transmitting
4776 power.

4777 The *Base Case Analysis* estimates the impacts of the Preferred Alternative using information
4778 available at the time of the development of the Base Case. This analysis uses certain
4779 assumptions regarding resource availability, resource costs, demand response, construction
4780 costs, coal plant retirements, carbon policies, and other factors that affected the output of the
4781 resulting power rates analysis. The *Base Case Analysis* represents the “base line” power rate
4782 pressure effect of the Preferred Alternative using the best available information at the time the
4783 analysis was performed.

4784 The *Rate Sensitivity Analysis* builds off of the *Base Case Analysis* by updating certain
4785 assumptions that have changed (or are likely to change) and adding new considerations that
4786 have arisen since the original analysis was performed. Many of the assumptions underlying the
4787 *Rate Sensitivity Analysis* were either unknown or speculative at the time the *Base Case Analysis*
4788 was developed. For that reason, these assumptions and considerations were not included in the
4789 *Base Case Analysis*, but instead were appended to the wholesale power rate analysis as a range
4790 of sensitivities. Six specific sensitivities were considered: (1) Fish and Wildlife Costs; (2) Hydro
4791 Flexibility; (3) Resource Financing; (4) Construction Contingencies (Cost Uncertainties); (5)
4792 Demand Response; and (6) Oversupply. An in-depth description of each of these sensitivities is
4793 provided in Chapter 3.7.3.1, under the heading “Rate Sensitivity Analysis.”

4794 **Table 7-31. Change in Bonneville's Priority Firm Tier 1 Rate, Bonneville Finances**

Change in Bonneville's Priority Firm Rate, Bonneville Finances				
	Zero-Carbon Portfolio		Conventional Least-Cost Portfolio	
	\$ rate pressure	change from NAA	\$ rate pressure	change from NAA
Base-Case Analysis (annual cost in \$ millions unless noted otherwise)				
1 Base Rate	Base Case Analysis		\$ /MWh	\$ /MWh
2 Change from NAA due to Costs	\$	%	\$	%
3 Change from NAA due to Load		%		%
4 Total Base Change in Rate		%		%
Rate Sensitivities (annual cost in \$ millions)				
5 Fish and Wildlife Costs	\$ to \$	% to %	\$ to \$	% to %
6 Integration Services	\$ to \$	% to %	\$ to \$	% to %
7 Resource Financing Assumptio	\$ to \$	% to %	\$ to \$	% to %
8 Resource Cost Uncertainties	\$ to \$	% to %	\$ to \$	% to %
9 Demand Response	\$ to \$	% to %	\$ to \$	% to %
10 Oversupply	\$ to \$	% to %	\$ to \$	% to %
11 Total Rate Sensitivities	\$ to \$	% to %	\$ to \$	% to %
12 Total Base Effect + Sensitivities	Base Case + Rate Sensitivity Analysis			% to %
Other Regional Cost Pressure (annual cost in \$ millions)				
	Zero-Carbon Portfolio		Conventional Least-Cost Portfolio	
	\$ pressure	change from NAA	\$ pressure	change from NAA
13 Regional Cost of Carbon Compliance	\$ to \$		\$ to \$	
14 Regional Coal Retirements (capital)	\$ to \$		\$ to \$	
15 Regional Coal Retirements (other)	\$ to \$		\$ to \$	

4795
4796 The *Other Regional Cost Pressure* analysis addresses two additional potential cost impacts that
4797 have been identified but remain speculative and uncertain at this time. These cost impacts
4798 include (1) the potential incremental costs associated with policies to reduce greenhouse gas
4799 emissions that place a direct or indirect price on carbon, and (2) the potential incremental costs
4800 associated with accelerated Coal Retirements (capital and other costs [e.g., market price
4801 effects]). These variables are presented at the end of the wholesale power rates analysis as a
4802 source of additional cost pressures to regional utilities. These costs would not all be directly
4803 assignable to Bonneville's power rates. However, it is possible that in some instances the
4804 regional costs identified in this section could affect Bonneville's cost of power (such as
4805 compliance price on carbon), while in other instances the effect would be indirect (such as
4806 through market price impacts arising from the accelerated retirement of coal).

4807 **Summary of the Preferred Alternative Impacts on Bonneville's Wholesale Power Rate and**
4808 **Other Regional Cost Pressure**

4809 Under the Preferred Alternative, the average wholesale Priority Firm (PF) power rate would
4810 experience upward rate pressure relative to the No Action Alternative. Should the upward rate
4811 pressure lead to rate increases (i.e., if Bonneville or other entities were unable to balance the
4812 additional costs), the average PF power rate would be \$35.47/MWh, which represents an
4813 increase of \$0.90/MWh or a 2.7 percent increase relative to the No Action Alternative in the
4814 base case, without accounting for additional coal plant retirements. Note, the wholesale rate
4815 represents the average rate paid by Bonneville's preference customers as calculated for the

4816 Preferred Alternative using the methodology and assumptions established for this EIS and is a
4817 useful comparison to the calculated rate for the No Action Alternative. It does not represent the
4818 effective rate paid by a particular Bonneville customer¹⁰ and it is not an actual or forecast rate
4819 in Bonneville rate cases.

4820 Summary results for power rate pressures are presented in Table 7-32. The table is the
4821 projected change in the Bonneville Wholesale Power Rate for the base analysis followed by a
4822 discussion of additional changes in costs that could affect the rate.

4823 **Table 7-32. Average Bonneville Wholesale Power Rate (\$/MWh), for the Base Case without**
4824 **Additional Coal Plant Retirements as well as the Rate Pressures Associated with Additional**
4825 **Sensitivity Analysis**

Change in Priority Firm Rate, Preferred Alternative		
	Zero-Carbon Portfolio	
	\$ rate pressure	change from NAA
Base-Case Analysis (annual cost in \$ millions unless noted otherwise)		
1 Base Rate	\$35.47 /MWh	\$0.90 /MWh
2 Change from NAA due to Costs	\$11	0.5%
3 Change from NAA due to Load		2.2%
4 Total Base Change in Rate		2.7%
Rate Sensitivities (annual cost in \$ millions)		
5 Fish and Wildlife Costs	-\$47 to \$0	-2.3% to 0%
6 Integration Services		
7 Resource Financing Assumptions		
8 Resource Cost Uncertainties		
9 Demand Response		
10 Oversupply	-\$1 to \$0	0% to 0%
11 Total Rate Sensitivities	-\$48 to \$0	-2.3% to 0.0%
12 Total Base Effect + Sensitivities	-\$37 to \$11	0.4% to 2.7%
Other Regional Cost Pressure (annual cost in \$ millions)		
	Zero-Carbon Portfolio	
	\$ pressure	change from NAA
13 Regional Cost of Carbon Compliance	\$9 to \$47	
14 Regional Coal Retirements (capital)	\$0 to \$0	
15 Regional Coal Retirements (other)	too uncertain to estimate	

4826 Note: Line 3 represents the effect of Bonneville selling less power through its long-term contracts to its preference
4827 customers. As volume of these sales decrease, Bonneville’s fixed costs (e.g., for energy efficiency or fish and
4828 wildlife) are recovered from a smaller pool of sales, leading to upward pressure on the wholesale rate.
4829

¹⁰ The effective rates paid by each customer are different due to the specifics of a particular customer, such as its load profile and the products and services it purchases from Bonneville.

4830 **Base Case**

4831 The Base Case rates analysis results show upward rate pressure of 2.7 percent relative to the
4832 No Action Alternative (lines 1-3). In this alternative, no replacement resources were needed to
4833 return the region to the No Action Alternative level of reliability (i.e., a Loss of Load Probability
4834 (LOLP) of 6.6 percent).¹¹ Approximately 0.5 percent of the rate pressure occurs because of
4835 expected cost increases of \$11 million per year (2019 dollars) primarily due to higher capital
4836 costs associated with the structural measures described in Section 7.7.21. The remaining 2.2
4837 percent of rate pressure occurs as a result of the loss of firm generation, which reduces the
4838 amount of firm power Bonneville is able to sell to its customers at the Tier 1 System Rate. With
4839 less firm power to sell, Bonneville must collect more of its costs over a smaller pool of firm
4840 power sales, resulting in the 2.2 percent of rate pressure.

4841 **Rate Sensitivity Analysis**

4842 The *Rate Sensitivity* analysis is presented in lines 5 through 11 to provide quantitative estimates
4843 described in the *Additional Rate Sensitivities*, in Chapter 3.7.3.1.

4844 **Fish and Wildlife Cost Sensitivities**

4845 In 2016, the Bonneville Fish and Wildlife Program budget was \$267,000,000, and the LSRCP
4846 budget was \$32,303,000. When these budgets are adjusted to represent 2019 dollars, they
4847 become \$281,536,000 and \$34,062,000, respectively. These values were modeled as part of the
4848 Base Case rate analysis, which is consistent with the approach taken for the No Action
4849 Alternative. However, over the last 3 years, Bonneville has adjusted the Fish and Wildlife
4850 Program budget to \$249 million and the LSRCP budget to \$30.5 million, changes that are
4851 captured within the rate sensitivity analysis. As a result, Bonneville does not anticipate
4852 additional reductions to the Fish and Wildlife Program or LSRCP with the implementation of the
4853 Preferred Alternative at this time.

4854 **Other Sensitivities**

4855 Because no replacement resources were needed to maintain an LOLP of 6.6 percent, no
4856 sensitivities for resource acquisitions were analyzed. Oversupply Management Protocol costs
4857 associated with oversupply events could be \$1 million per year lower due to increased spill and
4858 less generation in the spring.

4859 **Other Regional Cost Pressures**

4860 The *Other Regional Cost Pressures* analysis reflects the potential regional costs associated with
4861 greenhouse gas emission reduction policies that directly or indirectly put a price on carbon and
4862 accelerated coal retirements under the Preferred Alternative. This analysis does not calculate
4863 the potential impacts of these factors on Bonneville's power rates. Rather, this analysis

¹¹ See Chapter 3.7.3.2, where regional power reliability is described as maintaining the current LOLP of 6.6 percent.

4864 estimates the regional impact of the Preferred Alternative (lines 13 and 14), a portion of which
4865 may directly or indirectly affect Bonneville in the future. Effects associated with greenhouse gas
4866 emission reduction laws are not fully known given states are actively developing these policies
4867 in order to reduce greenhouse gas emissions in the electricity sector and across the economy,
4868 e.g., pending current legislation in Oregon and the currently in-progress rulemaking for
4869 Washington's Clean Energy Transformation Act (a 100 percent carbon-free standard) as
4870 discussed in the Additional Rate Sensitivities section in Chapter 3.7.3.1.

4871 Recent trends in state legislation and policies are directed at decarbonizing the electric grid,
4872 suggesting that in the future there may be a price associated with most or all fossil fuel
4873 generation located or serving load in the Pacific Northwest. The Preferred Alternative reduces
4874 the amount of hydropower production in the region as compared to the No Action Alternative,
4875 which in turn could affect compliance costs for utilities, and ultimately ratepayers, under
4876 policies that mandate a price on greenhouse gas emissions. Applying the same methodology as
4877 applied in Chapter 3.7.3.1, this analysis estimates that, in 2030, the reductions in hydropower
4878 generation in the Preferred Alternative would increase the cost of compliance with greenhouse
4879 gas emission reduction policies in the Pacific Northwest between \$9 and \$47 million per year.

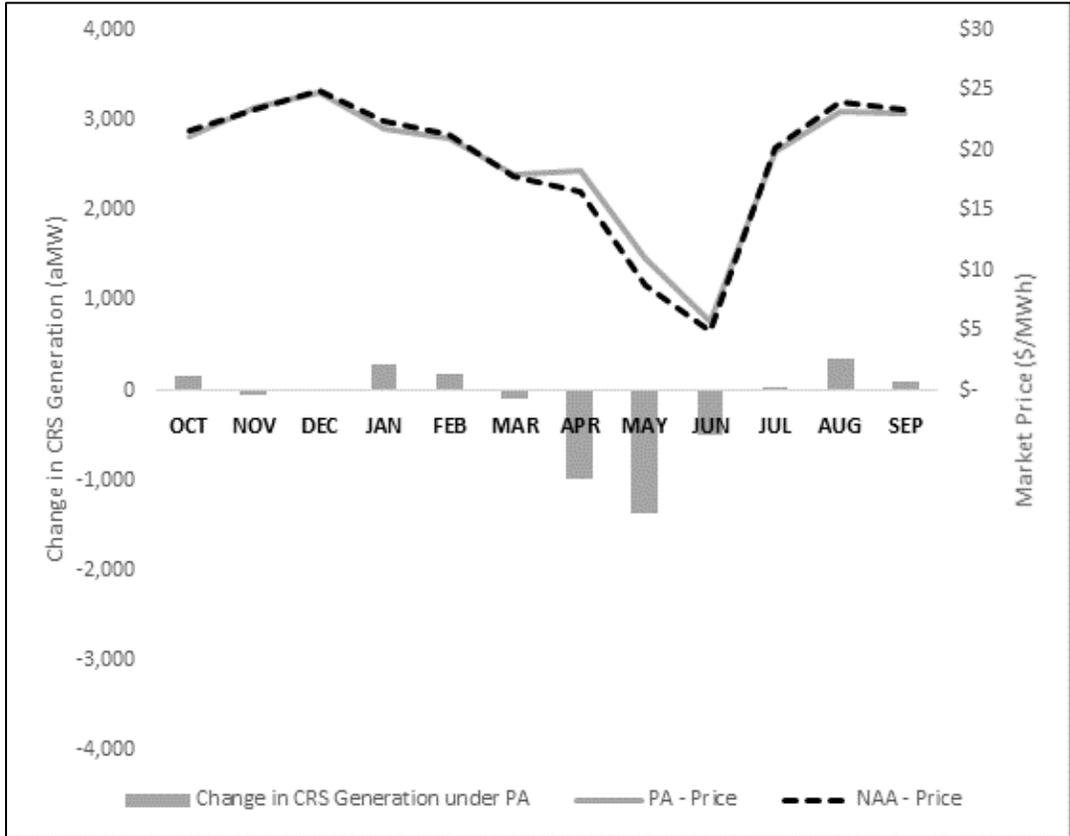
4880 As described in Sections 3.7.3.1 ("Availability of Coal Resources"), and in 3.7.3.2 ("Effects on
4881 Power System Reliability"), regional utilities would need to add 8,800 MW of additional zero
4882 carbon resources in the limited coal capacity scenario and 28,000 MW of additional zero carbon
4883 resources in the no coal scenario to maintain regional LOLP at the No Action Alternative levels
4884 (6.6 percent). The Preferred Alternative has a similar or slightly lower (better) LOLP than the No
4885 Action Alternative, so no additional resources are needed for the Preferred Alternative in these
4886 scenarios besides the resources needed for the No Action Alternative.

4887 For the limited coal capacity scenario under the PA, a minimum of 8,600 MW of zero-carbon
4888 resources would need to be added by the region to maintain regional LOLP at the No Action
4889 Alternative level of 6.6 percent before the coal-plant retirements. For the no coal scenario
4890 under the PA, a minimum of 27,000 MW of zero-carbon resources would be needed to
4891 maintain regional LOLP to the No Action Alternative levels before the coal-plant retirements.
4892 Because both of these starting values are below the No Action Alternative's 8,800 MW (for
4893 limited coal) and 28,000 MW (for no coal), no incremental zero-carbon resource costs would be
4894 incurred as a result of the PA under either a limited or no coal scenario.

4895 **Market Prices**

4896 The average market price for power in the Pacific Northwest (mid-Columbia trading hub) would
4897 be expected to increase under the Preferred Alternative to \$19.27/MWh. This represents an
4898 increase of \$0.19/MWh or 1.0 percent relative to the No Action Alternative. The decrease in
4899 hydropower generation decreases the amount of power sold into and/or increases amount of
4900 power purchased from the market relative to the No Action Alternative, leading to increases in
4901 the market price. Figure 7-21 presents the CRS projects' generation and the market prices
4902 under the Preferred Alternative for the average of the 80 historical water years. Prices would
4903 peak in August and December when demand is relatively high compared to generation, but

4904 would be slightly lower under the Preferred Alternative due to a slight increase in hydropower
4905 generation compared to the No Action Alternative., Conversely, prices would be lowest in June
4906 when generation exceeds 10,000 aMW, but would be increase in April through June under the
4907 Preferred Alternative. The spring price increase results from decreased generation resulting
4908 primarily from increased spill.



4909
4910 **Figure 7-21. Market Prices and Average CRS Hydropower Generation under the Preferred**
4911 **Alternative for the Base Case without Additional Coal Plant Retirements**
4912 Note: The right hand axis is the market price (\$/MWh). The left hand axis is generation from the CRS projects by
4913 month (aMW).

4914 ***Transmission Rate Pressure***

4915 Under the Preferred Alternative, there would be no changes in capital investments or long-term
4916 transmission sales. Upward transmission rate pressure would be about 0.09 percent annually
4917 (0.7 percent cumulatively over an 8-year period) relative to the No Action Alternative because
4918 transmission short-term sales would likely decrease as a result of the changes in hydropower
4919 generation and associated market pricing. For specific customers and product choices, the
4920 annualized upward rate pressure would range from 0.04 percent to 0.18 percent relative to the
4921 No Action Alternative.

4922 ***Retail Rate Effects***

4923 Under the Preferred Alternative, retail electricity rates (paid to individual utilities) would be
4924 similar to the No Action Alternative. Most counties would experience slight upward rate

4925 pressure on the electricity retail rate. Should the upward rate pressure lead to increases in
4926 rates, across the Pacific Northwest, residential retail rates could range from an increase of less
4927 than 0.01 cents/kWh to an increase of 0.10 cents/kWh (in percentage terms this represents an
4928 increase of less than 0.1 percent to an increase of 1.1 percent). For commercial end users, rate
4929 pressure effects could lead to an increase in rates of less than 0.01 cents/kWh to an increase of
4930 0.10 cents/kWh (an increase of 0.0057 percent to an increase of 1.3 percent), and for industrial
4931 customers, from an increase of less than 0.01 cents/kWh to an increase of 0.10 cents/kWh (an
4932 increase of less than 0.01percent to an increase of 1.9 percent). The rate pressure effects would
4933 be larger for customers of utilities that receive power from Bonneville and smaller for
4934 customers whose electricity is not supplied by Bonneville.

4935 **Bonneville Financial Analysis**

4936 The purpose of the financial analysis is to enable comparisons between alternative investment
4937 opportunities. The financial analysis quantifies the expected stream of cash inflows and outflows
4938 over time and then discounts those cash flows over time to produce a single net present value
4939 (NPV) representing how much an investment is worth at a specific point in time. Discounting
4940 accounts for the time-value of money; a dollar received today is worth more than a dollar
4941 received in 10 years. Present value calculations are therefore sensitive to the discount rate used.

4942 For the Preferred Alternative, the NPV of the cash flow effects are described in Table 7-33
4943 below. This NPV analysis is Bonneville specific and does not capture wider societal impacts. This
4944 Bonneville NPV analysis uses a risk-adjusted discount rate of 7.9 percent and a 30-year
4945 timeframe.¹² The financial analysis includes only those cash flows that differ between the
4946 Preferred Alternative and the No Action Alternative. Ultimately, these cash flows determine
4947 revenue requirements and lead to changes in power and transmission rate pressures.

4948 The sensitivities in this analysis are described in the Power Rates section, above.

4949 **Table 7-33. Bonneville Financial Analysis Results Incremental Compared to No Action**
4950 **Alternative**

Type	Preferred Alternative (Millions of 2019 dollars)
Power	(\$290)
Transmission	(\$4)
Total Base Impact – Bonneville	(\$294)

4951 Notes: Discount Rate: Risk Adjusted rate of 7.9 percent (2019 assumptions), 30-year timeframe
4952 Analysis does not account for the cost uncertainty as risk is captured in the discount rate, rather than the cash
4953 flows

¹² A risk-adjusted discount rate is used for making investment decisions. It includes a risk premium, resulting in a higher discount rate that has the effect of reducing the present values of riskier investments for which the expected return-on-investment is increasingly uncertain over time. [The Bonneville risk-adjusted discount rate of 7.9 percent represents the BPA average cost of debt at 3.9%, then a 4% risk premium adder to account for cost uncertainty over the term of the analysis.](#)

4954 **SOCIAL AND ECONOMIC EFFECTS OF CHANGES IN POWER AND TRANSMISSION**

4955 **Social Welfare Effects**

4956 From an economic perspective, the conceptual basis for measuring economic value is society’s
4957 “willingness-to-pay” (WTP) for a good or service.¹³ Absent data to directly measure WTP, it is
4958 common to estimate WTP based on additional indicators of value, including market prices and
4959 replacement costs. This analysis applies two separate methods to estimate social welfare values
4960 of the changes in power generation and transmission. Both methods are consistent with the
4961 Corps’ guidance for valuing social welfare effects of changes in power, and are presented as
4962 changes relative to the No Action Alternative for the base case (i.e., not accounting for the rate
4963 sensitivities and the additional coal plant retirements).¹⁴

4964 Table 7-34 presents the market value of the decrease in Pacific Northwest hydropower
4965 generation under the Preferred Alternative as compared with the No Action Alternative. Based
4966 on the market price method, the average annual economic effect of the Preferred Alternative is
4967 a \$6.7 million cost. This is based on the 160aMW reduction in regional hydro power priced at
4968 the average monthly market prices, resulting in a net loss compared to the No Action
4969 Alternative.

4970 **Table 7-34. Average Annual Social Welfare Effect of the Preferred Alternative Based on the**
4971 **Market Price of Changes in Pacific Northwest Hydropower Generation**

Change in Generation (aMW)	Change in Generation (MWh)	Average Annual Social Welfare Effect (2019 dollars)
-160	-1,400,000	-\$6,700,000

4972 Note: Estimates are rounded to two significant digits. Negative values in the table represent a net loss in social
4973 welfare.

4974 Table 7-35 evaluates the social welfare effects of the Preferred Alternative based on the
4975 additional costs of providing power to meet demand given the reduction in hydropower
4976 generation. That is, the social welfare effects quantified based on the production cost method
4977 are estimated on the marginal increase in the cost of producing power to maintain power
4978 system reliability. The social welfare effects based on the production cost method reflect the
4979 potential for: increased fuel costs, operations and maintenance costs, start-up costs and carbon
4980 emissions penalties (in California) for fossil fuel-based generation. The change in these variable
4981 costs reflect changes across the entire Western Interconnection. Replacement resources are
4982 not required under the Preferred Alternative and the value of the slightly improved level of
4983 power system reliability is not quantified; the resource portfolio that would be equivalent to

¹³ WTP measures the maximum amount that an individual (or population) would be willing to pay rather than do without a good or service above and beyond what the individual (or population) does pay.

¹⁴ The Corps’ guidance describes the following: “Primary benefit measure for hydropower: Market value of output, or alternative cost of providing equivalent output when market price does not reflect marginal costs.” (Source: U.S. Army Corps of Engineers Institute for Water Resources. June 2009. National Economic Development Procedures Manual.)

4984 the improvement in power system reliability under the Preferred Alternative would likely be
4985 small. Based on this approach, the social welfare effect of the Preferred Alternative is an
4986 average annual cost of \$25 million.¹⁵

4987 **Table 7-35. Average Annual Social Welfare Effect of the Preferred Alternative based on the**
4988 **Increased Cost of Producing Power to Meet Demand**

Production Cost Factor	Average Annual Social Welfare Effect (2019 dollars)
Annualized Fixed Cost of Replacement Resources	\$0
Annualized Fixed Cost of Transmission Infrastructure	\$0
Average Annual Variable Costs	-\$25,000,000
Average Annual Social Welfare Effects	-\$25,000,000

4989 Notes: Estimates are rounded to two significant digits. The negative numbers in this table represent net costs
4990 (positive numbers would reflect net benefits).

4991 **Regional Economic Effects**

4992 Under the Preferred Alternative, the Pacific Northwest would generally experience slight
4993 upward retail electricity rate pressure relative to the No Action Alternative, though effects
4994 range by household and by commercial or industrial business.

4995 **Residential Effects**

4996 A large portion of the counties in the Pacific Northwest would experience slight upward
4997 residential retail rates pressure under the Preferred Alternative. Residential retail rate pressure
4998 under the Preferred Alternative would range from a less than 0.01 percent increase to 1.1
4999 percent increase across the region. In addition, in the scenarios with limited or no coal in the
5000 region, the rate pressure might be slightly lower in the Preferred Alternative relative to the No
5001 Action Alternative due to the benefit to the power system of additional system reliability that
5002 would reduce the need to build new generating capacity.

5003 Both urban areas and rural areas would experience slight upward rate pressure under the
5004 Preferred Alternative (Table 7-36). On average, all CRSO regions experience rate pressure of
5005 less than 0.5 percent, with Regions A and D experiencing the highest average rate pressure as
5006 the utilities serving these areas purchase more power from Bonneville.

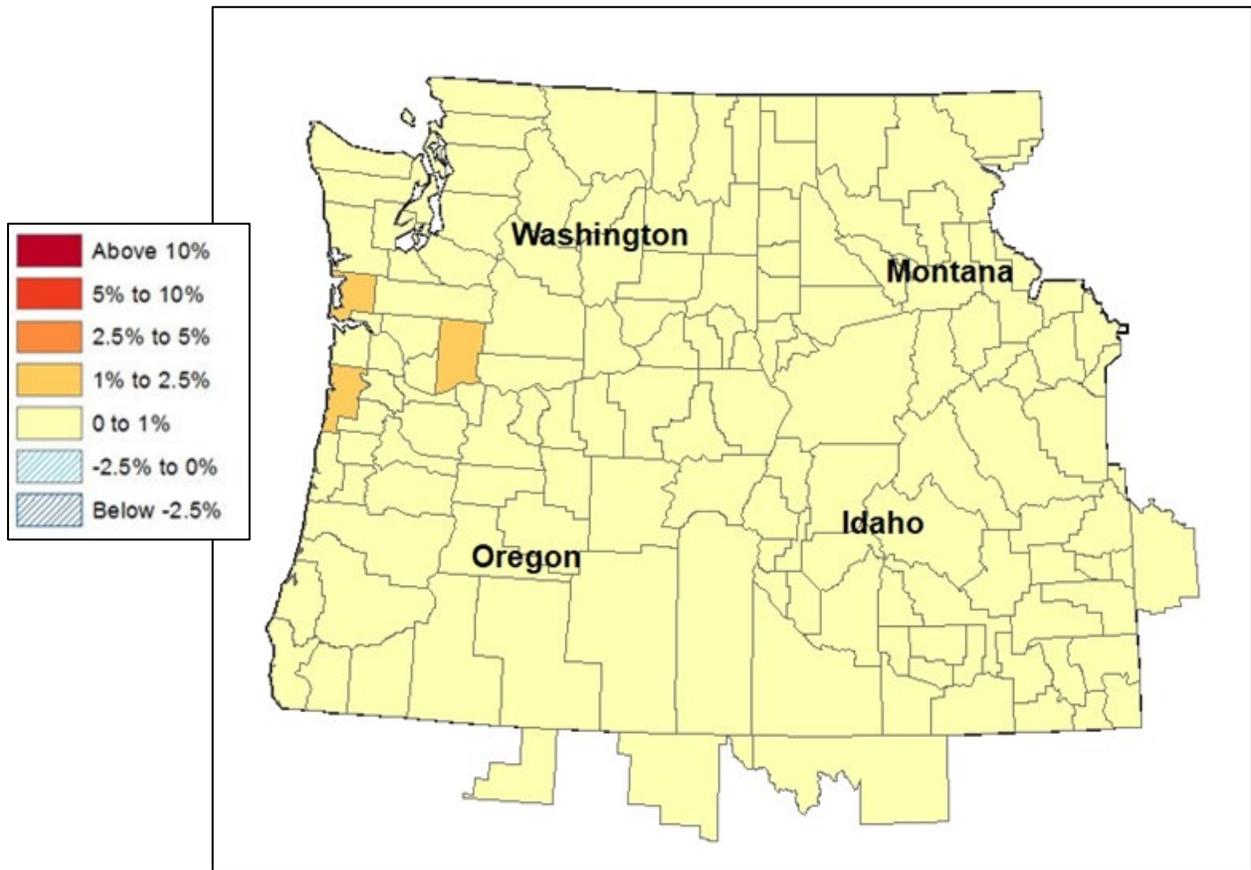
5007 Figure 7-22 maps potential residential retail rate pressure effects by county for the Preferred
5008 Alternative relative to the No Action Alternative. As illustrated in this figure, counties would
5009 generally experience slight upward residential retail rate pressure across the region with three
5010 counties experiencing a larger increase (1.0 to 2.5 percent increases).

¹⁵ Note that this welfare estimate does not consider the benefits of increased power system reliability under the Draft Preferred Alternative.

5011 **Table 7-36. Average Residential Rate Pressure Effects by Columbia River System Operations**
 5012 **Region under the Preferred Alternative**

CRSO Region	Average Residential Rate Pressure Relative to No Action
Region A	0.34%
Region B	0.24%
Region C	0.21%
Region D	0.44%
Other	0.34%

5013 Note: The "Other" region encompasses the counties outside of the four CRSO EIS regions but within the Bonneville
 5014 service area. See Chapter 3.7.1.3 for the definition of the area of analysis as well as the map of the Bonneville
 5015 service area and CRSO regions.



5016 **Figure 7-22. Residential Rate Pressure Effects under the Preferred Alternative Relative to the**
 5017 **No Action Alternative**
 5018

5019 Given rate pressure over time, the upward rate pressures would increase faster under the
 5020 Preferred Alternative relative to the No Action Alternative, stabilizing around an average effect
 5021 of 0.40 percent compared to the No Action Alternative by 2041.

5022 To the extent that the upward rate pressure leads to changes in rates, end users would increase
 5023 spending on electricity (See Table 7-37). Ninety-nine percent of all households in the region
 5024 would pay between zero and 1 percent more for electricity per year. Less than 1 percent of

5025 households would pay between 1 percent and 2.5 percent more for electricity, while the rest of
5026 regional households would pay between zero and 1 percent more for electricity, assuming
5027 these additional costs were passed on directly to end users.

5028 **Table 7-37. Percentage of Residential End Users who may Experience Changes in Electricity**
5029 **Expenditures by Size of Expenditure Change under the Preferred Alternative**

Sector	Change in Household Spending on Electricity	Percent of Households
Residential	>+10%	0%
	+5% to 10%	0%
	+2.5% to 5 %	0%
	+2.5% to 1%	0.66%
	+0% to 1%	99%
	Decrease	0%

5030 Note: Estimates are rounded to two significant digits and may not sum to 100 percent due to rounding.

5031 Given the relatively small upward rate pressure under the Preferred Alternative, the effects on
5032 the demand for electricity would also likely be small. Residential end users could adjust their
5033 consumption based on changes between less than 0.01 percent and 1.1 percent, varying by the
5034 county rate effect. On average, households would experience a less than 1 percent change.

5035 If the upward rate pressure results in increased retail rates for electricity, average annual
5036 household spending on electricity as a percentage of median household income region-wide
5037 could increase very slightly from 1.69 percent under the No Action Alternative to 1.70 percent
5038 under the Preferred Alternative. This equates to a total increase in household spending on
5039 electricity across all Pacific Northwest households of \$19 million per year.

5040 This analysis considers how the region-wide changes in household spending on electricity could
5041 affect demand for other goods and services across the region. That is, increased spending on
5042 electricity may reduce spending on other items, affecting regional economic productivity. This
5043 analysis applies IMPLAN to model the increased spending on electricity as a reduction in
5044 household income (direct effect), and quantifies the multiplier effects on interrelated economic
5045 sectors (indirect and induced effects). This analysis finds that, assuming upward retail rate
5046 pressure reduces regional spending on other goods and services, regional economic impacts
5047 across the Pacific Northwest could be on the order of \$20 million reduction in regional output
5048 (sales) and 130 jobs (Table 7-38).

5049 These estimates are a 1-year snapshot of the potential impacts and do not account for broader
5050 adjustments in regional economic activity that may occur over time that would offset these
5051 impacts. Furthermore, the estimated effects, while likely focused most in Washington and
5052 Oregon, would be distributed over a broad geographic area, including all of Washington,
5053 Oregon, Idaho, and parts of Montana and Nevada. Of note, the impacts presented in Table 7-38
5054 are conservative (i.e., more likely to overestimate than underestimate the regional economic
5055 impacts) given assumptions that the upward rate pressure would increase retail rates, and that
5056 the retail rate effects would in turn affect household spending patterns.

5057 **Table 7-38. Regional Economic Effects from Changes in Household Spending on Electricity**

Effect	Annual Impact of the Preferred Alternative
Output	-\$20 million
Value Added	-\$12 million
Labor Income	-\$6.7 million
Employment	-130 jobs

5058 Note: Negative values in the table represent a net loss in output (sales) and employment for the regional economy

5059 **Commercial and Industrial Effects**

5060 Under the Preferred Alternative, commercial and industrial rates would also experience upward
5061 rate pressure. The average upward rate pressure effects for commercial and industrial end
5062 users would be 0.35 percent and 0.46 percent, respectively. The counties with the largest
5063 number of commercial entities would experience rate pressure effects between a 0.18 percent
5064 and a 1.0 percent commercial rate change.

5065 Table 7-39 presents the fraction of commercial and industrial end users (i.e., businesses) that
5066 would experience upward rate pressure potentially leading to increases in expenditures on
5067 electricity. Under the Preferred Alternative, 98 percent of commercial businesses in the Pacific
5068 Northwest could increase spending on electricity by less than 1 percent. Another 2.1 percent
5069 could increase spending by 1 percent to 2.5 percent.

5070 Additionally, 90 percent of industrial businesses in the Pacific Northwest could increase
5071 spending on electricity by less than 1 percent. Another 10 percent could increase spending by 1
5072 percent to 2.5 percent.

5073 **Table 7-39. Percentage of Commercial and Industrial End Users who Experience Changes in**
5074 **Electricity Expenditures by Size of Expenditure Change under the Preferred Alternative**

Sector	Change in Spending on Electricity	Percentage of Businesses
Commercial	>+10%	0%
	+5% to 10%	0%
	+2.5% to 5%	0%
	+2.5% to 1%	2.1%
	+0% to 1%	98%
	Decrease	0%
Industrial	>+10%	0%
	+5% to 10%	0%
	+2.5% to 5%	0%
	+2.5% to 1%	10%
	+0% to 1%	90%
	Decrease	0%

5075 Note: Estimates are rounded to two significant digits and may not sum to 100 percent due to rounding.

5076 Under the Preferred Alternative, the upward rate pressure across commercial businesses in the
5077 Pacific Northwest could result in increased spending on electricity of \$6.3 million. This analysis
5078 uses the IMPLAN model to quantify the multiplier effects of the change in commercial sector
5079 productivity (Table 7-40). The multiplier effects reflect how the increased costs of doing
5080 business may affect demand for inputs to production across commercial businesses. This
5081 analysis finds that regional economic impacts across the Pacific Northwest could result in the
5082 loss of \$10 million in regional output (sales) and 70 jobs. As described above, the estimated
5083 regional economic impacts reflect conservative assumptions that the increased rate pressure
5084 would increase the cost of electricity to end users, and reduce commercial sector spending on
5085 other regional goods and services. The majority of regional economic effects would occur in
5086 Washington and Oregon.

5087 **Table 7-40. Regional Economic Effects from Changes in Commercial Business Spending on**
5088 **Electricity**

Effect	Annual Impact of the Preferred Alternative
Output	-\$10 million
Value Added	-\$6.5 million
Labor Income	-\$3.3 million
Employment	-70 jobs

5089 Note: Negative values in the table represent a net loss in output (sales) and employment for the regional economy

5090 Under the Preferred Alternative, upward rate pressure across industrial businesses in the
5091 Pacific Northwest could result in increased spending on electricity of \$23 million. Like the
5092 commercial spending analysis, the IMPLAN model is used to quantify the multiplier effects of
5093 the change in industrial sector productivity (Table 7-41). This analysis finds that regional
5094 economic impacts across the Pacific Northwest could result in the loss of \$37 million in regional
5095 output (sales) and 240 jobs. As described above, the estimated regional economic impacts
5096 reflect conservative assumptions that the increased rate pressure would increase the cost of
5097 electricity to end users, and reduce industrial sector spending on other regional goods and
5098 services. The majority of regional economic effects would occur in Washington and Oregon.

5099 **Table 7-41. Regional Economic Effects from Changes in Industrial Business Spending on**
5100 **Electricity**

Effect	Annual Impact of the Preferred Alternative
Output	-\$37 million
Value Added	-\$24 million
Labor Income	-\$12 million
Employment	-240 jobs

5101 Note: Negative values in the table represent a net loss in output (sales) and employment for the regional economy.

5102 **Tribal Interests**

5103 Many tribes in the study area receive electricity through Bonneville. Some have tribal utilities
5104 that get power directly from Bonneville and some are served by public utilities that get power
5105 from Bonneville. Therefore, any upward or downward movement in power rate pressures
5106 would directly affect tribes. The Confederated Tribes of the Colville Reservation (CTCR) and the
5107 Spokane Tribe of Indians (likely starting in 2021) receive annual payments from Bonneville as
5108 compensation for tribal lands inundated by Lake Roosevelt. The payment is based on annual
5109 average generation produced at Grand Coulee Dam as well as the power used to pump water to
5110 Banks Lake for irrigation. Based on the combination of changes in generation (reduced), at
5111 Grand Coulee, and market prices of power, the Preferred Alternative results in upward
5112 payment pressure of about 1 percent relative to the No Action Alternative.

5113 **Other Social Effects**

5114 Under the Preferred Alternative, household spending on electricity would generally increase
5115 slightly. This change would be unlikely to create a burden on household end users and would
5116 not be expected to cause households to reduce electricity consumption due to changes in
5117 electricity bills. The Preferred Alternative would not reduce power system reliability; the slight
5118 increase in power system reliability (i.e., reduction in LOLP) would potentially slightly reduce
5119 the risk of safety concerns related to power outages relative to the No Action Alternative.

5120 **SUMMARY OF POWER AND TRANSMISSION EFFECTS UNDER THE PREFERRED ALTERNATIVE**

5121 Under the Preferred Alternative, hydropower generation would decrease relative to the No
5122 Action Alternative, and the FCRPS would lose 304 aMW of firm power available for long-term
5123 firm power sales (roughly the amount of power consumed by about 250,000 Northwest homes
5124 in a year).

5125 The decrease in hydropower generation across the Pacific Northwest (an average decrease of
5126 160 aMW including Federal and non-Federal projects) results in social welfare costs ranging
5127 between \$6.7 million and \$25 million. These values are estimates of the net economic cost of
5128 the Preferred Alternative from a national societal perspective. In addition, the Preferred
5129 Alternative would result in additional cost of compliance with greenhouse gas emission
5130 reduction programs in the region of between \$9 and \$47 million per year.

5131 Residential, commercial, and industrial end users would experience slight upward retail rate
5132 pressure. In the scenarios with limited or no coal, the rates would likely be lower than the No
5133 Action Alternative. Regional utilities that purchase most or all of their power from Bonneville
5134 would experience larger effects than Investor Owned Utilities (IOUs) or other public utilities
5135 that do not purchase Bonneville power directly.

5136 Assuming the upward rate pressure would slightly increase the costs of living (residential rate
5137 pressure) and doing business (commercial and industrial rate pressure), and reduce regional
5138 spending on other goods and services, combined regional economic impacts across the Pacific

5139 Northwest could result in approximately \$68 million in lost output (sales) and approximately
5140 440 jobs. As previously described, these estimates reflect conservative assumptions about the
5141 likelihood that upward rate pressures would reduce regional spending on other goods and
5142 services across the region. They are a 1-year snapshot of the potential impacts and do not
5143 account for broader adjustments in regional economic activity that may occur over time that
5144 would offset these impacts. Furthermore, the estimated effects, while focused in Washington
5145 and Oregon, would be distributed over a broad geographic area, including all of Washington,
5146 Oregon, Idaho, and parts of Montana and Nevada (Table 7-42).

5147 **Table 7-42. Summary of Effects under the Preferred Alternative Without Additional Coal Plant**
5148 **Closures**

Effect	No Action Alternative ^{/1}	Effects of the Preferred Alternative Relative to No Action
CRSO Hydropower Generation (aMW)	8,300	-160
Firm power of FCRPS (aMW)	7,100	-300
LOLP	6.6%	-0.1 LOLP %
Replacement Resources to return LOLP to No Action Alternative level	—/1	— ²
Replacement Resource Cost to return LOLP to No Action Alternative level (annual cost)	—/1	— ³
Transmission Infrastructure to return LOLP and/or transmission system reliability to No Action Alternative level (annualized reinforcement and/or interconnection cost)	—/1	— ³
Average Bonneville wholesale power rate pressure (base analysis)	\$34.56 —/1	+2.7% \$35.49
Potential Bonneville wholesale power rate (\$/MWh)		0.4% to 2.7%
Potential range of Bonneville wholesale power rate including rate sensitivities		
Annualized Transmission Rate Pressure relative to No Action Alternative (%)	—/1	+0.087%
Average Annual Social Welfare Effects (\$): Market Price Method Estimate	—/1	-\$6.7million
Average Annual Social Welfare Effects (\$): Production Cost Method Estimate	—/4	-\$25 million
Average Residential Rate, weighted average and range (cents/kWh)	10.21	+0.33% (less than +0.01% to +1.1%)
Commercial Rate, weighted average and range (cents/kWh)	8.89	+0.36% (less than +0.01% to +1.3%)
Industrial Rate, weighted average and range (cents/kWh)	7.25	+0.47% (less than +0.01% to +1.9%)
Regional Economic Productivity Effects: Change in Output	—/1	-\$68 million/year
Regional Economic Productivity Effects: Change in Employment	—/1	-440 jobs

Effect	No Action Alternative ^{/1}	Effects of the Preferred Alternative Relative to No Action
Share of households experiencing >5% increase in rates relative to No Action Alternative, highest across scenarios	— ^{/1}	0%
Share of businesses with >5% increase in rates relative to No Action Alternative, highest across scenarios	— ^{/1}	0%
Regional Cost of Carbon Compliance	— ^{/1}	+\$9-47 million/year

5149 The estimated LOLP effect and resulting social welfare and rate effects rely on the best available information
5150 regarding planned coal plant retirements as of 2017 when the modeling efforts began for this analysis. Based on
5151 regional energy policy developments and expected coal plant closures as of 2019, Chapter 3.7.3.1 discusses the
5152 sensitivity of the results of the analysis to these revised assumptions.

5153 /1 The analysis of the No Action Alternative for these effect categories provides a baseline against which the action
5154 alternatives are compared. Thus, the No Action Alternative results presented in this table describe the baseline
5155 magnitude of power and transmission values (e.g., for LOLP and rates) and the Preferred Alternative results
5156 describe the change relative to the No Action Alternative. A “—” indicates an effect category that is not relevant
5157 to the No Action Alternative because it only occurs as a result of implementing the action alternatives (e.g., the
5158 need for new generation and transmission infrastructure and associated costs).

5159 /2 Because the Preferred Alternative has essentially the same power supply adequacy and system reliability as the
5160 No Action Alternative, the analysis did not identify a need for replacement resources.

5161 /3 The social welfare value presented is an estimate of the economic value of hydropower generated by the U.S.
5162 System (hydropower projects in the U.S. portion of the Columbia River system [Federal plus non-Federal projects])
5163 under the No Action Alternative.

5164 /4 The production cost method for valuing social welfare effects of the Preferred Alternatives and MOs relies on
5165 information regarding the changes in the fixed and variable costs of the system. Negative values in the table
5166 represent an increase (net cost) in the cost of producing power. These costs are not relevant to the No Action
5167 Alternative.

5168 **7.7.10 Air Quality and Greenhouse Gases**

5169 Consistent with Chapter 3, due to the reduction in hydropower generation, air quality would
5170 most likely be degraded slightly and greenhouse gas emissions would most likely increase by an
5171 estimated 0.54 MT per year (or 0.33 percent) relative to the No Action Alternative across the
5172 Western Interconnection. In the Pacific Northwest region, greenhouse gas emissions would
5173 increase by 0.26 MMT (or 0.70 percent) compared to the No Action Alternative. Other
5174 emissions sources (e.g., navigation, construction, fugitive dust) are most likely to have a
5175 negligible effect on air quality and greenhouse gas emissions relative to the No Action
5176 Alternative across the basin. Effects to air quality are expected to be negligible across the basin
5177 including any potential impacts to non-attainment or maintenance areas. Most effects related
5178 to construction activities at the projects are expected to be temporary and short-term.

5179 **7.7.11 Flood Risk Management**

5180 This section describes changes in flood risk that would be anticipated under the Preferred
5181 Alternative, as measured in terms of changes in Annual Exceedance Probability (AEP). A

5182 discussion of the methodology employed to evaluate flood risk is provided in Section 3.9.4.1. A
5183 more detailed presentation of quantitative results for alternatives including the Preferred
5184 Alternative are provided in Appendix K.

5185 **7.7.11.1 Region A – Libby, Hungry Horse, and Albeni Falls Dams**

5186 There is little change anticipated to AEP in Region A under the Preferred Alternative. As
5187 discussed in Section 3.9, AEP is a measurement of the likelihood that established flood risk
5188 thresholds would be exceeded. In Region A, flow conditions measured at some locations,
5189 indicate flood risk is anticipated to decrease (refer to Table 6 in Appendix K, Flood Risk
5190 Management).

5191 No effect is anticipated to flood risk in the Kootenai River reach within Region A under the
5192 Preferred Alternative. Under typical to lower annual peak flow conditions, flood risk is
5193 anticipated to decrease in probability under this alternative. In particular, the probability of
5194 flooding at Bonners Ferry, Idaho, is anticipated to decrease by 6 percent under the Preferred
5195 Alternative at the action stage. This is due to a combination of operational measures at Libby
5196 Dam including the *Modified Draft at Libby* measure that would result in deeper drafts earlier in
5197 the spring. There are negligible changes to the probability of higher flood stage at the Bonners
5198 Ferry gage that would result in no effect to flood risk conditions. Likewise, since the Canadian
5199 border is downstream of Bonners Ferry no effect to Canada is expected under the Preferred
5200 Alternative.

5201 No change in flood risk is anticipated to occur on the Flathead River below Hungry Horse Dam.
5202 No change in flood risk is anticipated to occur at the Clark Fork reach near Plains, Montana.

5203 **7.7.11.2 Region B – Grand Coulee and Chief Joseph Dams**

5204 No changes to flood risk are anticipated in Region B under the Preferred Alternative.

5205 **7.7.11.3 Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice**
5206 **Harbor Dams**

5207 No changes to flood risk are anticipated in Region C under the Preferred Alternative.

5208 **7.7.11.4 Region D – McNary, John Day, The Dalles, and Bonneville Dams**

5209 No changes to flood risk are anticipated in Region D under the Preferred Alternative.

5210 **7.7.11.5 Summary of Effects**

5211 No increase in flood risk is anticipated under the Preferred Alternative. As described above,
5212 Region A could experience a slight decrease in flood risk, particularly in areas around Bonners
5213 Ferry, Idaho. But in general, the measures and system operations included under the Preferred
5214 Alternative meet the overall goal of not increasing flood risk associated with the system.

5215 **7.7.12 Navigation and Transportation**

5216 In Region A, there would likely be no effects to navigation from reservoir elevation changes. In
5217 Region B, the effects to the operation of the Inchelium-Gifford Ferry resulted in minor effects
5218 due to the *Planned Draft Rate at Grand Coulee* measure and would be addressed by extending
5219 the boat ramp for the Inchelium-Gifford Ferry in Lake Roosevelt. Ferry operations on Lake
5220 Roosevelt could be affected under the Preferred Alternative due to anticipated drawdowns in
5221 wet years, the wettest 20 percent of years as measured at The Dalles. In the median wet years,
5222 when Lake Roosevelt's draw down for flood risk management begins sooner than for No Action
5223 Alternative, the Inchelium-Gifford Ferry on Lake Roosevelt would not be able to operate for
5224 approximately 31 days in the year, which is four additional days than would have been
5225 anticipated under the No Action Alternative at this location. Effects would primarily occur on
5226 the Confederated Tribes of the Colville Reservation. Other operational measures within the
5227 Preferred Alternative may have notable effects on water levels and flow in upstream regions,
5228 but these flow changes are increasingly attenuated as they reach the mainstem Columbia River.

5229 The planned structural measures under the Preferred Alternative are unlikely to have
5230 measurable impacts to commercial navigation or cruise lines in the Columbia-Snake Navigation
5231 System (CSNS) because they do not affect flow or elevation of water. Some of the operational
5232 measures have the potential to affect operations on the CSNS. In particular, *Summer Spill Stop*
5233 *Trigger*, *Modified Dworshak Summer Draft*, and *Planned Draft Rate at Grand Coulee* measures
5234 may alter reservoir levels or the quantity or the timing of the flows in the Snake River and lower
5235 Columbia River (or both) and have the potential to impact how vessels move on the CSNS. It is
5236 expected that higher spill and variable timing of the spill over the course of a day due to the
5237 *Juvenile Fish Passage Spill* measure could result in changes to the tailraces at Lower
5238 Monumental and Lower Granite projects. The Corps would monitor the tailrace at each project
5239 to track changes that could affect safe navigation. If changes to the tailrace warrant action,
5240 coffer cells to dissipate energy may be constructed in the tailrace at either of the projects.

5241 **7.7.12.1 Social Welfare Effects**

5242 **COMMERCIAL NAVIGATION AND TRANSPORTATION SYSTEMS**

5243 The hydrology & hydraulics data used as input into the SCENT model, as presented in
5244 Table 7-43, show that the Preferred Alternative could result in approximately a 1 day per year
5245 decrease in navigable days under low flow conditions when compared to the No Action
5246 Alternative, and approximately a 1-day increase in navigable days during normal flow
5247 conditions. In all other flow conditions there would be negligible or no effect compared to the
5248 No Action Alternative.

5249 Table 7-44 presents anticipated changes in average annual operating costs that would occur
5250 under the Preferred Alternative as a result of flow changes. Costs of operations under normal
5251 flow range categories would not be affected under the Preferred Alternative.

5252 **Table 7-43. Changes in Average Commercial Navigation Flow Days Under the Preferred**
5253 **Alternative Relative to No Action Alternative, over 50 years**

River Segment	Number of Days Under Various Flow Condition (Days Per Year)					Number of Days Experiencing Draft Restriction (Days Per Year)					
	Low	Normal	High	Very High	Too High	37 ft	38 ft	39 ft	40 ft	41 ft	42 ft
Shallow ¹⁶	-1.2	1.2	–	<0.1	–	–	–	–	–	–	–
Deep Draft	-1.2	1.2	<-0.1	–	–	–	–	–	–<0.1	–	< -0.1

5254 Source: SCENT modeling

5255 The average annual extra transportation costs for transportation in the Deep Draft segment are
5256 estimated to be \$93,000 less under the Preferred Alternative than under the No Action
5257 Alternative. The reason for the minor decrease in costs is that there would be slightly fewer
5258 days of low flow under this alternative related to the *John Day Full Pool* measure. The average
5259 annual change in transportation costs under the Preferred Alternative in the Columbia-Snake
5260 Shallow segment is estimated to be \$4,000 higher than the No Action Alternative due to the
5261 *Slightly Deeper Draft for Hydropower (Dworshak)*. In the spring in the Deep draft the slight
5262 increase in cost would occur from a combination of upstream measures, primarily at Grand
5263 Coulee and Libby Dams. As shown in Table 7-44, the total decrease in average annual costs to
5264 commercial navigation operations would be approximately \$93,000.

¹⁶ The Columbia-Snake Shallow category refers to traffic that traveled on both the Columbia and Snake Rivers while the Columbia Shallow presents the impact to traffic only traveling on the Columbia River.

5265 **Table 7-44. Changes in Average Annual Costs of Commercial Navigation Operations Under the Preferred Alternative Relative to**
5266 **No Action Alternative (2019 dollars), over 50 years**

River Segment	Change in Costs Associated with Flow Range Categories				Changes in Costs Associated with Draft Restrictions						
	Low	High	Very High	Too High	37 ft	38 ft	39 ft	40 ft	41 ft	42 ft	Total
Columbia-Snake Shallow	–	\$1,000	\$1,000	\$1,000	–	–	–	–	–	–	\$4,000
Columbia Shallow	–	-\$1,000	\$1,000	\$1,000	–	–	–	–	–	–	–
Deep Draft	-\$118,000	-\$1,000	\$4,000	\$14,000	\$1,000	-\$2,000	\$1,000	\$1,000	\$3,000	–	-\$97,000
Total	-\$118,000	-\$1,000	\$6,000	\$16,000	\$1,000	-\$2,000	\$1,000	\$1,000	\$3,000	–	-\$93,000

5267 Note: These effects are all within one standard deviation of the No Action Alternative conditions. Costs of operations under normal flow range categories are
5268 not anticipated to be affected under any alternatives and are therefore excluded from the table. Numbers may not sum due to rounding.
5269 Source: SCENT modeling.

5270 **7.7.13 Recreation**

5271 The environmental consequences analysis for recreation evaluates how changes in reservoir,
5272 river, and habitat conditions under the MOs and the Preferred Alternative could affect
5273 visitation, recreational opportunities, and the value of the recreation experience. The Preferred
5274 Alternative includes operational changes to Libby, Hungry Horse, Grand Coulee, Dworshak, and
5275 John Day dams. The anticipated changes in reservoir elevations at Lake Koochanusa (Libby Dam),
5276 Lake Roosevelt (Grand Coulee Dam), and Dworshak Reservoir (Dworshak Dam) could affect
5277 boat ramp accessibility for some periods of time during the year, and hence, access and
5278 visitation for some water-based visitors. Water quality and fishing conditions within reservoirs,
5279 as well as in some stream reaches below reservoirs, may also be affected under the Preferred
5280 Alternative. The effects of the Preferred Alternative on recreation are described for each
5281 region.

5282 **7.7.13.1 Social Welfare Effects**

5283 The focus of effects on water-based visitation in this section is described as annual effects that
5284 would occur after implementation of the Preferred Alternative. Over time, visitors may adjust
5285 their behavior to adapt to changes in accessibility and site quality, such as utilizing different
5286 sites on the system. These long-term adaptations could reduce effects on recreation.

5287 **REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

5288 Under the Preferred Alternative, measures impacting recreation in Region A include the *Sliding*
5289 *Scale at Libby and Hungry Horse* and *Modified Draft at Libby* measures. Because no structural
5290 measures are planned for Region A under the Preferred Alternative, the effect on recreation is
5291 directly tied to changes in water elevations and flows related to operational changes. These
5292 changes in recreational visitation would be negligible compared to the No Action Alternative.
5293 However, as noted above, recreationists may adjust their behavior over time, which could
5294 reduce effects on project visitation.

5295 **Water-based Recreational Visitation**

5296 Anticipated changes in reservoir elevations under the Preferred Alternative would affect boat
5297 ramp accessibility and visitation relative to the No Action Alternative at Lake Koochanusa (Libby
5298 Dam) in Region A for some periods of time in a typical year. Changes in water levels at other
5299 reservoirs in the region would not affect accessibility and visitation. Due to changes in project
5300 outflows, recreational activities occurring in river reaches downstream of Libby Dam could
5301 cause both beneficial effects or adverse localized effects, or both, depending upon the river-
5302 based recreation activity.

5303 At Lake Koochanusa, median reservoir elevations would be higher for most of the year under the
5304 Preferred Alternative relative to the No Action Alternative, but would be lower by 1 to 4.5 feet
5305 in a typical water year from February through June. The reservoir elevations in March through
5306 May under the Preferred Alternative would fall below the minimum usable elevations at some

5307 boat ramps, causing a decrease in boat ramp accessibility at the reservoir relative to the No
5308 Action Alternative. No accessibility effects are expected in February or June. Due to minor
5309 decreases in boat ramp accessibility (e.g., some Lake Kooncanusa boat ramps would remain
5310 usable), water-based recreational visitation is estimated to decrease slightly (by less than 1
5311 percent, or approximately 416 visits). In a high-water year, water-based visitation would not
5312 change relative to the No Action Alternative. In a low-water year, water-based visitation would
5313 decrease slightly (about 1 percent) relative to the No Action Alternative. The change in social
5314 welfare value associated with the change in visitation at Lake Kooncanusa would be negligible,
5315 about \$4,000 in a typical year.

5316 In addition to changes in reservoir elevations, river flows and stages in the region would change
5317 relative to the No Action Alternative. Under the Preferred Alternative, there would be a
5318 decrease of 14 percent in monthly median outflow in May from Libby Dam relative to the No
5319 Action Alternative. This may reduce water turbidity and beneficially affect nearby in-river
5320 recreational fishing activities. Smaller changes in river flows and stages (less than 10 percent)
5321 would occur during peak recreation season at Libby Dam under the Preferred Alternative.
5322 Rafting and paddling activities may be adversely affected. The small changes in the river flows
5323 and reservoir elevations at Hungry Horse Dam are not anticipated to affect recreation at the
5324 reservoir. These changes are not expected to affect downstream reaches including the Pend
5325 Oreille Lake and River.

5326 **Quality of Recreational Experience**

5327 Changes in the quality of recreational experience are anticipated to be negligible in Region A
5328 under the Preferred Alternative. In Region A, as described in Section 7.7.5, *Resident Fish*, effects
5329 to resident fish at Libby are expected to have both minor adverse effects due to higher river
5330 elevations during the winter and minor beneficial effects due to the changes in reservoir
5331 elevation, downstream water temperatures, and restoration of native riparian vegetation.
5332 Effects at Hungry Horse are expected to be minor beneficial due to higher reservoir levels in
5333 late summer. None of these changes would likely be noticeable to recreational anglers.

5334 **REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS**

5335 For Region B under the Preferred Alternative, the effect on recreation is directly tied to changes
5336 in reservoir elevations and flows related to operational changes upstream in Region A and in
5337 Region B. These changes in recreational visitation are negligible compared to the No Action
5338 Alternative. However, as noted above, recreationists may adjust their behavior over time,
5339 which could reduce estimated effects on visitation.

5340 **Water-based Recreational Visitation**

5341 Anticipated changes in reservoir elevations under the Preferred Alternative would affect boat
5342 ramp accessibility at Lake Roosevelt in Region B relative to the No Action Alternative. Other
5343 reservoirs in the region would not be affected. Relative to the No Action Alternative,
5344 anticipated reservoir elevations would be the same or higher for the majority of a typical year,

5345 though decreases of 1 to 2 feet would occur in September and October. These changes in
5346 reservoir elevations would result in decreased boat ramp accessibility in September and
5347 October, but increases in accessibility in May and June.

5348 Due to minor changes in monthly boat ramp accessibility (both decreases and increases), water-
5349 based visitation is estimated to increase slightly by less than 0.1 percent (approximately 171
5350 visits) in a typical year. In a high-water year, visitation would increase by less than 1 percent
5351 relative to the No Action Alternative. In a low-water year, visitation would decrease by less than
5352 1 percent relative to the No Action Alternative. Changes in social welfare value associated with
5353 the visitation change in a typical year would be about \$3,000. A negligible effect on water-
5354 based reservoir recreation is expected.

5355 Changes in river flows and stages between dams would be minor (less than 10 percent) relative
5356 to the No Action Alternative, and therefore, would not be expected to affect river recreation.

5357 **Quality of Recreational Experience**

5358 Changes in the quality of recreational experience are anticipated to be negligible in Region B
5359 under the Preferred Alternative, as described in Section 7.7.4, *Anadromous Fish*. These effects
5360 are expected to be negligible due to minor changes in operations. As described in Section 7.7.5,
5361 *Resident Fish*, there would be minor to moderate adverse effects to Kokanee, burbot, and
5362 redband rainbow trout from operations and minor benefits from mitigation. And as described
5363 in the Section 7.7.7, *Vegetation, Wildlife, Wetlands, and Floodplains*, under the Preferred
5364 Alternative in Region B, changes would be minimal. As such, there could be negligible changes
5365 in the recreational experiences for anglers, hunters and wildlife viewers in Region B under the
5366 Preferred Alternative.

5367 **REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE** 5368 **HARBOR DAMS**

5369 Under the Preferred Alternative, operational measures impacting recreation in Region C include
5370 the *Slightly Deeper Draft for Hydropower (Dworshak)* measure. As discussed previously,
5371 recreationists may adjust their behavior over time, which would reduce effects on visitation.

5372 Structural measures impacting recreation in Region C include the *Additional Powerhouse*
5373 *Surface Passage, Upgrade to Adjustable Spillway Weirs, Lower Granite Trap Modifications*, and
5374 *Lower Snake Ladder Pumps* measures. The structural measures could have localized, short-term
5375 effects to recreation during the anticipated 2-year period when construction occurs in
5376 proximity to the recreation sites close to dams. Effects could include disruption at project sites,
5377 noise, potential traffic congestion, and access limitations during the construction period.

5378 **Water-Based Recreational Visitation**

5379 Anticipated changes in reservoir elevations under the Preferred Alternative would not affect
5380 boat ramp accessibility in most years at reservoirs in Region C relative to the No Action

5381 Alternative. In years where high run-off is projected (i.e., wet years), there would be decreased
5382 reservoir elevations in January through March that could affect boat ramp accessibility relative
5383 to the No Action Alternative. Water-based visitation would decrease by less than 1 percent at
5384 Dworshak Reservoir relative to the No Action Alternative, or 1,286 visits, during these years
5385 when high run-off is projected. Other reservoirs in the region would not be affected.
5386 Reductions in social welfare associated with the visitation change are anticipated to be about
5387 \$14,000 in these wet years when high run-off is projected.

5388 Changes in river flows and stages between dams would be minor (less than 10 percent) relative
5389 to the No Action Alternative, and therefore, would not be expected to affect river recreation.

5390 **Quality of Recreational Experience**

5391 Changes in the quality of recreational experience are anticipated to be moderate adverse to
5392 major beneficial in Region C under the Preferred Alternative. As described in Section 7.7.4,
5393 *Anadromous Fish*, effects to anadromous fish in Regions C and D have the potential to range
5394 from moderate adverse impact to a major beneficial impact. The range in potential effects are
5395 due to uncertainty and spread between modeled estimates. Resident fish in the lower Snake
5396 River reservoirs would see minor effects under the Preferred Alternative from elevated TDG,
5397 but populations would be similar to the No Action Alternative, as described in Section 7.7.5
5398 *Resident Fish*. These would be minor changes that would not likely be noticeable to most
5399 recreational anglers.

5400 **REGION D – MCNARY, JOHN DAY, THE DALLES, AND BONNEVILLE DAMS**

5401 Under the Preferred Alternative, operational measures impacting recreation in Region D
5402 include the *Increased Forebay Range Flexibility* measure and the *Predator Disruption*
5403 *Operations* measure. Structural measures that could impact recreation in Region D include the
5404 *McNary Turbine Replacement*, *Improved Fish Passage Turbines at John Day*, *Additional*
5405 *Powerhouse Surface Passage*, and *Modify Bonneville Ladder Serpentine Weir* measures. Similar
5406 to Region C, structural measures included for Region D projects could have localized, short-term
5407 effects to recreation during the anticipated 2-year period when construction occurs in
5408 proximity to the recreation sites close to dams. Effects could include disruption at project sites,
5409 noise, potential traffic congestion, and access limitations during the construction period.

5410 **Water-based Recreational Visitation**

5411 Changes in reservoir elevations and river flows are expected to be minor and are not
5412 anticipated to affect recreational access and visitation at recreation sites at the four reservoirs
5413 and river reaches in Region D.

5414 **Quality of Recreational Experience**

5415 Changes in the quality of recreational experience are anticipated to be minor adverse to
5416 moderate beneficial in Region D under the Preferred Alternative. As described in Section 7.7.4,

5417 *Anadromous Fish*, effects to anadromous fish in Region D have the potential to range from
5418 moderate adverse impact to a major beneficial impact. The range in potential effects are due to
5419 uncertainty and spread between modeled estimates. Resident fish in the lower Columbia River
5420 would see minor effects under the Preferred Alternative but populations would be similar to
5421 the No Action Alternative, as described in Section 7.7.5, *Resident Fish*. These would be minor
5422 effects from elevated TDG that would not likely be noticeable to most recreational anglers.

5423 **REGIONAL ECONOMIC EFFECTS**

5424 As a result of changes in boat ramp accessibility in a typical year, recreational expenditures
5425 associated with non-local visitation at Lake Kocanusa in Region A would decrease annually by
5426 \$18,000 under the Preferred Alternative. Recreational expenditures associated with non-local
5427 visitation at Lake Roosevelt in Region B would increase annually by \$7,000 in a typical year
5428 under the Preferred Alternative. No changes to visitation are anticipated in Region C or Region
5429 D in a typical year. The changes in Regions A and B represent less than 0.1 percent of non-local
5430 recreational expenditures in the basin under the No Action Alternative. Overall, the change in
5431 regional expenditures and the regional economic implications of those changes would be
5432 negligible. Over time, visitors would likely adjust their behavior to adapt to the minor
5433 anticipated changes in accessibility, such as utilizing different sites on the system. These long-
5434 term adaptations would reduce effects to visitation.

5435 **OTHER SOCIAL EFFECTS**

5436 Because of the modest anticipated changes to visitation described in the social welfare
5437 evaluation and the moderate adverse impact to a major beneficial impact to fish anticipated
5438 under the Preferred Alternative, other social effects associated with the well-being of
5439 recreationists, particularly those who value recreational fishing, changes are anticipated to
5440 range from no or negligible change to recreation fishing (primarily for resident fishing) to
5441 moderate adverse to major beneficial under the Preferred Alternative.

5442 **SUMMARY OF EFFECTS – PREFERRED ALTERNATIVE**

5443 Table 7-45 presents a summary of the Preferred Alternative effects, including the anticipated
5444 changes in average annual recreational visitation, social welfare, and regional economic effects
5445 by region and in total relative to the No Action Alternative. Across the study area, total
5446 recreational visitation and associated social welfare effects are anticipated to decrease by less
5447 than 0.1 percent annually (approximately 250 visits and \$2,000) in a typical year associated due
5448 to changes in boat ramp access. Expenditures associated with non-local visitation would
5449 decrease by \$12,000 annually across the study area, a change of less than 0.1 percent
5450 compared to the No Action Alternative. Regional economic effects of this change in
5451 expenditures would be negligible. Effects to the quality of hunting, wildlife viewing, swimming,
5452 and water sports at river recreation sites in the study area would be generally negligible under
5453 the Preferred Alternative.

5454 **Table 7-45. Changes in Economic Effects of Recreation Under the Preferred Alternative Relative to the No Action Alternative**

Region	Social Welfare Effects (2019 dollars)	Regional Economic Effects (2019 dollars)	Other Social Effects
Region A	A decrease of approximately 400 water-based recreational visits would occur at Lake Koochanusa (less than 1.0 percent of water-based visitation at the site) in a typical year associated with changes in boat ramp access. In high-water-level years, water-based visitation would not change at Lake Koochanusa and would decrease by about 1.0 percent in low-water-level years. Annual social welfare benefits would decrease by \$4,300 in a typical year. Negligible effects to the quality of recreation experiences would occur.	Expenditures associated with non-local recreational visits would decrease by \$18,000 across the region (less than 0.1 percent) associated with changes in boat ramp access. Regional economic effects of this change in expenditures would be negligible.	Negligible change resulting in no noticeable effect to recreationist well-being when compared to the No Action Alternative.
Region B	An increase of approximately 200 water-based visits at Lake Roosevelt (less than 0.1 percent of water-based visitation at the site) would occur in a typical year. In years with high or low water, visitation would decrease by less than 1.0 percent. Annual social welfare benefits would increase by approximately \$2,600 in a typical year. Negligible effects to the quality of recreation experiences would occur.	Expenditures associated with non-local recreational visits would increase by \$7,000 across the region (less than 0.1 percent) associated with changes in boat ramp access. Regional economic effects of this change in expenditures would be negligible.	Negligible change resulting in no noticeable effect to recreationist well-being when compared to the No Action Alternative.
Region C	No changes in reservoir visitation associated with changes in boat ramp access in a typical year or high-water-level year. A reduction of approximately 1,300 water-based visits at Dworshak Reservoir (less than 1 percent of water-based visitation at the site) would occur in a low-water-level year. Annual social welfare benefits would not change in typical or high-water-level years, but would decrease by about \$14,000 in a low-water-level year. Moderate adverse to major beneficial effects to quality of fishing may occur. Impacts to hunting, wildlife viewing, swimming, and water sports associated with changing river and reservoir conditions are likely to be negligible.	No changes in visitor expenditures or regional effects associated with changes in boat ramp access in most years. Regional effects of potential changes in expenditures during low-water-levels years would be negligible.	No change to visitor well-being associated with access to reservoir-based recreation. Moderate adverse to major beneficial change in recreationist well-being when compared to the No Action Alternative.

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Region	Social Welfare Effects (2019 dollars)	Regional Economic Effects (2019 dollars)	Other Social Effects
Region D	No changes in reservoir visitation associated with changes in boat ramp access. Moderate adverse to major beneficial effects to quality of fishing may occur. Effects to hunting, wildlife viewing, swimming, and water sports associated with changing river and reservoir conditions are likely to be negligible.	No changes in visitor expenditures or regional effects associated with changes in boat ramp access.	No change to visitor well-being associated with access to reservoir-based recreation. Moderate adverse to major beneficial change in recreationist well-being when compared to the No Action Alternative.
Total	Negligible effects to reservoir visitation (reduction of 250 visits, representing less than 0.1 percent of total visitation compared to the No Action Alternative) in a typical year, with decreases in social welfare of approximately \$2,000 annually associated with changes in boat ramp access. Negligible to minor effects in most areas to quality of fishing, hunting, wildlife viewing, swimming, and water sports associated with changing river and reservoir conditions may occur. There is the potential for minor adverse effects to moderate beneficial effects in recreational fishing conditions along in Regions C and D.	Expenditures associated with non-local recreational visits would decrease by \$12,000 across the study area (a change of less than 0.1 percent from No Action) in a typical year associated with changes in boat ramp access. Regional economic effects of this change in expenditures would be negligible.	Recreation would continue to provide other social effects associated with considerable recreational opportunities in the study area. Continued operation of the system would provide benefits to community well-being and identity. Negligible change from No Action in most locations, with the exception of potential moderate beneficial social effects to anglers in Regions C and D.

5455

5456 **7.7.14 Water Supply**

5457 Consistent with Chapter 3, the Preferred Alternative is not expected to change the ability to
5458 deliver existing water supply as compared to the No Action Alternative because the changes in
5459 flow and reservoir elevations are expected to be negligible. In addition, the operation of
5460 withdrawals is timed to minimize impacts to flows. The additional 45 kaf from Lake Roosevelt
5461 proposed for storage in this measure is expected to increase water supply in Region B, but is
5462 not expected to affect other regions.

5463 **7.7.15 Visual**

5464 Effects to visual resources from structural measures for Regions A and B would be negligible
5465 because they would not substantially differ from the No Action Alternative. There would be
5466 minor, short-term visual effects for viewers in the vicinity of projects in Regions C and D
5467 because of increased construction activity from implementing structural measures such as new
5468 fish-passage structures, modifications to fish ladders, and changes to spillway weirs, but these
5469 measures would not contribute to a substantial visual change in the landscape surrounding
5470 those projects. To the extent operational or structural measures affect the viewshed, this can
5471 have unique effects on spiritual practices for tribes. Because operational measures across all
5472 regions would result in minor changes in pool elevation management, carrying out those
5473 measures would have a minor effect on the viewshed and viewers in the vicinity of changes in
5474 duration and timing of reservoir elevations compared to the No Action Alternative.

5475 **7.7.16 Noise**

5476 Sound levels in the vicinity of the projects throughout all regions would be similar to the No
5477 Action Alternative with the exception of temporary increases in sound levels from the
5478 construction of structural measures at projects in Regions A, C and D, which would result in
5479 minor, short-term construction-related noise effects. In all regions, there would be negligible
5480 noise effects from those changes compared to the No Action Alternative because the seasonal
5481 timing or duration of spill levels would change under the operational measures.

5482 **7.7.17 Fisheries and Passive Use**

5483 The effects from the Preferred Alternative on anadromous fish are expected to be negligible in
5484 Region B downstream of Chief Joseph Dam, but have the potential to range from moderate
5485 adverse effects to major beneficial effects in Regions C and D (direction and magnitude of
5486 effects is dependent upon the model used and the relevant ESU/DPS). To the extent that
5487 increases or decreases in fish abundance occur as a result, this could result in a minor decrease
5488 to a potentially major increase in opportunities for commercial and ceremonial and subsistence
5489 fishing for anadromous species, such as salmon and steelhead throughout the Columbia River
5490 Basin.

5491 The effects for resident fish range from moderate adverse to moderate beneficial. These effects
5492 could result in abundance changes, which could affect resident ceremonial and subsistence
5493 fisheries depending on the region and species.

5494 **7.7.18 Cultural Resources**

5495 Cultural resources were evaluated for effects to four categories: archaeological resources,
5496 traditional cultural properties, the built environment, and sacred sites. Consistent with Chapter
5497 3, sacred sites were identified after discussions with the tribes and based on these discussions,
5498 evaluated at Albeni Falls and Grand Coulee.

5499 The following discussion focuses primarily on the differences between the storage reservoirs
5500 and the run-of-river projects, as opposed to a region-by-region organization.

5501 **7.7.18.1 Archaeological Resources**

5502 **EXPOSURE**

5503 Table 7-46 shows the number of acre-days that archaeological resources would be exposed if
5504 the Preferred Alternative was selected. Exposure amounts for the other alternatives are also
5505 provided to facilitate comparison. Table 7-47 expresses the differences as a percentage relative
5506 to the No Action Alternative. For example, if there was an increase in the amount of
5507 archaeological resource exposure under the Preferred Alternative at a reservoir, this is
5508 indicated as a positive percentage. If there is a reduction in the amount of exposure, this is
5509 shown as a negative percentage. The methodology behind this analysis is provided in Section
5510 3.16.

5511 **Table 7-46. Effects to Archaeological Resources – Acre-Day Calculations by Reservoir and**
5512 **Alternative**

Reservoir	No Action Alternative	MO1	MO2	MO3	MO4	Preferred Alternative
John Day	135,000	132,000	135,000	135,000	166,000	135,000
Lower Granite	26,000	26,000	26,000	265,000	27,000	24,000
Dworshak	112,000	112,000	127,000	111,000	111,000	113,000
Grand Coulee	315,000	348,000	355,000	314,000	463,000	316,000
Albeni Falls	141,000	141,000	142,000	141,000	152,000	141,000
Libby	16,000	16,000	18,000	18,000	16,000	17,000
Hungry Horse	38,000	44,000	40,000	45,000	47,000	37,000

5513 Note: Values have been rounded to the nearest thousand.

5514 **Table 7-47. Effects to Archaeological Resources – Increases or Decreases in Exposure of**
5515 **Archaeological Resources by Reservoir and Multiple Objective Alternatives**

Reservoir	No Action Alternative	MO1	MO2	MO3	MO4	Preferred Alternative
John Day	0% ^{1/}	-3% ^{1/}	0% ^{1/}	0% ^{1/}	23% ^{3/}	-18% ^{4/}
Lower Granite	0% ^{1/}	0% ^{1/}	0% ^{1/}	915% ^{3/}	4% ^{1/}	-7% ^{4/}
Dworshak	0% ^{1/}	0% ^{1/}	13% ^{3/}	-1% ^{1/}	-1% ^{1/}	1% ^{1/}
Grand Coulee	0% ^{1/}	10% ^{3/}	13% ^{3/}	0% ^{1/}	47% ^{3/}	0% ^{1/}
Albeni Falls	0% ^{1/}	0% ^{1/}	0% ^{1/}	0% ^{1/}	7% ^{2/}	0% ^{1/}
Libby	0% ^{1/}	-1% ^{1/}	8% ^{2/}	8% ^{2/}	-2% ^{1/}	4% ^{1/}
Hungry Horse	0% ^{1/}	17% ^{3/}	6% ^{2/}	18% ^{3/}	23% ^{3/}	-3% ^{1/}

5516 Note: Values have been rounded to the nearest whole percent. A positive value indicates an increase in exposure
5517 (an adverse effect), while a negative value indicates a decrease in exposure (a beneficial effect).

5518 1/ Percentage change indicates a ±5% change in the amount of exposure and is considered negligible.

5519 2/ Percentage change indicates an increase in amount of exposure between 5% and 10% and is a moderate
5520 adverse effect.

5521 3/ Percentage change indicates an increase in the amount of exposure greater than 10% is considered a major
5522 adverse effect.

5523 4/ Percentage change indicates a reduction in the amount of exposure greater than 5% and is considered a
5524 beneficial effect.

5525 As illustrated in Table 7-47, the Preferred Alternative would not result in any major increases in
5526 the acre-days exposure of archaeological resources. The biggest increase is seen at Libby,
5527 where the change in operations under the Preferred Alternative would result in an increase of
5528 about 4 percent. At three of the projects (John Day, Lower Granite, and Hungry Horse), the
5529 Preferred Alternative would result in a reduction of exposure of archaeological resources,
5530 largely as a result of retention of greater amounts of water in these reservoirs than under the
5531 other action alternatives. Downstream of Dworshak, exposure of archaeological resources
5532 would decrease under the Preferred Alternative due to changes in outflow from Dworshak as
5533 compared to the No Action Alternative. While there would still be ongoing adverse effects, the
5534 Preferred Alternative would be expected to lessen some impacts at these three projects in
5535 comparison to the No Action Alternative.

5536 **EROSION**

5537 Because of the lack of a means of estimating the amount of shoreline erosion that would take
5538 place along the reservoirs under these various alternatives, three proxy measures of erosion
5539 have been adopted: changes in the frequency of reservoir elevation changes, changes in the
5540 amplitude of reservoir elevation changes, and the frequency of relatively high draft rate events.
5541 Repeated monitoring of archaeological sites along the project reservoirs has shown that, as
5542 these three variables are increased, it tends to increase the rate at which archaeological
5543 resources erode. The methodology behind this analysis is provided in Section 3.16.

5544 Table 7-48, Table 7-49, and Table 7-50 provide a percentage comparison between each of the
5545 action alternatives and the No Action Alternative. If there is an increase in one of these
5546 statistics relative to the No Action Alternative (and thus an increase in the factors that tend to

5547 promote archaeological resource erosion), then there will be a positive percentage. If there is a
5548 decrease in one of these statistics (and thus a decrease in the factors that promote erosion),
5549 there will be a negative percentage.

5550 **Table 7-48. Effects to Archaeological Resources – Average Frequency of Reservoir Elevation**
5551 **Change by Alternative**

Project	No Action Alternative	MO1	MO2	MO3	MO4	Preferred Alternative
Albeni Falls	0% ^{4/}	0% ^{4/}	0% ^{4/}	0% ^{4/}	1% ^{3/}	0% ^{4/}
Dworshak	0% ^{4/}	-1% ^{5/}	3% ^{3/}	1% ^{3/}	1% ^{3/}	-2% ^{5/}
Grand Coulee	0% ^{4/}	32% ^{1/}	26% ^{1/}	-4% ^{5/}	24% ^{1/}	0% ^{4/}
Hungry Horse	0% ^{4/}	4% ^{3/}	-5% ^{6/}	4% ^{3/}	8% ^{2/}	-2% ^{5/}
Libby	0% ^{4/}	-1% ^{5/}	0% ^{4/}	0% ^{4/}	9% ^{2/}	0% ^{4/}

5552 Note: Values have been rounded to the nearest whole percent. A positive value indicates an increase in the
5553 average frequency of reservoir elevation changes, which is an adverse effect. A negative value indicates a decrease
5554 in the average frequency of reservoir elevation changes, which is a beneficial effect.

5555 1/ Increase is greater than 10% relative to the No Action Alternative and is considered moderate adverse.

5556 2/ Increase is between 5% and 10% and is considered minor adverse.

5557 3/ Increase is between 0% and 5% is considered negligible.

5558 4/ No difference between the No Action Alternative and the alternative.

5559 5/ Decrease between 0% and 5% is considered negligible.

5560 6/ Decrease between 5% and 10% and is considered minor beneficial.

5561 7/ Decrease is greater than 10% relative to the No Action Alternative is considered a moderate beneficial.

5562 **Table 7-49. Effects to Archaeological Resources – Changes in Average Amplitude of Reservoir**
5563 **Elevation Change by Alternative**

Reservoir	No Action Alternative	MO1	MO2	MO3	MO4	Preferred Alternative
Albeni Falls	0% ^{4/}	0% ^{4/}	0% ^{4/}	0% ^{4/}	0% ^{4/}	0% ^{4/}
Dworshak	0% ^{4/}	0% ^{4/}	28% ^{1/}	0% ^{4/}	0% ^{4/}	0% ^{4/}
Grand Coulee	0% ^{4/}	1% ^{3/}	0% ^{4/}	1% ^{3/}	9% ^{2/}	-1% ^{5/}
Hungry Horse	0% ^{4/}	10% ^{2/}	13% ^{1/}	11% ^{1/}	10% ^{2/}	-1% ^{5/}
Libby	0% ^{4/}	4% ^{3/}	3% ^{3/}	3% ^{3/}	-1% ^{5/}	5% ^{2/}

5564 Note: Values have been rounded to the nearest whole percent. A positive value indicates an increase in the
5565 average amplitude of reservoir elevation changes, which is an adverse effect. A negative value indicates a decrease
5566 in the average amplitude of reservoir elevation changes, which is a beneficial effect.

5567 1/ Increase is greater than 10% relative to the No Action Alternative and is considered moderate adverse.

5568 2/ Increase is between 5% and 10% and is considered minor negative.

5569 3/ Increase is between 0% and 5% is considered negligible.

5570 4/ No difference between the No Action Alternative and the alternative.

5571 5/ Decrease between 0% and 5% is considered negligible.

5572 6 Decrease between 5% and 10% and is considered minor positive.

5573 7 Decrease is greater than 10% relative to the No Action Alternative is considered a moderate beneficial.

5574 **Table 7-50. Effects to Archaeological Resources – Changes in the Average Frequency of High**
5575 **Draft Rate Events by Reservoir and Alternative**

Reservoir	No Action Alternative	MO1	MO2	MO3	MO4	Preferred Alternative
Albeni Falls	0% ^{4/}	1% ^{3/}	0% ^{4/}	0% ^{4/}	-4% ^{5/}	0% ^{4/}
Dworshak	0% ^{4/}	126% ^{1/}	-25% ^{7/}	0% ^{4/}	1% ^{3/}	-2% ^{5/}
Grand Coulee	0% ^{4/}	1% ^{3/}	3% ^{3/}	7% ^{2/}	8% ^{2/}	6% ^{2/}
Hungry Horse	0% ^{4/}	-19% ^{7/}	71% ^{1/}	-18% ^{7/}	-26% ^{7/}	4% ^{3/}
Libby	0% ^{4/}	-66% ^{7/}	88% ^{1/}	78% ^{1/}	-59% ^{7/}	-34.2% ^{7/}

5576 Note: Values have been rounded to the nearest whole percent. A positive value indicates an increase in the
5577 average frequency of high amplitude of reservoir elevation changes, which is an adverse effect. A negative value
5578 indicates a decrease in the average frequency of high amplitude of reservoir elevation changes, which is a
5579 beneficial effect.

5580 1/ Increase is greater than 10% relative to the No Action Alternative and is considered moderate adverse.

5581 2/ Increase is between 5% and 10% and is considered minor adverse.

5582 3/ Increase is between 0% and 5% is considered negligible.

5583 4/ No difference between the No Action Alternative and the alternative.

5584 5/ Decrease between 0% and 5% is considered negligible.

5585 6/ Decrease between 5% and 10% and is considered minor beneficial.

5586 7/ Decrease is greater than 10% relative to the No Action Alternative is considered a moderate beneficial.

5587 Review of the three tables regarding proxy measures of shoreline erosion show that the
5588 Preferred Alternative would tend to minimize those conditions that foster erosion, especially in
5589 comparison to the other action alternatives. Experience has shown that, as reservoir elevations
5590 fluctuate more frequently, erosion also tends to accelerate. Comparison of the Preferred
5591 Alternative to the No Action Alternative with regard to the frequency of reservoir elevation
5592 changes shows that the Preferred Alternative would result in negligible or neutral effects
5593 (Table 7-48). Similarly, erosion tends to increase as the average amplitude of reservoir elevation
5594 changes increase. For the storage reservoirs, only Libby shows an increase when the Preferred
5595 Alternative is compared to the No Action Alternative (Table 7-49). That is, the average
5596 amplitude of reservoir elevation changes would increase by about 5 percent at Libby,
5597 suggesting that erosion may be accelerated, but this is considered negligible; neutral effects are
5598 seen at the other reservoirs. The third proxy measure of erosion is the average frequency of
5599 high draft rate events. This measure is based on the observation that erosion, particularly bank
5600 slumping, tends to accelerate as reservation elevations are dropped more quickly. Slow
5601 drawdowns, on the other, tend to minimize slumping. Under the Preferred Alternative, Grand
5602 Coulee and Hungry Horse would see some increase in high draft rate events (Table 7-50),
5603 suggesting that erosion would accelerate. That said, these effects are expected to be minor at
5604 Grand Coulee and negligible at Hungry Horse.

5605 When viewed from an overall perspective, the Preferred Alternative would result in less
5606 adverse effects to archaeological resources than the other action alternatives, especially when
5607 compared to the No Action Alternative. Except for Lake Kocanusa, the Preferred Alternative is
5608 neutral or even slightly better than the No Action Alternative. This does not mean that the
5609 Preferred Alternative would eliminate the ongoing adverse effects of operating the reservoirs,

5610 but there may be a slight reduction in the rate at which archaeological sites decay. The adverse
5611 impacts at Libby to archaeological resources resulting from the Preferred Alternative are minor.

5612 **TRADITIONAL CULTURAL PROPERTIES**

5613 As with the other alternatives, and similar to archaeological resources, TCPs would continue to
5614 experience major effects associated with the operations and maintenance of the CRS. These
5615 effects that have occurred and would continue to occur under the Preferred Alternative are
5616 summarized in Chapter 3.16 and listed in Table 3-268. However, based on available
5617 information, and with reference to the assumptions and constraints previously described for
5618 TCPs, the Preferred Alternative would likely not result in an appreciable increase in effects
5619 relative to the No Action Alternative. As previously noted, the co-lead agencies do not have
5620 geospatial data available for TCPs at the Libby Project. Due to available information, the co-lead
5621 agencies do not expect effects, but if new information becomes available, the agencies would
5622 evaluate it to determine if their effect analysis needs to be updated.

5623 **ELEMENTS OF THE BUILT ENVIRONMENT**

5624 There would be several structural modifications constructed at various projects as part of the
5625 Preferred Alternative. A few of these modifications would have an effect on the built resources.
5626 As Bonneville Dam is a built resource more than 50 years old and a National Historic Landmark,
5627 any modification, including the gatewell orifice and ladder serpentine weir structural
5628 modifications, would potentially be an effect to a built resource. At both McNary and Ice
5629 Harbor dams, proposed structural measures include replacing the turbines, which is an adverse
5630 effect to a built resource as the structures are more than 50 years old. The power plant at
5631 Hungry Horse Dam began an extensive modernization effort in fiscal year 2018. This work
5632 would update the facilities to current industry standards. It would include the full overhaul or
5633 replacement of governors, exciters, fixed-wheel gates, and turbines; a generator rewind;
5634 overhaul of the selective withdrawal system; and recoating the penstocks. In addition, cranes
5635 that service the power plant would be refurbished or replaced, and the powerplant would meet
5636 modern fire protection standards. The replacement of original components of the project
5637 would be an effect to built resources by affecting the historic integrity. All other structural
5638 measures to the existing projects would have no effect to built resources.

5639 In addition to structural measures, there are planned operations that may impact built
5640 resources. Water level changes at Grand Coulee could be more or less rapid. Where reservoir
5641 elevation change rapidly, it could cause landslides and erosion, which could cause minor to
5642 moderate effects to built resources. There could also be structural stabilization issues,
5643 especially to roads and bridges that could be caused by water undercutting these resources.
5644 Similar to the No Action Alternative, this change could impact built resources, such as ferry
5645 terminals, recreational facilities, and irrigation infrastructure. If water levels are too low, these
5646 resources could be unusable in their current condition. To make them usable, portions of the
5647 resources may need to be modified, which would affect the historic value of the built resources.

5648 **SACRED SITES**

5649 Consistent with the sacred sites identified for Chapter 3, the Preferred Alternative evaluates
5650 effects to two sacred sites. Operational changes at Grand Coulee and Albeni Falls as described
5651 for the Preferred Alternative would be negligible when compared to the No Action Alternative.
5652 The quantitative analysis discussed above shows that the period of site exposure at Kettle Falls
5653 and Bear Paw Rock would not increase. Other metrics indicative of the potential for increased
5654 erosion (i.e., frequency of reservoir elevation changes, amplitude of reservoir elevation
5655 changes, and frequency of high draft rate events) are also consistent with the assessment that
5656 the Preferred Alternative is not likely to result in increased erosion in comparison the No Action
5657 Alternative. Based on the similarity between the Preferred Alternative and the No Action
5658 Alternative, the effects to sacred sites under the Preferred Alternative are negligible.

5659 **7.7.19 Indian Trust Assets, Tribal Perspectives, and Tribal Interests**

5660 No direct or indirect effects to Indian Trust Assets were identified for any of the alternatives,
5661 including the Preferred Alternative. Trust lands identified during the geospatial database query
5662 and tribal outreach are located outside of any direct or indirect effects identified in the
5663 alternatives. These include lands from the Confederated Tribes of Warm Springs Reservation,
5664 the Yakama Nation, and the Kootenai Tribe of Idaho, as well as the following Indian
5665 reservations: The Confederated Tribes of the Colville Indian Reservation; Spokane Tribe of
5666 Indians; Kootenai Tribe of Idaho; Nez Perce Tribe; and The Confederated Salish & Kootenai
5667 Tribes of the Flathead Reservation.

5668 The co-lead agencies reviewed the Tribal Perspectives (Appendix P) provided from 11 tribal
5669 governments (also see Section 3.17.2). Based on the wide distribution of issues discussed in
5670 these submissions, the co-lead agencies considered each Tribal Perspective while developing
5671 the Preferred Alternative. For more information on the Tribal Perspectives from these tribes
5672 see Appendix P, Tribal Perspectives.

5673 Effects to tribal interests under the Preferred Alternative would be negligible for most
5674 resources (Vegetation, Wildlife, Wetlands, and Floodplains, Air Quality and Greenhouse Gases,
5675 Power Generation, Flood Risk Management, Navigation and Transportation, and Recreation).

5676 The Preferred Alternative also includes measures to benefit ESA-listed juvenile adult salmon
5677 and steelhead and resident fish as well as to improve conditions for Pacific lamprey within the
5678 CRS. As with salmon and steelhead, Pacific lamprey is a species that is important to many tribes.
5679 The Preferred Alternative includes structural modifications to infrastructure at the dams to
5680 benefit passage of adult salmon and steelhead, as well as Pacific lamprey. Ongoing actions to
5681 benefit resident fish would be continued into the future. The *Juvenile Fish Passage Spill*
5682 measure in the Preferred Alternative builds off the successful collaboration of the *2019-2021*
5683 *Spill Operation Agreement* and includes an updated approach to adaptively implementing
5684 flexible spill.

5685 There is a range of expected effects, including minor beneficial effects such as those from the
5686 updated operations in Region A, and potentially minor adverse effects to resident fish in Lake
5687 Roosevelt due to deeper drawdowns in high water years. However, mitigation incorporated
5688 into the Preferred Alternative includes spawning habitat augmentation to offset these adverse
5689 effects. The expected ranges of impacts to fish is described in more detail in Sections 7.5.4 and
5690 7.5.5. Ongoing fish and wildlife programs are expected to continue under the Preferred
5691 Alternative. The effects to water quality and fisheries (both anadromous and resident fish)
5692 would result in benefits to tribal interests. These effects could mitigate this impact if overall,
5693 longer term benefits to fish are realized in terms of productivity and improvements in fish
5694 stocks.

5695 Extending the boat ramp at Inchelium Ferry would mitigate some of the drawdown effects at
5696 Grand Coulee, including accessibility to the Inchelium-Gifford ferry.

5697 **7.7.20 Environmental Justice**

5698 According to the Council on Environmental Quality (CEQ) guidance for implementing Executive
5699 Order 12898 under NEPA, “[a]gencies should consider the composition of the affected area, to
5700 determine whether minority populations, low-income populations, or Indian tribes are present
5701 in the area affected by the proposed action, and if so whether there may be disproportionately
5702 high and adverse human health or environmental effects on minority populations, low-income
5703 populations, or Indian tribes” (CEQ 1997). Consistent with Chapter 3 and based on the effects
5704 analysis for the Preferred Alternative, there is not likely to be a disproportionately high and
5705 adverse effect on low income, minority or tribal populations.

- 5706 • **Fish.** As discussed in Sections 7.5.4 and 7.5.5, the Preferred Alternative would have effects
5707 ranging from negligible to minor adverse up to major beneficial effects on fish, depending
5708 on species, ESU/DPS and model assumptions and location. The Preferred Alternative has the
5709 potential to affect the availability of fish for harvest for low-income populations, minority
5710 populations or Indian tribes participating in these activities. These effects to environmental
5711 justice populations are not substantially different than the effects in the No Action
5712 Alternative.
- 5713 • **Power generation and transmission.** As discussed in Section 7.7.9, increases to power and
5714 transmission rates from the Preferred Alternative would occur across the region. For the
5715 Preferred Alternative, the co-lead agencies expect that the Settlement payments to the
5716 Confederated Tribes of the Colville Reservation and the Spokane Tribe of Indians would be 1
5717 percent higher than under the No Action Alternative.
- 5718 • **Navigation and transportation.** As discussed in Section 7.7.12, Ferry operations on Lake
5719 Roosevelt could be affected under the Preferred Alternative due to anticipated drawdowns
5720 in wet years. In wet years, Lake Roosevelt is drawn down for flood risk management earlier
5721 and for a longer duration than under the No Action Alternative. Due to this earlier and
5722 longer duration draft, the Inchelium-Gifford Ferry on Lake Roosevelt would not be able to
5723 operate for approximately 31 days in the year, which is four additional days than occurs
5724 under the No Action Alternative. The co-lead agencies are proposing a mitigation measure

5725 to extend the boat ramp for the Inchelium-Gifford Ferry in Lake Roosevelt, which would
5726 avoid the additional effects to local access compared to the No Action Alternative.

5727 • **Cultural Resources.** As discussed in Section 7.7.18, implementation of the Preferred
5728 Alternative is expected to adversely affect cultural resources through increasing exposure
5729 and erosion of reservoir areas associated with increased reservoir level fluctuations.
5730 Specifically, the Preferred Alternative is expected to increase the exposure of archaeological
5731 resources at Lake Roosevelt in Region B and the Dworshak Project in Region C. However,
5732 these impacts would be mitigated through the FCRPS Cultural Resource Program.

5733 **7.7.21 Costs**

5734 As shown in Table 7-51, the estimated total cost for operating and maintaining the CRS under
5735 the No Action Alternative is approximately \$1.06 billion annually. As described in Section
5736 3.19.2, the CRS costs for the No Action Alternative and MOs include capital, operations and
5737 maintenance (O&M), and mitigation costs. Mitigation costs include the Bonneville F&W
5738 Program; Bonneville's funding of U.S. Fish and Wildlife Service for the Lower Snake River
5739 Compensation Plan (LSRCP); the Corps' Columbia River Fish Mitigation (CRFM) costs; and
5740 Reclamation's ESA-related costs. Note: this discussion of costs in Section 7.7.21 represents only
5741 direct expenditures. It does not represent costs to Bonneville in the form of lost revenues from
5742 reduced hydropower generation (discussed in Section 7.7.9).

5743 The Preferred Alternative is estimated to cost from \$6 million more annually (+0.6 percent) to
5744 \$41 million less than the No Action Alternative (-3.9 percent) (Table 7-51). Present value of the
5745 structural measure costs for the Preferred Alternative are estimated to be \$104 million, and
5746 when amortized over the 50-year period of analysis, the annual equivalent cost is
5747 approximately \$4.0 million. Most of the costs of the structural measures would occur at the
5748 Bonneville project for the Lamprey passage structures and the ladder serpentine weir and at
5749 Lower Granite and Little Goose projects associated with the bypass screen modifications for
5750 Lamprey. Additionally, there could be slight decreases in capital and O&M costs under the
5751 Preferred Alternative driven by ceasing installation of fish screens at Ice Harbor, McNary and
5752 John Day. The timing for ceasing the installation of these screens would be coordinated with
5753 NMFS. However, the changes in CRS capital and O&M costs compared to the No Action
5754 Alternative would be negligible.

5755 Funding decisions for the Bonneville F&W Program are not being made as part of the CRSO EIS
5756 process. However, a range of potential F&W Program costs are included to inform the broader
5757 cost analysis for each alternative in the EIS, which is discussed in Section 3.19. Future budget
5758 adjustments would be made in consultation with the region through Bonneville's budget-
5759 making processes and other appropriate forums and consistent with existing agreements. In the
5760 case of the Preferred Alternative, Bonneville included a range of potential F&W Program costs
5761 to acknowledge the possibility that the Preferred Alternative could provide biological benefits
5762 to anadromous fish species (see Section 7.7.4) and that this could, in turn, reduce the need for
5763 some offsite mitigation funded through the Bonneville F&W Program. By analyzing a range of
5764 costs, Bonneville reflects the year-to-year fluctuations related to managing its program and also

5765 acknowledges the uncertainty around both the magnitude of biological benefits and the
5766 potential impacts on funding, including the timing of funding decisions. In 2016, Bonneville's
5767 F&W Program budget was \$267,000,000, and the LSRCP budget was \$32,303,000. When these
5768 budgets are adjusted to represent 2019 dollars, they become \$281,536,000 and \$34,062,000,
5769 respectively, which are the budgets used under the No Action Alternative.

5770 For the Preferred Alternative, Bonneville would continue funding the operations and
5771 maintenance of the LSRCP facilities, consistent with the No Action Alternative. Bonneville's
5772 F&W Program costs under the Preferred Alternative are estimated to range from no change
5773 from the No Action Alternative to a decrease of approximately 17 percent, or approximately
5774 \$47 million, annually. Bonneville's fiscal year 2020 decisions to adjust the F&W Program budget
5775 to \$249 million and the LSRCP budget to \$30.5 million (BP-18 Rate Case) are consistent with the
5776 range of costs analyzed for the Preferred Alternative. As a result, Bonneville does not anticipate
5777 additional reductions to the F&W Program or Bonneville's direct-funding of USFWS's LSRCP
5778 with the implementation of the Preferred Alternative at this time.

5779 The CRFM, F&W O&M, and the Reclamation ESA-related mitigation would remain the same as
5780 under the No Action Alternative. The Preferred Alternative would include additional mitigation
5781 measures, estimated to cost approximately \$2 million, annually (see Section 7.6.4 and Annex B
5782 of the Cost Analysis appendix for additional details).

5783 In addition, as part of the ESA process, the Preferred Alternative is being coordinated for
5784 consultation with the USFWS and NMFS. Section 7.6.4.3 describes the specific preliminary
5785 measures proposed for ESA compliance. A number of the ESA measures would be implemented
5786 through existing funding mechanisms, for example, through the Bonneville F&W Program or
5787 the CRFM program, while others would require additional appropriations or funding sources.
5788 Therefore, it is expected that there would be some small additional annual costs for these ESA
5789 measures. These costs would occur under the Preferred Alternative as well as under the other
5790 MOs.¹⁷

¹⁷ The costs of the ESA measures were not included in Table 7-51 (below) because a number of the measures would be implemented under existing programs and funding sources and the specific implementation of the measures have not been identified. In addition, the ESA-compliance measures could be similar for the Preferred Alternative and the other MOs, but the final measures would need to be determined through consultation with USFWS and NMFS.

5791 **Table 7-51. Annual-Equivalent Costs and Change in Costs for the Preferred Alternatives (2019 dollars)**

Alternative	Construction Costs of Structural Measures (present value)	Construction Costs of Structural Measures (annual)	Capital Costs (annual)	O&M Costs (annual)	Mitigation Costs (Low F&W Program Costs) (annual)	Mitigation Costs (High F&W Program Costs) (annual)	Annual-Equivalent Costs (Low F&W Program Costs)	Annual-Equivalent Costs (High F&W Program Costs)
NAA	NA	NA	\$245,000,000	\$478,000,000	\$332,000,000	\$332,000,000	\$1,055,000,000	1,055,000,000
Preferred Alternative	\$104,000,000	\$4,000,000	\$245,000,000	\$478,000,000	\$287,000,000	\$334,000,000	\$1,014,000,000	\$1,061,000,000
Change in Costs Compared to the NAA	\$104,000,000	\$4,000,000	\$0	\$0	-\$45,000,000	\$2,000,000	-\$41,000,000	\$6,000,000
Percentage Change in Costs from NAA	NA	NA	0%	0%	-13.6%	0.6%	-3.9%	0.6%

5792

5793 **7.8 POTENTIAL CLIMATE EFFECTS BY RESOURCE**

5794 Warming temperatures and changes in precipitation trends are likely to result in declining
5795 snowpack, higher average fall and winter flows, earlier peak spring runoff, and longer periods of
5796 low summer flows. In the timeframe of this EIS, these changes in climate are expected to have
5797 negligible to moderate impacts on resources. The analysis described below of climate effects by
5798 resource is consistent with the analysis contained in Chapter 4.

5799 **7.8.1 Hydrology & Hydraulics**

5800 It is expected that climate change may result in moderate changes in seasonal flow volume and
5801 timing, resulting in higher and more variable winter flows. Reservoirs may refill early but draft
5802 deeper, and there may be lower flows during summer months across all regions. The effects to
5803 hydrology and hydraulics for the Preferred Alternative are expected to be negligible. Potential
5804 changes in climate could exacerbate this effect leading to moderate effects.

5805 **7.8.2 River Mechanics**

5806 Relative to the No Action Alternative, the effects to geomorphological processes for the
5807 Preferred Alternative are expected to be negligible. It is unknown to what degree climate
5808 change, increased demand for water, and other cumulative actions may impact future sediment
5809 processes. However, changes in climate not directly associated with the Preferred Alternative
5810 could potentially influence these processes, leading to moderate or major effects as described
5811 below.

5812 Changes in climate have the potential to influence erosion, sediment transport, and sediment
5813 deposition throughout the CRS regions. The increase in summer warm and dry cycles would
5814 result in reduced soil moisture content, and widening gaps in rock and soil. Vegetative land
5815 cover is a key component of erosion resistance and vegetation stress caused from increased
5816 warm and dry cycles would likely correspond with increased disturbance events (wildfires,
5817 insects, disease) or water stress. A reduction in vegetative cover can increase surface erosion
5818 during rain events and elevate soil moisture resulting in reduced stability and greater landslide
5819 susceptibility. Following wildfires, soils have the decreased ability to absorb water, leading to
5820 increased surface runoff, surface erosion, and sediment transport. Summer water demands on
5821 the CRS that increase draft elevation would increase shoreline exposure and erosion processes
5822 and increase head of reservoir sediment mobilization. Increased winter temperatures would
5823 reduce snowpack and increase the amount of time that underlying erodible soils are exposed to
5824 surface erosion. Increased winter precipitation and flows would increase surface runoff and
5825 watershed sediment loads delivered into river systems and could increase river erosion,
5826 potentially resulting in geomorphic change.

5827 **7.8.3 Water Quality**

5828 It is expected that climate change may result in moderate decreases in summer flow and
5829 increased summer air temperature that would likely lead to warmer summer water

5830 temperatures across all regions. The decreases in summer flow volumes could make meeting
5831 the spill targets in Regions C and D harder because there would be less total flow to pass over
5832 the spillways and still provide minimum turbine generation. Deeper reservoir drafts and higher
5833 outflows may cause suspended solids to move further down into the reservoir and downstream
5834 of Libby Dam, and potentially increase water temperature downstream of Libby Dam. Thus, the
5835 effects to water temperature from the Preferred Alternative, which range from no change in
5836 Regions B and D to negligible in C and minor in A could be exacerbated by climate change,
5837 leading to increased effects.

5838 **7.8.4 Anadromous Fish**

5839 Because temperature is such a critical factor to anadromous fish habitat, increases in stream
5840 temperature due to increased air temperature and changes in hydrology, including declining
5841 snowpack, could further impact fish in all regions. Increased water temperatures could also
5842 increase suitable habitat for invasive species (e.g., shad and small mouth bass) that could have
5843 adverse impacts to native anadromous fish. Positive effects for anadromous species in this
5844 Preferred Alternative could be offset by adverse effects from changes in flow and increased
5845 stream temperature due to climate change.

5846 **7.8.5 Resident Fish**

5847 It is expected that climate change may result in increases in stream temperature and impact
5848 food supply. Increased water temperatures could also increase suitable habitat for invasive
5849 species (e.g., shad and small mouth bass) that could have adverse impacts. The timing of
5850 outflows could result in an increased risk of entrainment that could exacerbate negative effects
5851 to resident fish and zooplankton.

5852 **7.8.6 Vegetation, Wildlife, Wetlands, and Floodplains**

5853 It is expected that changes in climate may result in higher inflows and deeper drafts that could
5854 increase erosion and expose barren zones in Regions A, B and C. It could also increase suitable
5855 habitat for invasive plant species across all regions. For floodplains, it is expected that changes
5856 in precipitation coupled with warming temperatures could result in increased frequency and
5857 magnitude of winter floods across all regions. Increases in winter precipitation coupled with
5858 projected increases in spring temperature could also lead to increased snowmelt flooding in the
5859 spring, particularly in high elevation regions. Thus, climate change could exacerbate the effects
5860 from the Preferred Alternative on vegetation, wetlands, wildlife, and floodplains.

5861 **7.8.7 Power Generation and Transmission**

5862 Similar to the analysis in Chapter 4.2.5, climate change is likely to add additional uncertainty
5863 to the annual magnitude of total hydropower generation, and uncertainty to the monthly
5864 magnitude of generation impacts associated with the Preferred Alternative as compared to the
5865 No Action Alternative. However, it is not likely to change the relative conclusions from the
5866 power analysis for the Preferred Alternative relative to other alternatives in this EIS. Increasing

5867 temperatures and loads in July and the first half of August are likely to exacerbate reliability
5868 concerns in those months. Conversely, the increased reliability in late August could potentially
5869 ameliorate projected power shortages in that period due to increasing temperatures and loads.
5870 During the winter months, increasing temperatures and decreasing loads are likely to at least
5871 partially ameliorate power shortages in those months.

5872 **7.8.8 Air Quality and Greenhouse Gases**

5873 It is expected that greenhouse gas emissions would increase for the Preferred Alternative due
5874 to the reduction in hydropower, but the impact is expected to be negligible. Climate change is
5875 not expected to have additional effects.

5876 **7.8.9 Flood Risk Management**

5877 Projected changes in precipitation coupled with warming temperatures could result in
5878 increased frequency and magnitude of winter floods. Increases in winter precipitation coupled
5879 with projected increases in spring temperature could also lead to increased snowmelt flooding
5880 in the spring, particularly in high elevation regions.

5881 **7.8.10 Navigation and Transportation**

5882 It is expected that changes in climate may result in changes in streamflow, which could result in
5883 an increased frequency of shallow river conditions and may impact navigation at some
5884 locations. Projected higher flows and higher extreme flows in November to March could slow or
5885 interrupt barge traffic more frequently in Regions C and D. Climate change could reduce the
5886 amount of time Lake Roosevelt is drafted to an inoperable range thereby reducing the effects
5887 to the operation of the Inchelium-Gifford Ferry, an improvement over the Preferred Alternative
5888 impact without mitigation. Thus, climate change could exacerbate certain effects from the
5889 Preferred Alternative on navigation and transportation, but potentially reduce the effects on
5890 the Inchelium-Gifford Ferry.

5891 **7.8.11 Recreation**

5892 It is expected that changes in climate may result in earlier reservoir refill, which could shift the
5893 seasonal period for recreational activities that depend on high lake levels for water access
5894 earlier in the year, and potentially lengthen the reservoir recreation season depending upon
5895 later summer and fall conditions. Decreased summer and fall flow volume could potentially lead
5896 to lower reservoir outflows that could affect river recreation (e.g., river kayaking, boating, etc.).
5897 Changes in flow volume and/or increased water temperatures could decrease recreational
5898 fishing opportunities. Impacts to water-based recreation under the Preferred Alternative are
5899 expected to be negligible, but the impacts from climate change could exacerbate the effects
5900 from the Preferred Alternative particularly for river recreation.

5901 **7.8.12 Water Supply**

5902 The Preferred Alternative is not expected to change the ability to meet existing water supply
5903 obligations because the changes in flow and reservoir elevations are expected to be negligible.
5904 In addition, the operation of withdrawals is timed to minimize impacts to flows. The impacts
5905 from climate change are expected to be negligible, so the impacts on water supply from the
5906 Preferred Alternative coupled with climate change would remain negligible.

5907 **7.8.13 Visual**

5908 Climate change is not expected to ameliorate or exacerbate effects to visual resources.

5909 **7.8.14 Noise**

5910 Climate change is not expected to ameliorate or exacerbate effects to noise.

5911 **7.8.15 Fisheries and Passive Use**

5912 Changes in flow and increased stream temperature due to climate change could adversely
5913 affect anadromous and resident fish species within the Columbia River Basin. Increased water
5914 temperatures could also increase suitable habitat for invasive species (e.g., shad and small
5915 mouth bass) that could have adverse impacts to native anadromous and resident fish. Climate
5916 effects that result in reduced abundance of anadromous and resident fish species of
5917 commercial and ceremonial and subsistence value could result in decreased fishing opportunity
5918 for those species.

5919 **7.8.16 Cultural Resources**

5920 In Regions A, B, and C the impacts from deeper drafts, combined with projected increases in
5921 precipitation, could result in greater exposure and erosion, which could accelerate decay of
5922 cultural resources while the impacts in Region D are expected to be negligible. Climate change
5923 may have additional minor effects due to changes to reservoir elevations.

5924 **7.8.17 Indian Trust Assets, Tribal Perspectives, and Tribal Interests**

5925 “Climate change impacts have the potential to affect the entire Basin and resources the Tribes
5926 stewarded from time immemorial. The change has the potential to impact both aquatic systems across
5927 the Basin and the generation of electricity from the System.” (Shoshone-Bannock Tribes Tribal
5928 Perspective Submittal; see Section 3.17.2.2).

5929 The Tribes of the Pacific Northwest are focused on the challenges posed by the projected
5930 changes in climate. These changes have the potential to adversely affect tribal culture given the
5931 relationship these cultures have with the natural environment. For many tribes, their culture of
5932 stewardship is an effort to restore the ecosystem to its natural condition. This is considered an
5933 essential element in their fight against, and to counteract the effects of climate change. Climate
5934 change presents a threat to critical cultural resources, thereby also threatening the lifeways and

5935 wellbeing of the Tribes. Some tribes view the CRS, particularly its reservoirs and loss of riverine
5936 ecosystem structure and function, as a contributor to climate change.

5937 **7.8.18 Environmental Justice**

5938 Climate change can exacerbate impacts on minority populations, low-income populations, and
5939 Indian tribes. At the same time, these populations are often less able to adapt or recover from
5940 these impacts (EPA 2016). Based on the effects analysis (including the potential impacts from
5941 climate) on fish, power generation and transmission, navigation and transportation, and
5942 cultural resources as well as the addition of applicable mitigation, it is not expected that there
5943 would be any disproportionately high and adverse human health or environmental effects on
5944 minority populations, low-income populations, or Indian tribes.

5945 **7.9 CUMULATIVE EFFECTS OF THE PREFERRED ALTERNATIVE**

5946 CEQ NEPA regulations require an assessment of cumulative effects. CEQ defines a cumulative
5947 effect as “the impact on the environment which results from the incremental impact of the
5948 action when added to other past, present, and reasonably foreseeable future actions regardless
5949 of what agency (Federal or non-Federal) or person undertakes such other actions” (40 C.F.R. §
5950 1508.7). This section describes the methods for identification of cumulative actions and
5951 presents the results of the cumulative impacts analysis.

5952 **7.9.1 Analysis Approach**

5953 The cumulative action analysis methods are described in Chapter 6 and follow CEQ guidance,
5954 which includes establishing the geographic and temporal boundaries of the analysis, identifying
5955 applicable cumulative actions, identifying affected resources and direct/indirect impacts, and
5956 analyzing the cumulative impacts.

5957 This section uses the effects of the Preferred Alternative and additionally considers the
5958 cumulative effects of reasonably foreseeable future actions. Climate change, for example, can
5959 be considered an effect of past, present, and future actions that may have a cumulative effect
5960 on certain resources in the analysis area. This section discusses the potential climate change
5961 effects described in Section 7.8 that may be additive to the direct and indirect effects from the
5962 Preferred Alternative.

5963 **7.9.2 Geographic and Temporal Scope**

5964 As discussed in Chapter 6, the geographic boundary for each resource considered in this
5965 cumulative effects analysis is referred to as the Cumulative Impact Analysis Area (CIAA). The
5966 CIAA follows the geographic boundaries of direct and indirect impacts for each resource
5967 described in Section 7.7. Additionally, as in Chapter 6, the temporal boundaries for cumulative
5968 effects in this analysis have three components; past, present, and future. Relevant past actions
5969 are discussed in Section 6.1.3.1 for the MOs, and this information was used to inform the past
5970 actions analysis for the Preferred Alternative. Similarly, ongoing and present actions and
5971 reasonably foreseeable future actions are discussed in Chapter 6.1.3.2 and 6.1.3.3, respectively,
5972 and this same information informed the cumulative effects analysis for the Preferred
5973 Alternative.

5974 **7.9.3 Cumulative Actions Scenario**

5975 Consistent with Chapter 6, the same cumulative action scenario was applied to the No Action
5976 Alternative and all Action Alternatives, including the Preferred Alternative. The cumulative
5977 actions scenario focuses on the actions and trends (i.e., Reasonably Foreseeable Future Actions
5978 [RFFAs]) that were not proposed by one of the MOs but are overlapping in space and time and
5979 may contribute to cumulative impacts in combination with direct and indirect impacts of the
5980 Preferred Alternative (Table 7-52 and Table 7-53).

5981 The co-lead agencies expect there would be a range of cumulative impacts to affected
5982 resources from the addition of the past, present and reasonably foreseeable future impacts to
5983 the impacts from the Preferred Alternative. As a reminder, the list of RFFAs is provided below,
5984 and Section 6.2 provides a brief description of each RFFA.

5985 **Table 7-52. Reasonably Foreseeable Future Actions**

RFFA ID	RFFA Description
RFFA1	Population Growth and Urban, Rural, Commercial, Industrial, and Agricultural Development
RFFA2	Water Withdrawals for Municipal, Agricultural, and Industrial Uses
RFFA3	New and Alternative Energy Development
RFFA4	Increasing Use of Renewable Energy Sources, Industrial and Vehicle Emissions Reductions, and Decarbonization
RFFA5	Federal and State Wildlife and Lands Management
RFFA6	Increase in Demand for New Water Storage Projects
RFFA7	Fishery Management
RFFA8	Bycatch and Incidental Take
RFFA9	Bull Trout Passage at Albeni Falls
RFFA10	Ongoing and Future Habitat Improvement Actions for Bull Trout
RFFA11	Resident Fisheries Management
RFFA12	Fish Hatcheries
RFFA13	Tribal, State, and Local Fish and Wildlife Improvement
RFFA14	Lower Columbia River Channel Maintenance Plan
RFFA15	Snake River Sediment Management Plan
RFFA16	Seli'š Ksanka Qlispe' Dam (Formerly Kerr Dam)
RFFA17	Invasive Species
RFFA18	Marine Energy and Coastal Development Projects
RFFA19	Climate Change
RFFA20	Clean Water Act–Related Actions
RFFA21	Idaho Power Hells Canyon Complex Mercury Contamination Issues/Remediation
RFFA22	Idaho Power Hells Canyon Complex Temperature Issues
RFFA23	Mining in Reaches Upstream of CRSO Dams
RFFA24	Hanford Site
RFFA25	Columbia Pulp Plant
RFFA26	Middle Columbia Dam Operations

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5987 **Table 7-53. Reasonably Foreseeable Future Actions and Potentially Affected Resources Matrix Under the Preferred Alternative**
5988 **(Pending Analysis)**

RFFA ID	Hydrology and Hydraulics	River Mechanics	Water Quality	Anadromous Fish	Resident Fish	Vegetation, Wildlife, Floodplains and Wetlands ^{1/}	Power Generation and Transmission	Air Quality and GHGs	Flood Risk Management	Navigation and Transportation	Recreation	Water Supply	Visual	Noise	Fisheries and Passive Use	Cultural Resources	Indian Trust Assets, Tribal Perspectives and Tribal Interests ^{1/}	Environmental Justice
RFFA1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
RFFA2	X	X	X	X	X	X			X	X	X	X			X	X	X	X
RFFA3	X		X	X	X	X	X	X	X				X	X		X	X	X
RFFA4	X		X			X	X	X	X					X		X	X	X
RFFA5		X		X	X	X		X							X	X	X	X
RFFA6	X	X		X	X	X			X		X	X				X	X	X
RFFA7				X	X	X				X					X		X	X
RFFA8				X	X										X			
RFFA9					X										X	X	X	X
RFFA10					X										X	X	X	X
RFFA11					X					X					X		X	X
RFFA12				X	X	X				X			X		X	X	X	X
RFFA13				X	X	X				X					X	X	X	X
RFFA14		X	X	X	X	X				X	X						X	X
RFFA15		X	X	X	X	X				X						X	X	X
RFFA16					X	X											X	X
RFFA17				X	X	X									X	X	X	X
RFFA18						X											X	X
RFFA19	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X
RFFA20		X	X	X	X												X	X
RFFA21			X														X	X

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RFFA ID	Hydrology and Hydraulics	River Mechanics	Water Quality	Anadromous Fish	Resident Fish	Vegetation, Wildlife, Floodplains and Wetlands ^{1/}	Power Generation and Transmission	Air Quality and GHGs	Flood Risk Management	Navigation and Transportation	Recreation	Water Supply	Visual	Noise	Fisheries and Passive Use	Cultural Resources	Indian Trust Assets, Tribal Perspectives and Tribal Interests ^{1/}	Environmental Justice
RFFA22			X	X	X												X	
RFFA23		X	X	X	X												X	X
RFFA24			X													X	X	X
RFFA25			X			X						X	X	X		X	X	X
RFFA26				X										X				X

5989 1/ Not every RFFA affects each resource; please see resource section below for more information.

5990 **7.9.4 Hydrology and Hydraulics**

5991 The impacts from the Preferred Alternative to hydrology and hydraulics are closer to the No
5992 Action Alternative than any other alternative. It is expected to have minor effects to hydrology
5993 and hydraulics in Region A and B due to changes in reservoir elevation and negligible effects to
5994 Regions C and D due to changes in flow and reservoir elevation. Because the impacts are similar
5995 to the No Action Alternative, the co-lead agencies used the cumulative effects information in
5996 Chapter 6.3.1.1, to determine which RFFAs would likely impact hydrology and hydraulics. These
5997 include RFFAs 1, 2, 3, 4, 6, and 19. While the Preferred Alternative's direct and indirect effects
5998 to hydrology and hydraulics would be negligible to minor compared to the No Action
5999 Alternative, the cumulative effects from population growth, changes in energy sources and
6000 consumption, climate change, increased water withdrawals to support municipal, agricultural,
6001 and industrial uses, and potential for an increase in new storage projects could exacerbate
6002 direct and indirect effects that are attributable to lower flows and reservoir elevations in the
6003 Preferred Alternative.

6004 **7.9.5 River Mechanics**

6005 Based on available information, the impacts from the Preferred Alternative on River Mechanics
6006 vary by region, reach and sub-reach due to changes in the magnitude, range and duration of
6007 flow and stage as detailed in Appendix C. The effects to the storage projects are expected to be
6008 negligible in Region A with the exception of the Kootenai River entering Lake Kookanusa
6009 upstream of Libby Dam where there is potential for a minor change in depositional patterns
6010 with temporary head-of-reservoir deposits shifting downstream. In Regions B and C, the
6011 Preferred Alternative effects to River Mechanics are estimated to be negligible. For the CRS
6012 projects in Region D, the effects to River Mechanics are expected to be negligible except for
6013 minor impacts in the John Day Reservoir where there is potential for a minor amount of bed
6014 sediment fining due to changes in reservoir stage relative to the No Action Alternative.
6015 Consistent with Chapter 6, the co-lead agencies determined RFFAs 1, 2, 5, 6, 14, 15, 19, 20, and
6016 23 would likely impact River Mechanics. While the Preferred Alternative's direct and indirect
6017 effects to River Mechanics would be negligible to minor, the cumulative effects from actions
6018 that could affect sediment processes, such as population growth, increased water withdrawals
6019 to support municipal, agricultural, and industrial uses, ongoing dredging activities, climate
6020 change, mining and potential for an increase in new storage projects, could exacerbate direct
6021 and indirect effects that are attributable to the Preferred Alternative.

6022 **7.9.6 Water Quality**

6023 Changes to water temperature ranged from no change in Regions B and D, to negligible in
6024 Region C and minor in Region A. TDG analysis found no change in Region A. Conversely, in some
6025 high flow years, additional spill would occur due to the operational constraints for ongoing
6026 Grand Coulee maintenance. This additional spill would increase TDG in Region B, mostly in the
6027 reach downstream of Grand Coulee, and potentially downstream of Chief Joseph Dam. As this
6028 maintenance is completed, it would eventually reduce TDG in comparison to the No Action
6029 Alternative. Operations to provide additional spill for juvenile fish up to 125 percent TDG at the

6030 lower Snake River and lower Columbia River projects would lead to major increases in TDG in
6031 Regions C and D. These effects would be monitored, and the spill operations could be modified
6032 to be consistent with state water quality standards. The effects to other water quality processes
6033 were minor across all regions except for Region D, where the effects are expected to be
6034 negligible because of changes in flow relative to the No Action Alternative.

6035 Consistent with Chapter 6, the co-lead agencies determined RFFAs 1, 2, 3, 4, 14, 15, 19, 20, 21,
6036 22, 23, 24, and 25 would likely impact water quality. There could be minor adverse cumulative
6037 impacts to temperature and TDG and negligible impacts to other water quality processes when
6038 the impacts from the RFFAs are added to the impacts of the Preferred Alternative. For TDG,
6039 higher winter flows due to climate change could lead to increased TDG in the winter and early
6040 spring. For temperature, the cumulative effects from actions that could affect water quantity,
6041 such as population growth, increased water withdrawals to support municipal, agricultural, and
6042 industrial uses, climate change, mining, and potential for an increase in new storage projects,
6043 could exacerbate direct and indirect effects that are attributable to the Preferred Alternative.
6044 There would also be decreases in summer flow volumes and increased summer air
6045 temperatures leading to warmer summer water temperatures. Warmer summer water
6046 temperatures expected from climate change are likely to exacerbate the effects from the
6047 Preferred Alternative. For other water quality processes, actions that affect flows, such as
6048 climate change, could lead to greater cumulative impacts than anticipated under the Preferred
6049 Alternative.

6050 **7.9.7 Anadromous Fish**

6051 There are no anadromous fish in Region A and upstream of Chief Joseph Dam in Region B under
6052 the Preferred Alternative. The effects of the Preferred Alternative on anadromous fish are
6053 expected to be negligible in Region B downstream of Chief Joseph Dam due to minor changes in
6054 operations. Depending on which model is used (LCM or CSS), the effects to anadromous fish in
6055 Regions C and D would likely have the potential to range from a major adverse effect to a major
6056 beneficial effect. These results also vary by ESU and DPS.

6057 Consistent with Chapter 6, the co-lead agencies determined RFFAs 1, 2, 3, 5, 6, 7, 8, 12, 13, 14,
6058 15, 17, 19, 20, 22, 23 and 26 would likely impact anadromous fish. RFFAs that have the
6059 potential to increase TDG, water temperatures, variability of flow, and reduce water levels in
6060 the future, such as population growth and development, changes in land use, water
6061 withdrawals, new storage projects in the mid-Columbia basin, habitat degradation, and climate
6062 change, which could adversely impact anadromous fish, but it is uncertain to what degree.
6063 Some of these adverse effects could be partially alleviated by other actions that have the goal
6064 of benefiting anadromous species (i.e., RFFA 13 Tribal, State, and Local Fish and Wildlife
6065 Improvement projects) as identified in Chapter 6.

6066 **7.9.8 Resident Fish**

6067 The impacts from the Preferred Alternative on Resident Fish vary by region due to changes in
6068 flow and elevation. In Region A, effects to resident fish at Libby are expected to have both

6069 minor adverse effects due to higher river elevations during the winter and reduced benthic
6070 insect production in Lake Koochanusa and minor to moderate beneficial effects due to increased
6071 zooplankton productivity from the changes in reservoir elevation, more suitable downstream
6072 water temperatures, and restoration of native riparian vegetation. Effects at Hungry Horse are
6073 expected to be minor and beneficial due to higher reservoir levels in late summer increasing
6074 productive and lower summer outflows improving habitat suitability. In Region B, resident fish
6075 in Lake Roosevelt at Grand Coulee are expected to have minor to moderate adverse effects.
6076 This is due to increased kokanee and burbot egg stranding as well as decreased tributary access
6077 because of changes in reservoir levels, but minor beneficial effects to burbot and kokanee due
6078 to spawning habitat augmentation. In Region C, the *Slightly Deeper Draft for Hydropower*
6079 (*Dworshak*) measure is expected to have minor adverse effects to bull trout and kokanee
6080 because of increased entrainment risk and increased drawdown that may isolate fish from
6081 tributaries. In both Regions C and D, the Preferred Alternative is expected to have minor
6082 adverse effects on resident fish due to the higher TDG from the *Juvenile Fish Passage Spill*
6083 *Operations* measure.

6084 Consistent with Chapter 6, the co-lead agencies determined RFFAs 1, 2, 3, 5, 6, 7, 8, 9, 10, 11,
6085 12, 13, 14, 15, 16, 17, 19, 20, 22, and 23 would likely impact resident fish. RFFAs that have the
6086 potential to cause cumulative impacts to resident fish when added to the direct and indirect
6087 impacts from the Preferred Alternative include climate change and water withdrawals if they
6088 cause lower water levels in the summer or if RFFAs, such as climate change, exacerbate TDG.
6089 RFFAs that have the potential to increase TDG levels, water temperatures, variability of flow,
6090 and reduce water levels in the future, such as population growth and development, changes in
6091 land use, water withdrawals, new storage projects in the mid-Columbia basin, habitat
6092 degradation, and climate change, which could adversely impact resident fish, but it is uncertain
6093 to what degree. In Region A, minor to moderate benefits from the Preferred Alternative could
6094 be offset by certain RFFAs, such as climate change and water withdrawals that may affect
6095 reservoir levels and outflows. In Region B, effects from egg stranding and spawning habitat
6096 access could be exacerbated by RFFAs that from changes (e.g., steeper) reservoir drawdowns.
6097 In Regions C and D, minor adverse effects to resident fish due to TDG levels that could be
6098 slightly increased by RFFAs. Some of these adverse effects could be partially mitigated by other
6099 RFFAs that have the goal of benefiting resident species (i.e., RFFA 13 Tribal, State, and Local Fish
6100 and Wildlife Improvement projects) as identified in Chapter 6.

6101 **7.9.9 Vegetation, Wildlife, Wetlands, and Floodplains**

6102 The impacts from the Preferred Alternative on vegetation, wildlife, wetlands, and floodplains
6103 vary by region due to changes in flow and elevation. Consistent with Chapter 3, the effects to
6104 vegetation and wildlife were minor at the storage reservoirs in Regions A and C due to deeper
6105 drafts, and negligible in Region B and at the run-of-river dams on the lower Snake and lower
6106 Columbia Rivers. *Slightly Deeper Drafts at Dworshak* in the winter may have a minor effect elk
6107 migration across the frozen reservoir. Overall there was no change from the No Action
6108 Alternative for the following ESA-listed species: southern resident killer whale (*Orcinus orca*),

6109 grizzly bear (*Ursus arctos horribilis*), yellow-billed cuckoo (*Coccyzus americanus*), and Ute lady's-
6110 tresses (*Spiranthes diluvialis*).

6111 The Preferred Alternative's impacts on floodplains are expected to be similar to those predicted
6112 under MOs 1 and 2, with negligible effects for most of the basin and minor impacts below
6113 Bonneville Dam. Flood elevation changes would typically be negligible (absolute value less than
6114 0.3 feet) with minor reductions (absolute value less than 1 foot) in flood elevations predicted in
6115 Region D for the Columbia River below Bonneville Dam for floods with moderate to low
6116 frequencies (Annual Exceedance Probability values from 15 to 2 percent). The annual average
6117 probability of inundation under the Preferred Alternative would remain unchanged from
6118 current conditions in most of the basin, with minor reductions in inundation frequency below
6119 Bonneville Dam.

6120 The effects to wetlands from the Preferred Alternative are expected to be similar to MO1 in
6121 Regions B and C. In Region A, the refined *Modified Draft at Libby* measure is expected to result
6122 in water surface elevations similar to the No Action Alternative, and therefore, would have
6123 negligible effects on wetlands downstream of the Libby project. At Umatilla Reservoir (John Day
6124 Reservoir) in Region D, the *Predator Disruption Operations* measure is expected to increase
6125 reservoir elevations higher than MO1 from April 10 to June 15. This increase is expected to alter
6126 the wetlands in Umatilla Reservoir including at the Umatilla National Wildlife Refuge because
6127 the increase in reservoir elevation would be during the growing season. In addition, this
6128 increase would potentially alter other vegetation habitats along the reservoir's shoreline and
6129 Blalock Islands.

6130 Consistent with Chapter 6, the co-lead agencies determined RFFAs 1, 2, 3, 4, 5, 6, 7, 12, 13, 14,
6131 15, 16, 17, 18, 19, 25, and 26 would likely impact vegetation, wildlife, floodplains and wetlands.
6132 Actions that have the potential to cause cumulative impacts to vegetation, wildlife, floodplains
6133 and wetlands when added to the direct and indirect impacts from the Preferred Alternative
6134 include climate change and increased water withdrawals if they cause lower water levels and
6135 cause habitat conversion from existing vegetation types to drier habitat types (e.g., convert
6136 wetlands to uplands). Habitat conversion can negatively impact wildlife that may not be able to
6137 adapt to this change, thus, cumulative effects to wildlife could occur. Several RFFAs, including
6138 RFFAs 1, 2 and 6, could reduce instream flow potentially affecting floodplain inundation timing
6139 and magnitude; thus, the impacts from the Preferred Alternative on floodplains added to the
6140 impacts from the RFFAs could lead to minor cumulative impacts on floodplains.

6141 **7.9.10 Power Generation and Transmission**

6142 Hydropower generation under the Preferred Alternative would decrease relative to the No
6143 Action Alternative, and the FCRPS would lose an average of 160 aMW of power and 304 aMW
6144 of firm power available for long-term firm power sales (roughly the amount of power consumed
6145 by about 250,000 Northwest homes in a year). Due to changes in the seasonal shape of
6146 hydropower under the Preferred Alternative, the reliability of the Northwest power system
6147 would be about the same as the No Action Alternative, despite an overall decrease in
6148 generation.

6149 Bonneville would continue to meet its transmission system reliability requirements. There could
6150 be an increase in generation from the lower Snake and lower Columbia River projects during
6151 the last half of August relative to the No Action Alternative. This generation would provide
6152 additional flexibility that could provide operational benefits for the transmission system. As a
6153 result, no additional reinforcements have been identified beyond those that are a part of
6154 Bonneville's regular system assessments. Additionally, changes in the patterns of CRS
6155 generation under the Preferred Alternative would have a relatively small impact on congestion
6156 for Pacific Northwest transmission paths.

6157 Moreover, Bonneville's wholesale power rate would experience an upward rate pressure of 2.7
6158 percent. For transmission, there would be no changes in transmission capital investments or
6159 long-term transmission sales under the Preferred Alternative. Upward transmission rate
6160 pressure would be about 0.09 percent annually (0.7 percent cumulatively over an 8-year
6161 period) relative to the No Action Alternative because transmission short-term sales would likely
6162 change as a result of the changes in hydropower generation and associated market pricing. For
6163 specific customers and product choices, the annualized upward transmission rate pressure
6164 would range from 0.04 percent to 0.18 percent relative to the No Action Alternative. Retail rate
6165 pressure (paid to individual utilities) would be similar to the No Action Alternative. Most
6166 counties would experience small amounts of upward pressure in their electricity retail rates.
6167 Across the Pacific Northwest, changes to the residential retail rate would range from a
6168 reduction of 0.068 cents/kWh to an increase of 0.11 cents/kWh (in percentage terms this
6169 represents a reduction of 0.94 percent to an increase of 1.2 percent). For commercial end
6170 users, rate effects range from a reduction of 0.081 cents/kWh to an increase of 0.11 cents/kWh
6171 (a reduction of 1.1 percent to an increase of 1.3 percent), and for industrial customers, from a
6172 reduction of 0.072 cents/kWh to an increase of 0.11 cents/kWh (a reduction of 1.3 percent to
6173 an increase of 2.0 percent). The rate effects would be larger for customers of utilities that
6174 receive power from Bonneville and smaller for customers whose electricity is not supplied by
6175 Bonneville.

6176 Consistent with Chapter 6, the co-lead agencies determined RFFAs 1, 3, 4, and 19 would likely
6177 impact power and transmission. Cumulative effects from RFFA1, RFFA3, and RFFA4, in
6178 combination with the power and transmission impacts analyzed under the Preferred
6179 Alternative are expected to be similar to that of the No Action Alternative. Moreover, the
6180 cumulative effects of other non-Federal hydroelectric projects and projected scenarios for coal
6181 power plant retirements are captured within the analysis of direct and indirect effects for
6182 power and transmission. The Preferred Alternative would reduce overall hydropower
6183 generation, which would exacerbate the regional need for more power generation resulting
6184 from coal plant retirements and electrification of transportation. Under the Preferred
6185 Alternative, there would be a cumulative benefit to power system flexibility with the addition of
6186 hydropower measures to increase flexibility with the cumulative effect of more new
6187 hydrosystem flexibility being available to integrate renewable power generation (especially
6188 wind and solar) being constructed in the region. The cumulative effects to power and
6189 transmission resources as a result of climate change are likely to affect generation under the
6190 Preferred Alternative relative to the No Action Alternative roughly the same on an annual basis.

6191 Finally, Bonneville would continue to meet its transmission system reliability requirements, but
6192 may experience shifts in regional congestion patterns or need to add reinforcements to
6193 accommodate changes in power generation beyond that identified in the planning base cases
6194 captured within the analysis of direct and indirect effects for power and transmission.

6195 **7.9.11 Air Quality and Greenhouse Gases**

6196 The impacts from the Preferred Alternative on air quality and greenhouse gases suggest air
6197 quality effects would be minor across Regions A, B, C and D based on increased greenhouse gas
6198 emissions due to the reduction in hydropower generation. Other emissions sources (e.g.,
6199 navigation, construction, fugitive dust) are most likely to have a negligible effect on air quality
6200 and greenhouse gas emissions. Specifically, under the Preferred Alternative, energy sector
6201 greenhouse gas emissions would increase by 0.7 percent across the Pacific Northwest. Most
6202 effects related to construction of structural measures in Regions A, C and D are expected to be
6203 temporary and short term.

6204 Consistent with Chapter 6, the co-lead agencies determined RFFAs 1, 3, 4, 5, and 19 would likely
6205 impact air quality and greenhouse gas emissions. Overall, hydropower generation would
6206 decrease under the Preferred Alternative, and climate change is likely to add additional
6207 uncertainty to the annual magnitude of generation, and uncertainty to the monthly magnitude.
6208 This reduction in hydropower combined with RFFAs, such as increased human development
6209 and resulting demand for energy could lead to a minor cumulative impact on air quality and
6210 greenhouse gas emissions.

6211 **7.9.12 Flood Risk Management**

6212 Flood risk management was evaluated for the Preferred Alternative to determine if there would
6213 be a change in flood hazards faced by communities, property, infrastructure or levees along the
6214 Columbia River System. Based on this analysis, flood risk management under the Preferred
6215 Alternative is expected to be consistent with conditions under the No Action Alternative as
6216 described in Section 3.9. The Preferred Alternative has the potential for a slight decrease in
6217 flood risk in Region A under lower annual peak flow conditions, as well as slight decreases
6218 under higher peak flow conditions near Spalding, Idaho in Region C.

6219 Consistent with Chapter 6, the co-lead agencies determined RFFAs 1, 2, 3, 4, 6, and 19 would
6220 likely affect flood risk management. Actions such as climate change (higher winter and spring
6221 runoff) and population growth and development, may adversely affect flood risk in the future,
6222 but the extent of those impacts is uncertain. Since the Preferred Alternative would have no
6223 direct or indirect adverse impacts to flood risk management when compared to the No Action
6224 Alternative, the addition of cumulative effects from RFFAs 1, 2, 3, 4, 6 and 19 could cause
6225 negligible impacts.

6226 **7.9.13 Navigation and Transportation**

6227 Potential effects to navigation and transportation systems including ferries and cruise lines
6228 were evaluated for the Preferred Alternative. Commercial navigation on the Columbia River
6229 System, occurs in Regions C and D. Under the Preferred Alternative, there could be an
6230 approximately one day per year decrease in navigable days under low flow conditions, when
6231 compared to No Action Alternative, and approximately a one day per year increase in navigable
6232 days during typical water year conditions. No change from the No Action Alternative is
6233 expected during high flow conditions. In Region B, Lake Roosevelt water elevations would be
6234 sufficient to allow operation of the Inchelium-Gifford Ferry operations every day out of the year
6235 under the Preferred Alternative during typical water years as well as in dry water years. Ferry
6236 operations during high water years could be affected slightly more under the Preferred
6237 Alternative than under the No Action Alternative meaning the ferry would not be able to
6238 operate for approximately 31 days in the year, which is four additional days than under the No
6239 Action Alternative.

6240 Consistent with Chapter 6, the co-lead agencies determined RFFAs 1, 2, 14, 15 and 19 would
6241 likely affect navigation and transportation. Future higher winter and spring runoff volumes due
6242 to climate change could increase the direct and indirect effects of the Preferred Alternative on
6243 the Inchelium-Gifford Ferry operations because of the need to vacate reservoir space to
6244 manage flood risk, especially during high water years, but it is not known to what extent. This
6245 effect could be mitigated by the extension of boat ramp for the ferry. Overall, there would likely
6246 be negligible to minor cumulative effects when the impacts from the Preferred Alternative are
6247 added to impacts from other RFFAs, such as climate change.

6248 **7.9.14 Recreation**

6249 The recreation analysis assessed effects from the Preferred Alternative focused primarily on
6250 water-based recreation access at system reservoirs and river reaches. The effects in Region A
6251 vary from no change at Albeni Falls similar to the No Action Alternative to negligible difference
6252 from No Action at Lake Kocanusa, where there could be up to a 1 percent decrease in
6253 recreation visitor days due to decreased water-based recreation access. Additionally, the river
6254 reach downstream of Libby Dam could benefit from a decrease of 14 percent in monthly
6255 median outflow in May from Libby Dam, decrease water turbidity and benefitting nearby in-
6256 river recreational fishing activities.

6257 Effects in Region B at Grand Coulee and Chief Joseph are also expected to be negligible based
6258 on changes to accessibility of water-based recreation facilities such as boat ramps driven by
6259 changes in reservoir elevations. For example, water surface elevations at Lake Roosevelt could
6260 be the same or higher for the majority of a typical year, when compared to the No Action
6261 Alternative, but decreases of 1 to 2 feet could occur in September and October. Due to minor
6262 changes in monthly boat ramp accessibility (both decreases and increases), water-based
6263 visitation is estimated to increase slightly by less than 0.1 percent (approximately 171 visits) in a
6264 typical year. In Region C, minor effects are expected at Dworshak due to the change in reservoir
6265 elevations and negligible effects at the lower Snake River projects. In Region D, the effects are

6266 also expected to be negligible. Effects to hunting, wildlife viewing, swimming, and water sports
6267 at river recreation sites for the Preferred Alternative would be negligible; however, there could
6268 be minor to moderate impacts to wildlife viewing at John Day Reservoir due to changes in
6269 water elevations. Finally, the Preferred Alternative is expected to improve fish survival and
6270 abundance through both operational and mitigation actions. To the extent that increases in
6271 abundance occur, this would increase opportunities for recreational (as well as tribal and
6272 commercial) fishing throughout the region on the Columbia River. Recreational wildlife
6273 watching opportunities could increase if these species experience benefits associated with an
6274 increase in anadromous fish abundance. This would result in beneficial effects for recreational
6275 fishing. In particular, the presence of additional fish may improve the quality of existing
6276 recreational fishing trips (e.g., through increased catch rates), resulting in additional value
6277 (consumer surplus) for anglers (i.e., a higher UDV). An increase of fish may also generate
6278 additional trips as more anglers could be supported.

6279 Consistent with Chapter 6, the co-lead agencies determined RFFAs 1, 2, 6, 7, 11, 12, 13, 14, and
6280 19 would likely impact recreation. In the future, there could be reduced boat ramp accessibility
6281 for some periods of time during the year due to an overall reduced volume of available water
6282 from increased demand and from the effects of climate change, causing lower summer
6283 volumes. When the impacts from the preferred alternative are added, this has the potential to
6284 increase the impacts to recreation from negligible to minor to minor to moderate. See the
6285 cumulative effects analysis for anadromous and resident fish above for additional information.

6286 **7.9.15 Water Supply**

6287 The effects from the Preferred Alternative on water supply is not expected to change the ability
6288 to deliver existing water supply as compared to the No Action Alternative because the changes
6289 in flow and reservoir elevations are expected to be negligible for water supply purposes. In
6290 addition, the operation of withdrawals is timed to minimize impacts to flows. The additional 45
6291 kaf from Lake Roosevelt is expected to increase available water supply in Region B, but is not
6292 expected to affect other regions.

6293 Consistent with Chapter 6, the co-lead agencies determined RFFAs 1, 2, 6, 19, and 25 would
6294 likely impact water supply. The cumulative effects of tributary water diversions added to
6295 Federal CRS water diversions are expected to continue in the future over the study period
6296 under the Preferred Alternative. Tributary diversions could negatively impact CRS water supply
6297 into the future by removing water supplies before they reach the mainstem of the Columbia
6298 and Snake Rivers, where CRS water diversions occur.

6299 **7.9.16 Visual**

6300 The effects from the Preferred Alternative on visual resources are expected to be minor due to
6301 deeper drafts at the storage reservoirs in Regions A and C, and negligible across Regions B and
6302 D. Effects to visual resources from structural measures for Regions A and B would be negligible
6303 because they would not substantially differ from the No Action Alternative. There would be
6304 minor, short-term visual effects for viewers in the vicinity of projects in Regions C and D

6305 because of increased construction activity from implementing structural measures such as new
6306 fish passage structures, modifications to fish ladders, and changes to spillway weirs, but these
6307 measures would not contribute to a substantial visual change in the landscape surrounding
6308 those projects. To the extent operational or structural measures affect the viewshed, this can
6309 have unique effects on spiritual practices for tribes. Because operational measures across all
6310 regions would result in minor changes in pool elevation management, carrying out those
6311 measures would have a minor effect on the viewshed and viewers in their vicinity from changes
6312 in duration and timing of reservoir elevations compared to the No Action Alternative. Informed
6313 by Chapter 6, the co-lead agencies determined RFFAs 1, 3, 12, and 25 would likely impact visual
6314 resources. Minor adverse visual effects from the Preferred Alternative due to deeper drafts at
6315 reservoirs could be exacerbated by cumulative actions such as climate change, increased water
6316 withdrawals to support municipal, agricultural, and industrial uses and ongoing land-based
6317 activities; however, the cumulative impact to visual resources would likely be minor.

6318 **7.9.17 Noise**

6319 The effects from the Preferred Alternative on noise are expected to be negligible in Regions A,
6320 B, C and D, with most effects from noise concentrated at the dam and reservoir projects in
6321 Regions A, C and D where structural measures would be constructed. These impacts are
6322 expected to be minor and short-term and dissipate based on distance from the project. In
6323 addition, because the seasonal timing or duration of high-flow and high-spillway-noise levels
6324 would change under the operational measures, there would be negligible effects to noise in
6325 Regions A, B, C and D. Informed by Chapter 6, the co-lead agencies determined that ongoing
6326 activities, such as driving and farming, development near the projects or along the reservoirs
6327 would continue. Also consistent with Chapter 6, the co-lead agencies determined RFFAs 1, 3, 4,
6328 25 and 26 would likely impact noise. In addition, no impacts to noise are anticipated from
6329 climate change (see Chapter 4.2). Overall, the impacts from the Preferred Alternative in
6330 combination with past, present, and reasonably foreseeable future actions would result in
6331 negligible cumulative impacts to noise, but these impacts are expected to be short-term and
6332 dissipate based on distance from the projects.

6333 **7.9.18 Fisheries and Passive Use**

6334 The effects from the Preferred Alternative on fisheries are expected to improve fish survival
6335 and abundance through both operational and mitigation actions. To the extent that increases in
6336 abundance occur, this would increase opportunities for tribal, commercial, and recreational
6337 fishing throughout the Columbia River Basin.

6338 The impacts from the Preferred Alternative on anadromous fisheries are expected to be
6339 negligible in Region B below Chief Joseph Dam, but have the potential to range from moderate
6340 adverse effects to potentially major beneficial effects in Regions C and D. The predicted effects
6341 on anadromous fish could result in changes in abundance and harvest opportunities in
6342 commercial and ceremonial and subsistence fisheries for anadromous species. Effects from the
6343 Preferred Alternative on ceremonial and subsistence fisheries for resident fish range from
6344 moderate adverse to moderate beneficial effects, depending on the region and species.

6345 Consistent with Chapter 6, the co-lead agencies determined RFFAs 1, 2, 5, 7, 8, 9, 10, 11, 12, 13,
6346 17, 18 and 19 would likely affect fisheries. Under the Preferred Alternative, the extent to which
6347 changes in the abundance of various fish populations result in changes in fisheries is driven by
6348 fishery management decisions that determine how much, when, and by whom fish can be
6349 caught. There are numerous past, present, and reasonably foreseeable future actions that
6350 could both beneficially and adversely affect species important to commercial and ceremonial
6351 and subsistence fisheries.

6352 **7.9.19 Cultural Resources**

6353 The impacts from the Preferred Alternative on cultural resources are grouped into three
6354 property-based categories: archaeological sites, traditional cultural properties (TCPs), and
6355 historic built resources. Effects to archaeological resources and TCPs were similar to the
6356 analysis for the No Action Alternative in Chapter 3.16 at all projects, with a few exceptions. At
6357 Libby and Dworshak, it is expected that the Preferred Alternative would result in negligible
6358 effects as compared to the No Action Alternative. In addition, the Preferred Alternative is
6359 expected to cause negligible beneficial effects for archaeological resources at Lower Granite,
6360 John Day, and Hungry Horse. At Bonneville Dam, McNary Dam, Ice Harbor Dam, and Hungry
6361 Horse Dam, proposed structural measures would have a negligible effect to the historic built
6362 resources by degrading their historic integrity through alteration or replacement of original
6363 components. For sacred sites, ongoing activities, such as recreation activities in Lake Roosevelt
6364 and Lake Pend Oreille would continue under all of the alternatives, including the Preferred
6365 Alternative.

6366 Consistent with Chapter 6, the co-lead agencies determined RFFAs 1, 2, 3, 4, 5, 6, 9, 10, 12, 13,
6367 15, 17, 19, 24, and 25 would likely affect cultural resources. RFFAs that could potentially
6368 decrease the amount of water in the future, such as increased development and associated
6369 water withdrawals, climate change, and increases in future storage projects, could lead to
6370 greater cumulative impacts than anticipated under the Preferred Alternative.

6371 **7.9.20 Indian Trust Assets, Tribal Perspectives, and Tribal Interests**

6372 The effects from the Preferred Alternative on Indian Trust Assets (ITA), Tribal Perspectives, and
6373 Tribal Interests vary. No direct or indirect effects to ITAs were identified from the Preferred
6374 Alternative. Trust lands identified during the geospatial database query and tribal outreach are
6375 located outside of any direct or indirect effects identified from the alternatives. These include
6376 lands from the Confederated Tribes of Warm Springs Reservation, the Yakama Nation, and the
6377 Kootenai Tribe of Idaho, as well as these Indian reservations: The Confederated Tribes of the
6378 Colville Indian Reservation; Spokane Tribe of Indians; Kootenai Tribe of Idaho; Nez Perce Tribe;
6379 and The Confederated Salish & Kootenai Tribes of the Flathead Reservation.

6380 Effects to tribal interests under the Preferred Alternative would be negligible for most
6381 resources (e.g., Vegetation, Wetlands, Wildlife, and Floodplains; Air Quality and Greenhouse
6382 Gases; Power and Transmission; Flood Risk Management; Navigation and Transportation; and
6383 Recreation). There is a range of expected effects, including minor beneficial effects such as

6384 those from the refined operations in Region A, and potentially minor adverse effects to resident
6385 fish in Lake Roosevelt due to deeper drawdowns in high water years. However, mitigation
6386 incorporated into the Preferred Alternative includes spawning habitat augmentation to offset
6387 these effects. The expected range of impacts to fish is described in more detail in the
6388 anadromous fish, resident fish, water quality, and fisheries sections above. Additionally,
6389 ongoing Fish and Wildlife programs would continue under the Preferred Alternative, and
6390 extending the boat ramp at the Inchelium-Gifford ferry would mitigate some of the operational
6391 effects at Grand Coulee, including accessibility.

6392 Consistent with Chapter 6, RFFAs 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21,
6393 22, 23, 24, 25, and 26 would likely affect Indian Trust Assets, Tribal Perspectives, and Tribal
6394 Interests. Ongoing activities on Indian Trust lands, for example, would be expected to continue
6395 under all of the alternatives. Since the alternatives would not have direct or indirect impacts on
6396 Indian Trust Assets, there would be no change in effects to these assets, and thus there would
6397 be no cumulative impacts to Indian Trust Assets. Cumulative effects to tribal interests are
6398 provided above for Anadromous Fish; Resident Fish; Water Quality; Vegetation, Wetlands,
6399 Wildlife, and Floodplains; Air Quality and Greenhouse Gases; Power and Transmission, Flood
6400 Risk Management; Navigation and Transportation, and Recreation.

6401 **7.9.21 Environmental Justice**

6402 The effects from the Preferred Alternative are not likely to cause a disproportionately high and
6403 adverse effect on low income, minority, or tribal populations (see Section 7.7.20). Consistent
6404 with Chapter 6, the co-lead agencies determined RFFAs 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14,
6405 15, 16, 17, 18, 19, 20, 21, 23, 24, 25, and 26 would likely impact environmental justice
6406 populations. Reasonably foreseeable future actions, such as climate change, could mean refill is
6407 initiated earlier more frequently, reducing the amount of time that Lake Roosevelt is drafted to
6408 inoperable range, and thus potentially reducing the impacts to the Inchelium-Gifford Ferry,
6409 including impacts to the Confederated Tribes of the Colville Reservation. As a result, effects to
6410 the ferry could be less than anticipated under the Preferred Alternative.

6411 **7.10 UNAVOIDABLE ADVERSE EFFECTS**

6412 Unavoidable adverse effects are those effects that cannot be avoided or fully mitigated should
6413 the alternatives be implemented. Although adverse effects could be avoided, minimized, or
6414 mitigated by the measures described in Section 7.6.4 some effects would remain. The effects of
6415 the Preferred Alternative are described in Section 7.7 and some of them may not be fully
6416 avoided, as identified in CEQ regulations (40 C.F.R. § 1502.16). Location and intensity of
6417 unavoidable effects would vary by alternative.

6418 Physical laws and processes make erosion and sedimentation unavoidable. If storage reservoirs
6419 are operated according to their intended function, with drafting and refilling cycles, the
6420 reservoir elevations may fluctuate substantially, reservoir shorelines would be exposed, and
6421 islands could be bridged. Unavoidable effects from storage reservoir operations include blowing
6422 dust from exposed sediments, diminished visual quality, damage to archaeological sites, and

6423 some degree of disruption to resident fish spawning and food availability. Seasonal limitations
6424 on use of recreation facilities could be avoided by modifying the facilities, but it would be
6425 impractical to eliminate all elevation-based recreation effects. Large changes in elevation are
6426 not normal operating conditions at the run-of-river projects. Several types of effects are
6427 nevertheless unavoidable with the current configuration of the system, such as some degree of
6428 disruption to anadromous and resident fish spawning and food availability. Projected effects at
6429 the CRS projects would result from operational changes that disrupt established uses
6430 dependent upon certain elevation patterns. If operations change those elevation patterns,
6431 some degree of effect to the established uses is unavoidable.

6432 **7.11 RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY**

6433 This analysis looks at the relationship between short-term uses of environmental resources and
6434 the maintenance and enhancement of long-term productivity. CRS operations may cause both
6435 short-term and long-term effects to the affected environment that cannot be mitigated. All of
6436 the alternatives would cause some mix of short-term effects, including soil erosion, dust
6437 generation, degradation of water quality, loss of riparian or wetland vegetation, disruption of
6438 fish and wildlife habitat, disruption of recreational use, degradation of visual quality, and
6439 effects to cultural resources.

6440 In general, the extent these would be long-term effects would depend upon how long a given
6441 operation was continued. Some of the short-term changes could soon lead to long-term
6442 decreases in productivity. For example, periodic drawdowns to levels below those required for
6443 irrigation pumps could result in long-term agricultural productivity losses, if irrigators do not
6444 modify their pumps. The short-term and long-term uses of the environment for CRS operations
6445 could have some beneficial effects on long-term productivity. The continued availability of
6446 power should help maintain the region's reliability. Operations intended to benefit anadromous
6447 and resident fish should contribute to the survival and recovery of ESA-listed species and to the
6448 maintenance of other stocks. Some of the alternatives would improve conditions for
6449 anadromous and resident fish and wildlife, and this could improve the long-term productivity of
6450 these resources.

6451 **7.12 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES**

6452 Irreversible and irretrievable commitments generally affect environmental resources such as
6453 soils, wetlands, and riparian areas, but can involve financial resources. Such commitments are
6454 considered irreversible and irretrievable because their implementation would affect a resource
6455 that has deteriorated to the point that renewal can occur only over a long period or at a great
6456 expense, or because they would cause the resource to be destroyed or removed.

6457 Because the adoption of the Preferred Alternative involves operation of existing facilities and
6458 not construction of new facilities, few of the operational effects identified would be irreversible
6459 or irretrievable. Loss of soil due to erosion is an irreversible and irretrievable commitment.
6460 Because all of the alternatives, including current operations, involve reservoir fluctuation at
6461 some of the projects, erosion would occur at these projects under all of the alternatives.

6462 Greater reservoir fluctuations at storage reservoirs would result in more erosion generally than
6463 at the run-of-river reservoirs.

6464 The abundance and quality of wetland and riparian habitat depend on water levels and timing.
6465 The desiccation of wetland plants due to drafting at storage reservoirs in some cases would be
6466 an irreversible commitment. The desiccation of submerged aquatic plants and mud-dwelling
6467 fauna and gradual loss of emergent marsh and riparian vegetation is also an irreversible and
6468 irretrievable commitment. These resources could conceivably be restored with higher water
6469 levels and replanting, but the existing resources would be lost.

6470 Loss of cultural resources resulting from accidental damage or vandalism would be an
6471 irreversible and irretrievable commitment. All of the alternatives, including current operations,
6472 would expose substantial percentages of known archaeological sites to such damage or
6473 vandalism.

6474 **7.13 INTENTIONAL DESTRUCTIVE ACTS**

6475 Bonneville, like other utilities and government agencies, experiences incidents of criminal
6476 activity such as vandalism, theft, and burglary. Some of these incidents cause substantial
6477 operational and financial impacts to the agency. Between 2007 and 2009, Bonneville
6478 experienced approximately 128 incidents of burglary, theft, and vandalism. These incidents cost
6479 the agency approximately \$1,624,110. The Bonneville Security and Emergency Response Office
6480 works closely with Federal Law Enforcement Agencies, and local and state police to ensure all
6481 incidents are appropriately reported, investigated, and prosecuted. This effort has resulted in
6482 the return of BPA property and in court ordered restitution to be paid by the convicted parties.

6483 Issues concerning international terrorist activity, domestic terrorism and sabotage remain a
6484 significant concern for Bonneville and other critical infrastructure operators. Bonneville
6485 maintains close liaisons with Federal Law Enforcement Agencies, Department of Homeland
6486 Security, and Local jurisdictions to ensure effective communication of information and
6487 intelligence. The impacts from vandalism, theft, and burglary, though expensive, do not
6488 generally cause a disruption of service to the area. Stealing equipment from electrical
6489 substations, however, can be extremely dangerous. Federal and other utilities use physical
6490 deterrents such as fencing, cameras, and warning signs to help prevent theft, vandalism, and
6491 unauthorized access to facilities. In addition, through its Crime Witness Program, Bonneville
6492 offers up to \$25,000 for information that leads to the arrest and conviction of individuals
6493 committing crimes against Bonneville facilities. Anyone having such information can call
6494 Bonneville's Crime Witness Hotline at (800) 437-2744. The line is confidential, and rewards are
6495 issued in such a way that the caller's identity remains confidential.

6496 Acts of sabotage or terrorism on electrical facilities in the Pacific Northwest are rare, though
6497 some have occurred. These acts generally focused on attempts to destroy large transmission
6498 line steel towers. Depending on the size and voltage of the line, destroying towers or other
6499 equipment could cause electrical service to be disrupted to utility customers and end users. The
6500 effects of these acts would be as varied as those from the occasional sudden storm, accident or

6501 blackout and would depend on the particular configuration of the transmission system in the
6502 area.

6503 When a loss of electricity occurs, all services provided by electrical energy cease. Illumination is
6504 lost. Lighting used by residential, commercial, industrial and municipal customers for safe
6505 movement and security is affected. Residential consumers lose heat. Electricity for cooking and
6506 refrigeration is also lost, so residential, commercial, and industrial customers cannot prepare or
6507 preserve food and perishables. Residential, commercial, and industrial customers experience
6508 comfort/safety and temperature impacts, increases in smoke and pollen, and changes in
6509 humidity, due to loss of ventilation. Mechanical drives stop, causing impacts as elevators, food
6510 preparation machines, and appliances for cleaning, hygiene, and grooming are unavailable to
6511 residential customers. Commercial and industrial customers also lose service for elevators, food
6512 preparation, cleaning, office equipment, heavy equipment, and fuel pumps. In addition,
6513 roadways experience gridlock where traffic signals fail to operate. Mass transit that depends on
6514 electricity, such as light rail systems, can be impacted. Sewage transportation and treatment
6515 can be disrupted.

6516 A special problem is the loss of industrial continuous process heat. Electricity loss also affects
6517 alarm systems, communication systems, cash registers, and equipment for fire and police
6518 departments. Loss of power to hospitals and people on life-support systems can be life-
6519 threatening.

6520 While the likelihood for sabotage or terrorist acts on the Preferred Alternative, No Action
6521 Alternative or Multiple Objective Alternatives is difficult to predict given the varied nature and
6522 wide geographic scope of the project, it is unlikely that such acts would occur. If such an act did
6523 occur, it could have a significant impact on electrical service because of the integral role these
6524 projects play in hydropower generation in the Pacific Northwest. The Department of Energy,
6525 including Bonneville, the Corps and Reclamation as well as public and private utilities, and
6526 energy resource developers include the security measures mentioned above and others to help
6527 prevent such acts and to respond quickly if human or natural disasters occur.

6528 **7.14 CONCLUSION**

6529 The Preferred Alternative contains a variety of measures to meet the Purpose and Need
6530 Statement and objectives developed for the EIS. Many of the new measures are intended to
6531 improve conditions for ESA-listed fish and lamprey. The remaining measures are intended to
6532 provide more flexible ways for the co-lead agencies to meet water demands for fish and
6533 wildlife, flood risk management, water supply, and hydropower in the Columbia Basin. Where
6534 appropriate, mitigation measures have been incorporated into the Preferred Alternative to
6535 offset new adverse impacts when compared to the No Action Alternative. Ongoing programs,
6536 operation and maintenance activities would continue from 2016 unless otherwise described.
6537 Preliminary measures agreed to by the co-lead agencies for compliance with the ESA Section
6538 7(a)(2) are also included. These may be modified or added to as the ESA consultation process is
6539 currently ongoing.

38 **8.3 FISH AND WILDLIFE CONSERVATION**

39 **8.3.1 Fish and Wildlife Conservation Act of 1980**

40 The Fish and Wildlife Conservation Act of 1980 (16 U.S.C. § 2901 et seq.) acknowledges the
41 historical focus of fish and wildlife conservation programs on recreationally and commercially
42 important species, without provisions for the conservation and management of nongame fish
43 and wildlife. This act encourages all Federal departments and agencies to utilize their statutory
44 and administrative authority, to the maximum extent practicable and consistent with each
45 agency's statutory responsibilities, to conserve and to promote conservation of nongame fish
46 and wildlife and their habitats through the implementation of conservation plans and programs
47 for nongame fish and wildlife. The co-lead agencies are in the process of consulting with USFWS
48 concerning fish and wildlife resources that could be affected by the Preferred Alternative. In
49 addition, the co-lead agencies worked with various cooperating agencies, including the Oregon
50 Department of Fish and Wildlife, Washington Department of Fish and Wildlife, Idaho
51 Department of Fish and Game, and Montana Fish, Wildlife & Parks, on recommendations to
52 avoid and minimize potential impacts to fish and wildlife resources. Mitigation designed to
53 avoid and minimize impacts to fish and wildlife and their habitat is identified in Chapter 5.

54 **8.3.2 Fish and Wildlife Coordination Act of 1934**

55 The Fish and Wildlife Coordination Act of 1934, as amended (16 U.S.C. §§ 661–667e), provides
56 authority for USFWS and NMFS involvement in evaluating impacts to fish and wildlife from
57 proposed water resource development projects. It requires that fish and wildlife resources
58 receive equal consideration to other development project features. It requires Federal agencies
59 that construct, license, or permit water resource development projects to consult with the
60 USFWS, NMFS, and state resource agencies regarding the impacts on fish and wildlife resources
61 and measures to mitigate these impacts when waters of any stream or other body of water are
62 “proposed . . . to be impounded, diverted . . . or . . . otherwise controlled or modified . . .”
63 Section 2(b) requires the USFWS to produce a Coordination Act Report (CAR) that describes fish
64 and wildlife resources in a project area, potential impacts of a proposed project, and
65 recommendations for a project.

66 The U.S. Army Corps of Engineers (Corps) received the draft CAR on January 14, 2019, and it is
67 included in Appendix U. In the draft CAR, the USFWS provided landscape findings and
68 conservation recommendations for the No Action Alternative and the Multi-Objective
69 Alternatives relating to: natural hydrologic regimes; habitat connectivity and fish passage;
70 National Wildlife Refuges; habitat complexity and heterogeneity; invasive species; and
71 monitoring and adaptive management. The co-lead agencies considered the findings and
72 recommendations while finalizing the DEIS and, in particular, while developing mitigation
73 measures for the effects of the alternatives (see Chapter 5). Coordination between the co-lead
74 agencies and the USFWS regarding the draft CAR and the final CAR is ongoing. The USFWS will
75 be updating the CAR for the preferred alternative and conservation recommendations provided
76 therein will be considered. Further coordination with USFWS is necessary. The final CAR is
77 expected be completed for inclusion in the final EIS.

78 **8.3.3 Migratory Bird Treaty Act and Executive Order 13186, Responsibilities of Federal**
79 **Agencies To Protect Migratory Birds**

80 The Migratory Bird Treaty Act (16 U.S.C. §§ 703–712), as amended, protects over 800 bird
81 species and their habitat, and implements various treaties and conventions between the United
82 States and other countries, including Canada, Japan, Mexico, and Russia, for the protection of
83 migratory birds. Under the act, taking, killing, or possessing migratory birds, or their eggs or
84 nests, is unlawful. The act classifies most species of birds as migratory, except for upland and
85 non-native birds such as pheasant, chukar, gray partridge, house sparrow, European starling,
86 and rock dove. Executive Order 13186, dated January 10, 2001, directs Federal agencies to
87 evaluate the effects of their actions on migratory birds, with emphasis on species of concern,
88 and inform USFWS of potential negative effects to migratory birds.

89 The U.S. Department of Energy (DOE) and USFWS signed a Memorandum of Understanding
90 (MOU), which is in the process of being renewed, that addresses migratory bird conservation in
91 accordance with Executive Order 13186 (DOE and USFWS 2013). The MOU addresses how both
92 agencies can work cooperatively to address migratory bird conservation and includes specific
93 measures to consider applying during project planning and implementation. Bonneville Power
94 Administration (Bonneville) follows this MOU to minimize potential impacts on migratory birds.

95 Prior to implementation of the Preferred Alternative, the co-lead agencies would coordinate
96 with USFWS if it is determined there will be effects to migratory birds.

97 **8.3.4 Marine Mammal Protection Act**

98 The Marine Mammal Protection Act (MMPA) of 1972 (16 U.S.C. §§ 1361–1407) prohibits the
99 take of marine mammals, including harassment, hunting, capturing, collecting, or killing, except
100 through permits and authorizations under the MMPA. The co-lead agencies would determine if
101 there are effects to marine mammals prior to implementation of the Preferred Alternative.

102 **8.3.5 Magnuson-Stevens Fishery Conservation and Management Act**

103 The Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. § 1801 et seq.)
104 requires Federal agencies to consult with NMFS on activities that may adversely affect Essential
105 Fish Habitat (EFH). The objective of an EFH assessment is to determine whether the proposed
106 action(s) “may adversely affect” designated EFH for relevant commercial, federally managed
107 fisheries species within the proposed action area. EFH includes those waters and substrate
108 necessary for fish spawning, breeding, feeding, or growth to maturity. The biological
109 assessment (appended to this EIS) describes conservation measures proposed to avoid,
110 minimize, or otherwise offset potential adverse effects to designated EFH resulting from the
111 proposed action.

112 The co-lead agencies are in consultation with NMFS on effects to EFH in conjunction with the
113 ESA Section 7 consultation.

114 **8.3.6 Pacific Northwest Electric Power Planning and Conservation Act**

115 Provisions of the Northwest Electric Power Planning and Conservation Act of 1980 (Northwest
116 Power Act) (16 U.S.C. § 839 et seq.) require Bonneville to balance multiple public duties and
117 purposes: helping to ensure the Pacific Northwest has an adequate, efficient, economical, and
118 reliable power supply; promoting energy conservation and the use of renewable resources;
119 and, consistent with the program developed by the Northwest Power and Conservation Council
120 (NW Council), protecting, enhancing, and mitigating fish and wildlife to the extent affected by
121 the development and operation of the Federal Columbia River Power System (FCRPS), which
122 includes the Columbia River System (CRS). Bonneville complies with these provisions of the
123 Northwest Power Act through the Fish and Wildlife Program and other actions.

124 Under the Northwest Power Act, Bonneville, the Corps, and the Bureau of Reclamation
125 (Reclamation) exercise their responsibilities of operating the CRS in a manner that provides
126 equitable treatment for fish and wildlife and with the other purposes for which CRS facilities are
127 operated and managed. In addition, the co-lead agencies consider in their decision making the
128 NW Council's Fish and Wildlife Program and Mainstem Amendments to the fullest extent
129 possible.

130 **8.3.7 Bald and Golden Eagle Protection Act**

131 The Bald and Golden Eagle Protection Act (16 U.S.C. §§ 668–668c) prohibits anyone without a
132 permit issued by the Secretary of the Interior from “taking” eagles, including their parts, nests,
133 or eggs. The act applies criminal penalties for persons who “take, possess, sell, purchase,
134 barter, offer to sell, purchase or barter, transport, export or import, at any time or any manner,
135 any [bald or golden] eagle alive or dead, or any part, nest, or egg thereof.” The act defines
136 “take” as “pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb.”

137 Prior to implementation of the Preferred Alternative, the appropriate co-lead agency would
138 determine if those activities would have the potential to take bald and golden eagles and
139 coordinate with USFWS. Effects from operational measures in the Multiple Objective
140 Alternatives (MOs) are anticipated to not exist or be negligible.

141 **8.4 CULTURAL RESOURCES**

142 **8.4.1 National Historic Preservation Act**

143 The National Historic Preservation Act (54 U.S.C. § 306108) and its implementing regulations,
144 36 Code of Federal Regulations (C.F.R.) Part 800, provides a regulatory framework for the
145 identification, documentation, and evaluation of historic and cultural resources that may be
146 affected by Federal undertakings. Under the act, Federal agencies must take into account the
147 effects of their undertakings on historic properties, including resources that are listed or are
148 eligible for listing in the National Register of Historic Places, and afford the Advisory Council on
149 Historic Preservation a reasonable opportunity to comment on such undertaking. Additionally,

150 a Federal agency shall consult with any tribe that attaches religious and cultural significance to
151 such properties.

152 After reviewing the changes in operations, maintenance, and configuration proposed as a part
153 of the Preferred Alternative, the co-lead agencies have determined that the existing
154 Systemwide Programmatic Agreement (SWPA) would cover the co-lead agencies'
155 responsibilities under the National Historic Preservation Act Section 106 for all proposed
156 operations, and many structural measures, under the Preferred Alternative. For proposed
157 structural measures not covered by the SWPA, separate Section 106 compliance would be
158 completed prior to construction, when sufficient, site-specific information on the undertaking
159 becomes available.

160 **8.4.2 Archaeological Resources Protection Act**

161 The Archaeological Resources Protection Act (ARPA) of 1979 (16 U.S.C. §§ 470aa–470mm;
162 Public Law 96-95, as amended) protects archaeological resources and sites on public and Indian
163 lands and fosters increased cooperation and exchange of information between governmental
164 authorities, the professional archaeological community, and private individuals. The act
165 established civil and criminal penalties for the destruction or alteration of cultural resources.

166 Unlike the National Historic Preservation Act, ARPA does not have a general consultation
167 requirement. Therefore, there is nothing specifically that the co-lead agencies would need to
168 do as a part of considering these changes in operations, maintenance, or configurations. In the
169 case of some of the proposed MOs, agencies may need to adjust their monitoring of
170 archaeological resources to see if changes in operations increase the amount of intentional
171 destruction, alteration, or unpermitted artifact collection by leaving the sites more exposed. For
172 all the MOs except MO3, this monitoring could be accommodated within the existing FCRPS
173 Cultural Resources Program. In the case of MO3, where the return of the lower Snake River to
174 pre-reservoir conditions would likely expose hundreds of sites inundated since the late 1960s
175 and early 1970s, additional law enforcement patrols would likely be needed in order to deter
176 unpermitted artifact collection or other acts prohibited under ARPA. Under the Preferred
177 Alternative, the primary land managing co-lead agencies (Reclamation, Corps) would continue
178 to issue ARPA-related permits to outside project proponents for any professional investigations
179 related to known archaeological sites, or surveys for unknown archaeological sites/items,
180 occurring on their respectively managed Federal land.

181 **8.4.3 Antiquities Act**

182 The Antiquities Act of 1906 (54 U.S.C. §§ 320301–320303; Public Law 59-209) gives the
183 President of the United States authority to create national monuments to protect important
184 natural, cultural, or scientific features and resources. The act requires a permit be issued from
185 the secretary of the department with land management responsibilities prior to any excavation
186 of archaeological material. It further requires all material excavated as a result of an Antiquities
187 Permit be properly housed in a museum or facility. This act is considered to be the beginning of
188 a long tradition of cultural resources management and protection by the Federal government.

189 The majority of archaeological permitting now occurs under ARPA (see above), and the co-lead
190 agencies do not anticipate taking any specific actions regarding implementation of the
191 Antiquities Act as a part of developing this EIS, as none of the actions will likely involve specific
192 Antiquities Act permitting actions or involve the creation of any national monuments.

193 **8.4.4 Native American Graves Protection and Repatriation Act**

194 The Native American Graves Protection and Repatriation Act (25 U.S.C. §§ 3001–3013; Public
195 Law 101-601) describes the rights of Native American lineal descendants, Indian tribes, and
196 Native Hawaiian organizations with respect to the treatment, repatriation, and disposition of
197 Native American human remains, funerary objects, sacred objects, and objects of cultural
198 patrimony, with which they can show a relationship of lineal descent or cultural affiliation.

199 This act does lay out a consultation process between Federal agencies and tribes, but these
200 consultations are focused on how the agencies will handle human remains and other funerary
201 and associated items in the event they are subsequently discovered. There is not a general
202 consultation requirement triggered by changes in operations, maintenance, or configuration
203 under the Preferred Alternative. The existing Cultural Resources Program maintained by the co-
204 lead agencies addresses discoveries of human remains and works to repatriate remains and
205 associated funerary objects currently held in museums, and those activities would continue
206 under the Preferred Alternative.

207 **8.4.5 American Indian Religious Freedom Act**

208 The American Indian Religious Freedom Act of 1978 (AIRFA) (42 U.S.C. § 1996) establishes
209 protection and preservation of Native Americans' rights of freedom of belief, expression, and
210 exercise of traditional religions. These rights include, but are not limited to, access to sacred
211 sites, freedom to worship through traditional ceremonial rites, and the possession and use of
212 objects traditionally considered sacred by their respective cultures. The act requires policies of
213 all governmental agencies to accommodate access to, and use of, Native American religious
214 sites to the extent that the use is practicable and is consistent with an agency's essential
215 missions.

216 The co-lead agencies do not anticipate taking any actions under the Preferred Alternative that
217 would infringe upon the rights afforded under the AIRFA to area Native American tribes. The
218 co-lead agencies would continue to consult and work with area tribes to protect and provide
219 access to sacred sites on CRS Federal lands, when possible and practicable to do so.

220 **8.4.6 Paleontological Resources Preservation Act**

221 The Paleontological Resources Preservation Act (PRPA) was passed in 2009 as a part of the
222 Omnibus Public Land Management Act of 2009 (16 U.S.C. §§ 470aaa - 470aaa-11; Public
223 Law 111-11). PRPA directs the Department of Agriculture (U.S. Forest Service) and the
224 Department of the Interior (National Park Service, Bureau of Land Management, Reclamation,
225 and USFWS) to implement comprehensive paleontological resource management programs. It

226 does not apply to Department of Defense lands. While opening some Federal lands to casual
227 collecting, PRPA makes it clear that collection of vertebrate fossils from Federal land will be
228 done under the terms of a permit only. It criminalizes collection of some paleontological
229 resources without a permit, and also establishes civil penalties. The U.S. Forest Service has
230 already adopted regulations implementing PRPA for use on their lands, and the Department of
231 the Interior is nearing finalization of their regulations. Under the Preferred Alternative,
232 Reclamation will continue to manage and protect paleontological resources as necessary.

233 **8.4.7 Curation of Federally Owned and Administered Collections**

234 Specific federal regulations, 36 C.F.R. Part 79 (16 U.S.C. §§ 470aa-mm, 16 U.S.C. § 470 et seq.)
235 were promulgated by the National Park Service to create standards and guidelines for the long-
236 term preservation and management of archaeological collections. This includes all collections
237 recovered under the authority of the Antiquities Act (16 U.S.C. §§ 431-433), the Reservoir
238 Salvage Act (16 U.S.C. §§ 469-469c), Section 110 of the National Historic Preservation Act (16
239 U.S.C. § 470h-2), or ARPA (16 U.S.C. §§ 470aa-mm). Under the Preferred Alternative, the co-
240 lead agencies would continue to implement the existing Cultural Resources Program which
241 ensures the ongoing responsibility of managing Federal archaeological collections generated
242 from Federal lands as a result of project construction, operations, and maintenance.

243 **8.5 CLEAN WATER ACT OF 1972**

244 The Federal Water Pollution Control Act of 1972 (33 U.S.C. § 1251 et seq.) is more commonly
245 referred to as the Clean Water Act (CWA). This act is the primary legislative vehicle for Federal
246 pollution control programs and the basic structure for regulating discharges of pollutants into
247 waters of the U.S. The CWA was established to “restore and maintain the chemical, physical,
248 and biological integrity of the nation’s waters.” The CWA sets goals to eliminate discharges of
249 pollutants into navigable waters, protect fish and wildlife, and prohibit the discharge of toxic
250 pollutants in quantities that could adversely affect the environment. The sections of the CWA
251 that may apply to the Preferred Alternative are Section 401, regarding state water quality
252 certifications that existing water quality standards would not be violated if a Federal permit
253 that causes discharges into navigable waters were issued; Section 402, regarding discharges of
254 pollutants from point sources under the National Pollutant Discharge Elimination System
255 (NPDES); and Section 404, regarding fill material discharged into the waters of the U.S.,
256 including wetlands.

257 Section 401 water quality certifications would be obtained for project-specific structural
258 measures, as required, prior to construction. Section 402 of the CWA also established the
259 national pollutant discharge elimination system for permitting point-source discharges to
260 waters of the U.S. The Corps and Reclamation have filed applications for Clean Water Act,
261 Section 402 permits for nine mainstem dams on the Columbia and Snake Rivers. The permits
262 are intended to regulate discharges of pollutants, including lubricants and heat additions from
263 cooling water, from point sources at these dams. The permit applications have been pending
264 since 2015, but no permits to date have been issued by the EPA or Oregon Department of

265 Environmental Quality. Compliance with Section 404 would be conducted prior to construction
266 of the project-specific structural measures, if needed.

267 The Spill Prevention Control and Countermeasures Rule (40 C.F.R. Part 112) includes
268 requirements to prevent discharges of oil and oil-related materials from reaching navigable
269 waters and adjoining shorelines. It applies to facilities with total aboveground oil storage
270 capacity (not actual gallons onsite) of greater than 1,320 gallons and facilities with
271 belowground storage capacity of 42,000 gallons. Construction activities associated with the
272 structural measures would comply with this rule in implementing the MOs, if needed.

273 **8.6 CLEAN AIR ACT OF 1972**

274 The Clean Air Act, as amended (42 U.S.C. § 7401, et seq.), requires EPA and the states to carry
275 out programs intended to ensure attainment of National Ambient Air Quality Standards
276 (NAAQS). EPA is authorized to establish air quality standards for six “criteria” air pollutants:
277 carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter (PM_{2.5}, PM₁₀), and sulfur
278 dioxide. EPA uses these six criteria pollutants as indicators of air quality. EPA has established
279 NAAQS for each criteria pollutant, which defines the maximum allowable concentration. If the
280 standard for a pollutant is exceeded, adverse effects on human health may occur. When an
281 area exceeds these standards, it is designated as a nonattainment area.

282 The General Conformity Requirements of the C.F.R. require that Federal actions do not
283 interfere with state programs to improve air quality in nonattainment areas. There are several
284 nonattainment areas in the study area, as well as several maintenance areas. Currently, the
285 only nonattainment areas in the region are for PM_{2.5} (in Oakridge County, Oregon; West Silver
286 Valley, Idaho; and Libby, Montana), and PM₁₀ (in Lane County, Oregon; Fort Hall Indian
287 Reservation, Idaho; and multiple counties in Montana).

288 Of the six criteria air pollutants, PM is the main concern for the activities associated with the
289 operation and maintenance of the CRS, including construction and navigation. PM₁₀ are
290 particles with an aerodynamic diameter smaller than 10 micrometers and include “dust, dirt,
291 soot, smoke, and liquid droplets directly emitted into the air by sources such as factories,
292 power plants, cars, construction activity, fires, and natural windblown dust” (EPA 2003). PM_{2.5}
293 are “fine particles” with an aerodynamic diameter smaller than 2.5 micrometers. PM_{2.5} particles
294 can be “directly emitted from sources such as forest fires or they can form when gases emitted
295 from power plants, industry and automobiles react in the air” (EPA 2006).

296 In the study area, authority for ensuring compliance with the Clean Air Act is delegated to the
297 Washington Department of Ecology, Southwest Region; the Oregon DEQ; the Montana DEQ;
298 and the Idaho DEQ. Each agency has regulations requiring all industrial activities (including
299 construction projects) to minimize windblown fugitive dust through prevention of fugitive dust
300 becoming airborne and by maintaining and operating sources to minimize emissions: Revised
301 Code of Washington, Chapter 70.94 (Washington Clean Air Act) and Washington Administrative
302 Code, Chapter 173.400 (general regulations for air pollution sources); Oregon Revised Statutes,
303 Chapter 468a (Oregon air quality statutes) and Oregon Administrative Rules, Divisions 200–268

304 (Oregon air quality rules); Idaho Administrative Procedures Act 58.01.01, et seq. (Idaho air
305 quality rules for control of air pollution in Idaho); and Montana Code Annotated 75-2-101, et
306 seq. (Montana).

307 Consistent with Chapter 3, due to the reduction in hydropower generation, air quality under
308 the Preferred Alternative would most likely be degraded slightly, and greenhouse gas (GHG)
309 emissions would most likely increase by an estimated 0.54 metric ton per year (or 0.33 percent)
310 across the Western Interconnection. In the Pacific Northwest region, GHG emissions would
311 increase by 0.26 million metric ton (or 0.70 percent) compared to the No Action Alternative.
312 Other emissions sources (e.g., navigation, construction, fugitive dust) are most likely to have a
313 negligible effect on air quality and GHG emissions relative to the No Action Alternative across
314 the basin. Effects to air quality are expected to be negligible across the basin, including any
315 potential impacts to nonattainment or maintenance areas. Most effects related to construction
316 activities at the projects are expected to be temporary and short term.

317 Based on available information, however, the effects from the Preferred Alternative on air
318 quality and greenhouse gases (GHG) suggest air quality would have negligible adverse effects
319 based on increased GHG emissions from the replacement power for hydropower generation.
320 Other emissions sources (e.g., construction, fugitive dust) are likely to have a negligible effect
321 on air quality and GHG emissions and are expected to be temporary and short-term.

322 Consistent with Chapter 6, the co-lead agencies determined Reasonably Foreseeable Future
323 Actions (RFFAs) 1, 3, 4, 5, and 20 would likely impact air quality and GHG emissions. Overall,
324 hydropower generation would decrease under the Preferred Alternative, and climate change is
325 likely to add additional uncertainty to the annual magnitude of generation, and uncertainty to
326 the monthly magnitude. This reduction in hydropower combined with RFFAs, such as increased
327 human development and resulting demand for energy, could lead to a minor cumulative impact
328 on air quality and GHG emissions.

329 **8.7 FARMLAND PROTECTION POLICY ACT**

330 The Farmland Protection Policy Act (7 U.S.C. § 4201 et seq.; 7 C.F.R. Part 658) of 1981 was
331 authorized to minimize the unnecessary and irreversible conversion of farmland to
332 nonagricultural use due to Federal projects. This act protects Prime and Unique farmland, and
333 land of statewide or local importance. The Farmland Protection Policy Act protects forestland,
334 pastureland, cropland, or other land that is not water or urban developed land. The Farmland
335 Protection Policy Act requires a Federal agency to consider the effects of its actions and
336 programs on the Nation's farmlands. This act is implemented by the Natural Resources
337 Conservation Service (NRCS). The NRCS is authorized to review Federal projects to see if the
338 project is regulated by the Farmland Protection Policy Act and establish what the farmland
339 conversion impact rating is for a Federal project.

340 The co-lead agencies would coordinate with NRCS, as appropriate, prior to construction of any
341 new structural measures under the Preferred Alternative, if needed.

342 **8.8 FEDERAL NOXIOUS WEED ACT**

343 This act, as amended in 2009, directs Federal agencies to manage undesirable plant species on
344 Federal lands when management programs for those species are in place on state or private
345 land in the same area. Undesirable plant species are defined as those that are classified as
346 undesirable, noxious, harmful, exotic, injurious, or poisonous, pursuant to state or Federal law.
347 A noxious weed list (7 C.F.R. § 360.200) is developed by the Secretary of Agriculture, which lists
348 noxious weeds (as defined by the Plant Protection Act) that are subject to restrictions on
349 interstate movement (7 U.S.C. § 7712). Construction activities associated with the structural
350 measures would comply with this statute in implementing the Preferred Alternative, if needed.
351 In addition, the existing invasive species management plans would continue under the
352 Preferred Alternative.

353 **8.9 RECREATION RESOURCES**

354 **8.9.1 Federal Water Project Recreation Act**

355 In the planning of any Federal navigation, flood control, reclamation, or water resources
356 project, the Federal Water Project Recreation Act, as amended (16 U.S.C. § 460l-12 et seq.)
357 requires that full consideration be given to the opportunities that the project affords for
358 outdoor recreation and fish and wildlife enhancement. The act requires planning with respect
359 to development of recreation potential. Projects must be constructed, maintained, and
360 operated in such a manner if recreational opportunities are consistent with the purpose of the
361 project.

362 Effects to recreation analyzed for the Preferred Alternative are described in Section 7.7.

363 **8.9.2 Wild and Scenic Rivers Act**

364 The Wild and Scenic Rivers Act (16 U.S.C. § 1271 et seq.) establishes a National Wild and Scenic
365 Rivers System to preserve, protect, and enhance the wilderness qualities, scenic beauties, and
366 ecological regimes of rivers and streams. Any construction within 100 feet of a scenic stream
367 requires a scenic streams permit.

368 The Preferred Alternative would not affect any wild and scenic rivers because there are no wild
369 and scenic river sections in the CRS.

370 **8.10 RIVERS AND HARBORS APPROPRIATION ACT OF 1899**

371 Section 10 of the Rivers and Harbors Appropriation Act of 1899 (33 U.S.C. § 403 et seq.),
372 commonly known as the Rivers and Harbors Act, prohibits the construction of any wharf, pier,
373 dolphin, boom, weir, breakwater, bulkhead, jetty, or other structures in any navigable water
374 without Congressional consent or approval by the Corps. Section 10 regulates structures in or
375 over any navigable water of the U.S., the excavating from or depositing of material in such
376 waters, or the accomplishment of any other work affecting the course, location, condition, or
377 capacity of such waters. Section 9 of the Rivers and Harbors Act (33 U.S.C. § 491) grants the

378 authority to approve the construction or modification of bridges over any of the navigable
379 waters of the U.S. to the U.S. Coast Guard. The Columbia River and its major tributaries, Snake,
380 Clark Fork, and Kootenai Rivers, are designated navigable waters under the Rivers and Harbor
381 Act.

382 Effects to navigable waters from the Preferred Alternative are described in Section 7.7. A
383 determination of whether a Section 9 or 10 permit would be required will be made prior to
384 construction of the project-specific structural measures. It is not anticipated that the co-lead
385 agencies would need to obtain a Section 9 permit from the U.S. Coast Guard.

386 **8.11 HAZARDOUS WASTE**

387 **8.11.1 Comprehensive Environmental Response, Compensation, and Liability Act**

388 The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as
389 amended (42 U.S.C. § 9601 et seq.), which was later amended by the Superfund Amendments
390 and Reauthorization Act of 1986, sets forth regulations for cleanup of hazardous substances
391 after improper disposal; identifies federal response authority; and outlines responsibilities and
392 liabilities of potentially responsible parties, who are past/present owners or operators of the
393 site, a person who arranged disposal of hazardous substances at a site, or a person who
394 transported hazardous substances to a site they selected for disposal. CERCLA also specifies
395 where Superfund money can be used for site cleanup.

396 Any hazardous waste generated from the implementation of the Preferred Alternative would
397 be properly disposed of, in accordance with applicable Federal and state laws. If contamination
398 is found during the operations, maintenance, or construction activities associated with the
399 Preferred Alternative, the co-lead agencies will comply with CERCLA.

400 **8.11.2 Resource Conservation and Recovery Act**

401 The Resource Conservation and Recovery Act, as amended (42 U.S.C. § 6901 et seq.), is
402 designed to provide a program for managing and controlling hazardous waste by imposing
403 requirements on generators and transporters of this waste, and on owners and operators of
404 treatment, storage, and disposal facilities. Each treatment, storage, and disposal facility owner
405 or operator is required to have a permit issued by EPA or the state. Construction, operation,
406 and maintenance activities at the CRS projects could generate hazardous wastes under the
407 Preferred Alternative. These materials would be disposed of according to the Resource
408 Conservation and Recovery Act and applicable state law.

409 **8.11.3 Toxic Substances Control Act**

410 The Toxic Substances Control Act (15 U.S.C. § 2601 et seq.) is intended to protect human health
411 and the environment from toxic chemicals. Section 6 of the act regulates the use, storage, and
412 disposal of polychlorinated biphenyls (PCBs). Any equipment that may have PCBs that is

413 removed from the CRS projects as part of the implementation of the Preferred Alternative will
414 be handled according to the disposal provisions of the Toxic Substances Control Act.

415 **8.12 EXECUTIVE ORDER 11990, PROTECTION OF WETLANDS**

416 Executive Order 11990, dated May 24, 1977, requires Federal agencies to take action to avoid
417 adversely impacting wetlands wherever possible, to minimize wetland destruction and preserve
418 the values of wetlands, and to prescribe procedures to implement the policies and procedures
419 of this executive order. In addition, Federal agencies shall incorporate floodplain management
420 goals and wetlands protection considerations into its planning, regulatory, and decision-making
421 processes.

422 Prior to any construction activities associated with the new structural measures of the
423 Preferred Alternative, wetland surveys would be conducted to determine if there are any
424 wetlands that would be affected. If wetlands are identified, applicable best management
425 practices and mitigation would be implemented.

426 As part of the NEPA review, DOE NEPA regulations require that effects on wetlands be assessed
427 and alternatives for protection of these resources be evaluated in accordance with the
428 Compliance with Floodplain/Wetlands Environmental Review Requirements (10 C.F.R. §
429 1022.12) and Executive Order 11990 (Protection of Wetlands). An evaluation of effects of the
430 MOs and Preferred Alternative on wetlands is discussed in more detail in Sections 3.6.3 and 7.6
431 of this EIS. Mitigation measures to address impacts to wetlands are found in Chapters 5 and 7.

432 **8.13 EXECUTIVE ORDER 11988, FLOODPLAIN MANAGEMENT**

433 Executive Order 11988, dated May 24, 1977, states that each Federal agency shall take action
434 to reduce the risk of flood loss, minimize the impacts of floods on human safety, and restore
435 and preserve the natural values of floodplains while carrying out its responsibilities for (1)
436 acquiring, managing, and disposing of Federal lands; (2) providing Federal investments in
437 construction and improvements; and (3) conducting activities affecting land use, including
438 water resources planning and regulating activities. To comply with this order, each Federal
439 agency has a responsibility to evaluate the potential effects of any actions it may take in the
440 floodplain, to ensure its planning programs consider flood hazards and floodplain management,
441 and to implement the policies and requirements of the order.

442 For the Preferred Alternative, no increase in flood risk is expected due to future operations,
443 though decreases in flood risk may occur in some areas. The operational, maintenance, and
444 system configuration measures considered in the MOs do not propose or support physical
445 actions in floodplains, nor are they likely to induce development.

446 As part of the NEPA review, DOE NEPA regulations require that impacts on floodplains be
447 assessed and alternatives for protection of these resources be evaluated in accordance with the
448 Compliance with Floodplain/Wetlands Environmental Review Requirements (10 C.F.R. §
449 1022.12) and Executive Order 11988 (Floodplain Management). An evaluation of impacts of the

450 MOs on floodplains is discussed in more detail in Section 3.6.3 of this EIS. Mitigation measures
451 to address impacts to floodplains are found in Chapters 5 and 7. As directed by the DOE
452 regulations at 10 C.F.R. § 1022, the Floodplain Statement of Findings is provided in Section 3.6
453 of the EIS and would be documented in Bonneville’s Record of Decision.

454 **8.14 EXECUTIVE ORDER 12898, ENVIRONMENTAL JUSTICE**

455 Executive Order 12898, dated February 11, 1994, requires Federal agencies to consider whether
456 agency actions may have disproportionately high and adverse human health or environmental
457 effects on minority populations, low-income populations, and Indian tribes. For the purpose of
458 Executive Order 12898, minority populations include people of the following origins: African-
459 American, American Indian and Alaska Native, Native Hawaiian or Other Pacific Islander, and
460 Hispanic (of any race). Low-income populations are populations that are at or below the
461 poverty line, as established by the U.S. Department of Health and Human Services.

462 Based on the discussion, analysis, and mitigation described in Chapters 3, 4, 5, 6, and 7, the
463 Preferred Alternative would not cause disproportionately high and adverse effects on any
464 environmental justice populations in accordance with the provisions of Executive Order 12898.

465 **8.15 EXECUTIVE ORDER 13112, INVASIVE SPECIES, SAFEGUARDING THE NATION FROM THE**
466 **IMPACTS OF INVASIVE SPECIES**

467 Executive Order 13112, dated February 3, 1999, as amended December 5, 2016, under
468 Executive Order 13751 establishes “the policy of the United States to prevent the introduction,
469 establishment, and spread of invasive species, as well as to eradicate and control populations of
470 invasive species that are established.” Under this executive order, Federal agencies are
471 required to employ integrated pest management practices to prevent the introduction and
472 spread of invasive species and provide for the restoration of ecosystems that have been
473 invaded. Under the Preferred Alternative, the existing invasive species management plans
474 would continue.

475 **8.16 EXECUTIVE ORDER 13007, INDIAN SACRED SITES**

476 Executive Order 13007, dated May 24, 1996, directs Federal agencies to accommodate access
477 to and ceremonial use of Indian sacred sites by Indian religious practitioners. To the extent
478 practicable, permitted by law, and not clearly inconsistent with essential agency functions, the
479 co-lead agencies are to avoid adversely affecting the physical integrity of such sacred sites and
480 to maintain the confidentiality of sacred sites when appropriate. The order encourages
481 government-to-government consultation with tribes concerning sacred sites. Some sacred sites
482 may qualify as historic properties under the National Historic Preservation Act.

483 Pursuant to the order, the co-lead agencies for the CRSO EIS contacted 19 tribes to request
484 their assistance in identifying sacred sites within the study area. Kettle Falls and Bear Paw Rock
485 have been identified as sacred sites. The effects to these sacred sites under the Preferred
486 Alternative are negligible as described in Section 7.7.

487 **8.17 EXECUTIVE ORDER 11593, PROTECTION AND ENHANCEMENT OF THE CULTURAL**
488 **ENVIRONMENT**

489 Executive Order 11593, dated May 13, 1971, directs Federal agencies to provide leadership in
490 preserving, restoring, and maintaining the historic and cultural environment of the Nation. The
491 co-lead agencies are addressing compliance with Executive Order 11593 by complying with the
492 National Historic Preservation Act.

493 **8.18 EXECUTIVE ORDER 13175, CONSULTATION AND COORDINATION WITH INDIAN TRIBAL**
494 **GOVERNMENTS**

495 The United States has a unique legal relationship with Indian tribal governments as set forth in
496 the Constitution of the United States, treaties, statutes, executive orders, and court decisions.
497 This order directs federal agencies to formulate and establish “regular and meaningful
498 consultation and collaboration with tribal officials in the development of federal policies that
499 have tribal implications, to strengthen the United States government-to-government
500 relationships with Indian tribes, and to reduce the imposition of unfunded mandates upon
501 Indian tribes.” This consultation is meant to work toward a mutual consensus and is intended to
502 begin at the earliest planning stages, before decisions are made and actions are taken.

503 Consistent with this executive order, the co-lead agencies established a three-tiered process in
504 coordination with all 19 federally recognized tribes potentially affected by operations and
505 maintenance of the CRS. The three tiers include staff-level technical meetings and information
506 sharing, deputy-level policy meetings, and executive-level government-to-government
507 meetings. Throughout development of the CRSO EIS, all three tiers of meetings were used on a
508 regular basis to facilitate meaningful consultation. Additionally, each tribe was informed of the
509 opportunity to request government-to-government consultation with co-lead agency
510 leadership anytime they believed it was necessary.

511 **8.19 SECRETARIAL ORDER 3175, U.S. DEPARTMENT OF THE INTERIOR RESPONSIBILITIES FOR**
512 **INDIAN TRUST ASSETS**

513 Secretarial Order 3175 requires U.S. Department of the Interior bureaus and offices to consult
514 with the recognized tribal government with jurisdiction over the trust property that a proposal
515 may affect and ensure that any anticipated effects are explicitly addressed in planning,
516 decision, and operational documents including EISs. In compliance with Secretarial Order 3175,
517 this EIS has analyzed potential effects to Indian Trust Assets in Sections 3.17 and 7.7.

1 **CHAPTER 9 - COORDINATION AND PUBLIC INVOLVEMENT PROCESS**

2 The Council on Environmental Quality’s implementing regulations for the National
3 Environmental Policy Act (NEPA) specify public involvement requirements for preparing an
4 environmental impact statement (EIS). In response to those requirements, the co-lead agencies
5 implemented a comprehensive public involvement plan that identified and coordinated an
6 array of public involvement opportunities for the public to provide the co-lead agencies with
7 information that would help define the issues, concerns, and the scope of alternatives to be
8 addressed in the EIS. Due to the geographical scope and wide array of interests associated with
9 the Columbia River System (CRS), the public involvement process required considerable time
10 and resources to ensure meaningful engagement. Government-to-government consultations
11 with tribal sovereigns and coordination with regional governments also were an integral part of
12 the coordination process.

13 During the public scoping period, the co-lead agencies offered numerous educational
14 opportunities to the public that were aimed at helping interested parties understand how the
15 CRS currently operates. Columbia River Basin residents were encouraged to take advantage of
16 open-house public scoping meetings to learn more about the NEPA process and about the way
17 the co-lead agencies currently operate the CRS. Public meetings, outreach, and an interactive
18 project website offered the public multiple opportunities to provide scoping comments that
19 could help define the issues, concerns, and thoughts on system operations for consideration in
20 the EIS. The co-lead agencies reviewed, evaluated and incorporated feedback from public
21 involvement into the EIS.

22 Furthermore, the co-lead agencies used various communication tools throughout the process
23 to share progress made on the EIS and build an understanding of the NEPA process. The
24 following sections lay out the various components of the outreach efforts undertaken
25 throughout the NEPA process for the development of this EIS.

26 **9.1 FEDERAL REGISTER NOTICES AND PUBLIC SCOPING MEETINGS**

27 **9.1.1 Notice of Intent and Public Scoping Meetings**

28 The Notice of Intent (NOI) to prepare the EIS provided a summary of the intent of the co-lead
29 agencies to prepare an EIS, established a schedule of public meetings, and provided points of
30 contact for each of the co-lead agencies. The co-lead agencies published the NOI in the Federal
31 Register on September 30, 2016 (81 Federal Register 67,382). That same day, the co-lead
32 agencies sent public scoping letters to interested parties and placed an announcement on the
33 Columbia River System Operations (CRSO) website, www.crso.info. The public involvement
34 team also distributed a news release announcing the NOI and provided dates, times, and
35 venues for the public scoping meetings. The NOI invited anyone interested to help the co-lead
36 agencies identify issues and concerns to be analyzed in the EIS. As stated in the NOI, the co-lead
37 agencies used the public scoping process to gather comments on the preservation of historic
38 properties subject to consideration under the National Historic Preservation Act.

39 The co-lead agencies held 16 public scoping meetings across the region and two webinars
40 during public scoping to allow the public to ask questions in person and contribute their
41 comments and ideas on what should be included in the EIS. The scoping comment period,
42 which began September 30, 2016, was originally scheduled to end on January 17, 2017 (81
43 Federal Register 67,383). However, at the request of interested stakeholders, the co-lead
44 agencies extended the comment period by three weeks to February 7, 2017 (82 Federal
45 Register 137 [January 3, 2017]). Additionally, the co-lead agencies received a request to hold a
46 public meeting in the Tri-Cities area of Washington State. The co-lead agencies considered the
47 request and added a meeting in Pasco, Washington. The NOI for the Pasco meeting was
48 published in the Federal Register on November 4, 2016 (81 Federal Register 214 [November 4,
49 2016]). The Scoping Report (“Public Scoping Report for the Columbia River System Operations
50 Environmental Impact Statement,” Appendix S [Scoping Report]) includes these NOIs, as well as
51 detailed descriptions, times, and locations of scoping meetings.

52 The scoping meetings were held in an informal open-house format, with 35 poster stations
53 staffed by technical experts from the co-lead agencies. The style of meeting was chosen to
54 provide attendees an opportunity to ask questions, to have informal one-on-one discussions
55 with various subject matter experts, and to comment after reviewing information about the
56 CRS and how it is currently operated. All materials from the public meetings were available on
57 the CRSO website so that participants could review and comment.

58 Two webinars were held on December 13, 2016, to accommodate individuals who were not
59 able to attend one of the public meetings in person. The online webinars were staffed by
60 subject matter experts who presented the same visual material provided during the open-
61 house public meetings. Through the webinars, the public was able to submit questions and
62 comments.

63 An interdisciplinary team from the U.S. Army Corps of Engineers, Bureau of Reclamation, and
64 Bonneville Power Administration attended all public scoping meetings to provide subject
65 matter expertise. This included resource areas of the NEPA process, such as cultural resources,
66 CRS operations, flood risk management, hydropower, water supply, navigation, fish and wildlife
67 conservation, recreation, climate change, water quality, and endangered species. Project-
68 specific experts representing each of the 14 projects were also available at each meeting to
69 discuss features and operations of a specific dam or reservoir complex.

70 Meeting attendees were invited to submit public scoping comments at the meeting in
71 numerous ways, including: (1) verbally through a stenographer, (2) online at a computer
72 station, or (3) in hard copy form. Attendees were also advised that they could review all scoping
73 materials, including the video, online. Public scoping attendees could submit comments via
74 email, online using a prepared webform, or via a hard copy mailed to a post office box
75 established specifically to collect scoping comments for this project. All meeting materials and
76 all comments submitted during the scoping period can be viewed online at www.crso.info.

77 **9.1.2 Public Scoping Comments**

78 While over 2,300 people signed in at the public scoping meetings, the co-lead agencies received
79 over 400,000 comments that reflected the full breadth and scope of most issues present in the
80 basin. Of those, approximately 61,000 were considered unique comments. The Scoping Report
81 was produced and made available to the public on October 24, 2017. The Scoping Report is
82 included as Appendix S to the EIS and can be found on the project website at
83 <https://www.nwd.usace.army.mil/CRSO/SSR/>.

84 The list of scoping comment topics included:

- | | |
|-------------------------------------|--|
| 85 • NEPA Process | 100 • Wetlands and Vegetation |
| 86 • Public Scoping Process | 101 • Invasive and Nuisance Species |
| 87 • Alternatives | 102 • Cultural and Historic Resources |
| 88 • Scope of Analysis | 103 • Tribal Interests/Resources |
| 89 • Impact Analysis Methodologies | 104 • Flood Risk Management |
| 90 • Hydrology and Hydraulics | 105 • Power Generation/Energy |
| 91 • Climate Change | 106 • Power Transmission |
| 92 • Water Quality | 107 • River Navigation |
| 93 • Water Supply | 108 • Transportation of Goods and Fish |
| 94 • Air Quality | 109 • Recreation |
| 95 • Anadromous and Resident Fish | 110 • Socioeconomics and Environmental |
| 96 • Threatened and Endangered Fish | 111 Justice |
| 97 Species – Dam Configuration and | 112 • General Opposition to EIS |
| 98 Operation | 113 Development |
| 99 • Wildlife | 114 • General Support of EIS Development |

115 **9.2 PUBLIC COMMUNICATION TOOLS**

116 **9.2.1 News Releases**

117 The co-lead agencies issued numerous press releases intended to keep the public informed
118 about the EIS public scoping process. The press releases also were provided on the CRSO
119 website (<https://www.nwd.usace.army.mil/CRSO/CRSO-News/>). Each public meeting was
120 announced in at least two local newspapers, with advertisements running two to three times
121 beginning approximately two weeks prior to the meeting.

122 **9.2.2 Mailing Lists**

123 As indicated earlier, public scoping meeting attendees were invited to sign up for future
124 communications about the EIS. Mailing lists were developed and maintained throughout the
125 life of the NEPA process. Respondents were then categorized for the most efficient means for
126 distributing information and for tailoring specific communication needs. For example, media

127 outlets often have a general inbox for receiving news releases. While news releases were
128 distributed to media outlets throughout the region, co-lead agency communicators would then
129 send a copy of the news release to those reporters who signed up to receive the news release,
130 ensuring they received it in a timely manner.

131 **9.2.3 Website**

132 A public website was established at the time the NOI was published to communicate and share
133 information about the CRSO EIS: www.crso.info. The website announced public scoping
134 meeting dates, times, and locations in addition to providing all the information shared during
135 the public scoping meetings (e.g., overview video and posters). The public could also use the
136 comment submission link on the website to submit comments during the public comment
137 period. News releases, documents, and upcoming public meeting information were available to
138 the public through the website.

139 **9.2.4 Newsletters**

140 Co-lead agencies produced and distributed newsletters and featured stories, such as about the
141 NEPA process, project articles, fish passage, resources evaluated for EIS, and introducing a
142 range of alternatives. The co-lead agencies used mailing lists and the website as the primary
143 mechanisms for communicating with the public. Doing so allowed for timely distribution of
144 information. All products are available on the www.crso.info website and were delivered
145 electronically to the mailing list.

146 **9.2.5 Webinars**

147 Webinars offered direct contact with the public without the need for interested parties to
148 travel to interact with the co-lead agencies. The co-lead agencies held three stakeholder
149 meetings in October 2017 and public updates were held on December 7, 2017, and May 30,
150 2018. Some webinars, such as the webinar held on December 7, 2017, used a combination of
151 in-person presentations with others participating by web interaction—an attempt to reach as
152 many people as possible at one time. These webinars allowed for subject matter experts and
153 policy leads to engage with the public.

154 **9.2.6 Videos**

155 Two videos have been produced and posted on the website ([https://www.nwd.usace.army.
156 mil/CRSO/Documents/](https://www.nwd.usace.army.mil/CRSO/Documents/)) for audiences to view. The first video was used as an introduction to
157 the public scoping meetings. The second video was produced to walk interested audiences
158 through the range of alternatives and what to expect.

159 **9.3 FEDERALLY RECOGNIZED TRIBES AND TRIBAL ENTITIES**

160 Executive Order No. 13175, *Consultation and Coordination with Indian Tribal Governments*, calls
161 for regular and meaningful consultation and collaboration with tribal officials in the
162 development of Federal policies that have tribal implications and for strengthening

163 government-to-government relationships between the United States and tribal governments.
164 The co-lead agencies committed from the outset to consult with federally recognized tribes
165 throughout the process. The co-lead agencies engaged with tribes in technical-level
166 coordination, regional tribal meetings, and formal government-to-government consultation.
167 The co-lead agencies also worked closely with tribal entities, which include multiple tribes, such
168 as the Upper Snake River Tribes, Columbia River Intertribal Fish Commission, and the Upper
169 Columbia United Tribes. Furthermore, tribes were able to request technical or formal
170 government-to-government meetings at any time.

171 **9.3.1 Tribal Engagement During Public Scoping**

172 The co-lead agencies held a kickoff meeting to initiate discussions with potentially affected
173 tribes during the Affiliated Tribes of Northwest Indians 2016 Annual meeting on September 28,
174 2016. They discussed the overall NEPA process, proposed tribal consultation, and schedule.

175 As part of the co-lead agencies' CRSO EIS tribal outreach, four regional tribal meetings were
176 scheduled and took place the same days and locations as the public scoping meetings. The
177 same content and subject matter experts were available at both the tribal and public meetings.
178 Tribal members were welcome to attend any of the regional tribal meetings, as well as any of
179 the public scoping meetings.

180 Regional tribal outreach meetings were held:

- 181 • November 14, 2016, in Spokane, Washington
- 182 • November 29, 2016, in Boise, Idaho
- 183 • December 6, 2016, in The Dalles, Oregon
- 184 • December 7, 2016, in Portland, Oregon

185 **9.3.2 Government-to-Government Consultation and Tribal Engagement**

186 As previously stated, part of the government's treaty and trust responsibilities is for the Federal
187 government to consult on a government-to-government basis with Indian tribes. The
188 government-to-government relationship and the process for developing open and transparent
189 communication, effective collaboration, and informed Federal decision-making is described in
190 Executive Order (EO) 13175, *Consultation and Coordination with Indian Tribal Governments*; EO
191 13007, *Indian Sacred Sites*; Secretarial Order 3206, *American Indian Tribal Rights, Federal-Tribal*
192 *Trust Responsibilities, and the Endangered Species Act*; the November 5, 2009, *Presidential*
193 *Memorandum on Tribal Consultation*; and the April 29, 1994, *Presidential Memorandum on*
194 *Government-to-Government Relations with Native American Tribal Governments*. In addition,
195 Section 106 of the National Historic Preservation Act requires Federal agencies to consult with
196 Indian tribes on undertakings on tribal lands and on historic properties of significance to the
197 tribes that may be affected by an undertaking (36 Code of Federal Regulations [C.F.R.] § 800.2
198 (c)(2)). The co-lead agencies coordinated and consulted with tribal governments and engaged
199 with tribal leaders and their staff whose interests might be affected by activities proposed in
200 the CRSO EIS.

201 Government-to-government consultation was conducted throughout development of this EIS,
202 in accordance with provisions included in the executive orders and secretarial orders listed
203 above, and any additional applicable laws, as well as agency-specific regulations and guidance,
204 such as the following:

- 205 • DOI, Departmental Manual (DM), *Departmental Responsibilities for Indian Trust Resources*,
206 512 DM 2 (1995)
- 207 • DOI, Departmental Manual, *Departmental Responsibilities for Protecting/Accommodating*
208 *Access to Indian Sacred Sites*, 512 DM 3 (1998)
- 209 • Bonneville Power Administration Tribal Policy, DOE-BP/2971 (Revised 2016)
- 210 • 33 C.F.R. § 230.16 on Lead and Cooperating Agencies
- 211 • U.S. Department of Energy, 10 C.F.R. § 1021.342 on Interagency Cooperation

212 At the outset of the EIS, tribes were formally invited to enter into government-to-government
213 consultation on the CRSO EIS. The letters, sent by the co-lead agencies, provided notification of
214 the intent to prepare the CRSO EIS; initiated government-to-government consultation; and
215 invited the tribes to identify concerns related to historic properties, including traditional
216 cultural properties and archaeological sites, natural resources, relevant Indian Trust Assets, and
217 other issues of importance.

218 In addition to tribal engagement, some tribes decided to engage in the NEPA process as
219 cooperating agencies by entering into memoranda of understanding (MOUs) with the co-lead
220 agencies. Tribes were offered opportunities to participate through a variety of venues. The
221 amount of information that could be shared with tribes depended on whether the tribe was a
222 cooperating agency and whether the information request came through a request to the co-
223 lead agency or not. In addition, there were numerous other interactions ranging from one-on-
224 one phone calls to technical teams to special briefings.

225 A description of the three tiered tribal engagement levels (technical, deputy or policy, and
226 executive) is provided in Chapter 1.5.2.3. There were numerous technical level webinars and
227 meetings held throughout the process to discuss scoping, alternatives development, and
228 evaluation, as well as one-on-one meetings held to address technical considerations. Deputy
229 and executive level regional tribal meetings were also offered to consult with individual tribes,
230 designated as one-on-one engagements, following each regional meeting. Webinars and tribal
231 regional meetings were open to all 19 tribes. Below is a list of organized meetings that took
232 place throughout the NEPA process where tribes could participate in discussions about EIS
233 development.

234 ***Deputy Level Meetings***

- | | |
|--|---|
| 235 • August 9, 2017, in Boise, Idaho | 239 • August 18, 2017, in Portland, Oregon |
| 236 • August 10, 2017, in Spokane,
237 Washington | 240 • June 11, 2018, in Portland, Oregon |
| 238 • August 17, 2017, in The Dalles, Oregon | 241 • June 12, 2018, in Spokane, Washington |
| | 242 • June 13, 2018, in Boise, Idaho |

- 243 • February 2, 2019, in Grand Ronde,
- 244 Oregon
- 247 **Executive Level Meetings**

- 248 • August 30, 2017, -in Spokane,
- 249 Washington
- 250 • August 31, 2017, in Portland, Oregon
- 251 • January 9, 2019, in Boise, Idaho
- 252 • January 10, 2019, in Spokane,
- 253 Washington

- 245 • March 20, 2019, in Portland, Oregon
- 246 • April 9, 2019, in Spokane, Washington

- 254 • January 17, 2019, in Portland, Oregon
- 255 • November 5, 2019, in Portland, Oregon
- 256 • November 6, 2019, in Spokane,
- 257 Washington
- 258 • November 7, 2019, in Boise, Idaho
- 259 • December 19, 2019, in Lapwai, Idaho

260 **9.4 COOPERATING AGENCIES**

261 On November 4, 2016, in accordance with Title 40 C.F.R. § 1501.6 of the Council on
 262 Environmental Quality’s regulations for implementing NEPA and 43 C.F.R. § 46.225 of DOI’s
 263 regulations for implementing NEPA, the co-lead agencies invited -Federal, tribal, state, and local
 264 government agencies with jurisdiction over resources or areas of special expertise to
 265 participate in the development of the EIS as cooperating agencies. This was so that sovereign
 266 entities with special expertise or jurisdiction concerning the proposal, or both, could assist the
 267 co-lead agencies with various parts of EIS development. -The cooperating agencies signed
 268 MOUs with the co-lead agencies to assist in the EIS development and are listed in Table 9-1.

269 **Table 9-1. Columbia River System Operations Environmental Impact Statement Cooperating**
 270 **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
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 Transportation Department
<i>Oregon</i>
Department of Fish and Wildlife ^{1/}
Department of Energy

Cooperating Agencies
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 Tribes and Bands of the Yakama Nation
Kootenai Tribe of Idaho
Shoshone-Bannock Tribes
Nez Perce Tribe
Confederated Tribes of the Grand Ronde Community of Oregon
Spokane Tribe of Indians
Confederated Tribes of the Colville Reservation
Cowlitz Indian Tribe
Confederated Salish and Kootenai Tribes
Confederated Tribes of the Umatilla Indian Reservation
Intertribal Organization
Upper Snake River Tribes Foundation on behalf of Burns Paiute Tribe, Fort McDermitt Paiute-Shoshone Tribe, and Shoshone-Paiute Tribes of Duck Valley Reservation.

271 1/ Lead for that state's Memorandum of Understanding.

272 Cooperating agencies were given the opportunity to participate in regular meetings,
 273 workshops, and webinars related to the development of this EIS as related to their special
 274 expertise or jurisdiction. Individuals from the cooperating agencies routinely participated in
 275 various technical team meetings and activities. In addition, cooperating agencies reviewed and
 276 commented on a variety of EIS products related to the development of alternatives, analytical
 277 results, existing conditions, environmental impacts, full chapters, and lastly, reviewed and
 278 commented on the administrative Draft EIS. In addition, meetings, webinars, and workshops
 279 were conducted with cooperating agencies to assist in the refinement of initial alternatives and
 280 to provide general status updates.

281 On October 22, 2019, in response to feedback from the tribes and cooperating agencies,
 282 executives from the three co-lead agencies established an engagement team to provide
 283 technical support for engagement activities with senior cooperating agency officials.

1

CHAPTER 10 - PREPARERS

2 **Table 10-1. Master List of Preparers**

Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored/Contributed
Brady Allen	Fish Biologist	19	M.S. Fisheries	Anadromous and Resident Fish	Bonneville	Resident Fish
Karl Anderson	Fish Biologist	10	M.S. Biology	Resident Fish	Corps	Resident Fish
Jim Anderson	Professor	50	Ph.D. Oceanography	Anadromous Fish/Modeling	UW	Anadromous Fish/TDG Effects
Felicia August	Technical Writer/Editor	9	B.A. Education	Technical Writer/Editor	Corps	Fish section compilation and references
W. Nicholas Beer	Research Consultant	20	M.S. Quantitative Ecology and Resource Management	Salmonid Ecology	UW	TDG Effects
Scott Bettin	Fish and Wildlife Administrator	37	B.S. Forest Science	Hydropower & Fish Passage	Bonneville	Anadromous and Resident Fish
Sue Camp	Fish Biologist	21	B.S. Fish and Wildlife Biology	Resident Fish	USBR	All Fish and Aquatic Sections
Charles Chamberlain	Fish Biologist	16	M.S. Fisheries Management	Anadromous and Resident Fish	Corps	All Fish and Aquatic Sections
Jim Faulkner	Mathimatical Statistician	19	Ph.D. Quantitative Ecology and Resource Management	Statistical Methods, Ecological modeling	NMFS	Anadromous Fish Modeling
Nancy Gleason	Fish Biologist	19	M.E.S. Environmental Studies	Salmonid Ecology	Corps	Anadromous fish, macroinvertebrates (both affected environment and environmental consequences); Adaptive Management Framework
Gregory C. Hoffman	Fishery Biologist	17	M.S. Natural Resources	Resident Fish	Corps	Kootenai Basin/Resident Fish

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Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored/Contributed
Michael J. Horn	Supervisory Biologist	26	Ph.D. Zoology	Resident/Anadromous Fish	USBR	Resident Fish upstream Chief Joseph
Steve Juhnke	Fish Biologist	23	B.S. Wildlife Biology	Anadromous Fish	Corps	Lamprey
Amy Mai	Fish and Wildlife Administrator	23	M.S. Biological Sciences	Resident Fish	Bonneville	Resident fish, white sturgeon, eulachon
Rachel Neuenhoff	Fish Biologist	12	M.S. Wildlife and Fisheries Science	Quantitative Fisheries Stock Assessment and Population Dynamics Modeling	Corps	Anadromous Fish
Christine Petersen	Fish Biologist	14	Ph.D. Biology	Ecological modeling, oceanography, population genetics	Bonneville	Climate, Anadromous Fish
Sandra L. Shelin	Environmental Resources Specialist	41	B.S. Wildlife Science	Environmental Compliance (NEPA, CWA)	Corps	Resident Fish
Marvin Shutters	Fish Biologist	29	M.S. Fish & Wildlife Ecology	Hydropower & fish passage	Corps	Reviewed analyses and provided background
Cindy Studebaker	Fish Biologist	25	M.S. Environmental Science and Engineering B.S. Forest Resource Management, , Minor Rangeland Resource Management	ecosystem restoration, juvenile salmon ecology and life history	Corps	Lower Columbia River populations (expert panel elicitation / analysis)
Bjorn Van der Leeuw	Fishery Biologist	22	B.S. Wildlife and Fisheries Biology	Resident Fish	Corps	White Sturgeon and Resident Fish
Ricardo Walker	Fisheries Biologist	12	M.S. Environmental Science; B.S. Biology	Anadromous fish, specifically salmonids and lamprey	Corps	Assisted mainly with the lamprey impacts and mitigation
Daniel Widener	Fisheries Biologist	8	M.S. Aquatic & Fisheries Science	Ecological Modeling	NMFS	Anadromous Fish Modeling

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Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored/Contributed
Rich Zabel	Division Director	25	Ph.D. University of Washington	Ecological Modeling	NMFS	Anadromous Fish Modeling

3 Note: Bonneville = Bonneville Power Administration; Corps = U.S. Army Corps of Engineers; EIS = environmental impact statement; GHG = greenhouse gas; HEC
4 = Hydrologic Engineering Center; MFWP = Montana Fish, Wildlife and Parks; NEPA = National Environmental Policy Act; NMFS = National Marine Fisheries
5 Service; Reclamation = U.S. Bureau of Reclamation; TDG = total dissolved gas.

6

7 **Table 10-2. List of Preparers for Fish**

Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
Aaron King	Environmental Engineer	12	M.S. Environmental Engineering; B.S. Chemical Engineering	Water quality, contaminant fate and transport, remediation technologies, CERCLA process, aqueous geochemistry	Corps	Lower Columbia River Water Quality Affected Environment; Lower Columbia River Water Quality Alternatives Analysis
Aaron Marshall	Hydrologist	18	B.S. Geology	Reservoir Regulation, Hydrology	Corps	H&H Affected Environment and Environmental Consequences; H&H Appendix; Lower Snake & Lower Columbia reservoir operations
Aaron Quinn	Environmental Resources Specialist	15	B.S. Environmental Science M.A. Geography M.A. Environmental Law	Environmental Compliance and Restoration	Corps	Cumulative Impacts (Author)
Alexis Mills	Water Quality Specialist	5	M.S. Water Resources Engineering, B.S. Environmental Resources Engineering	Water Quality and Water Resources	Corps	Temperature model and spill allocation review

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Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
Alisa Kaseweter	Climate Change Specialist	12	B.S. Environmental Economics, Policy, and Management; J.D.	Power sector: GHG emissions; GHG emissions reduction policy and regulation; climate change impacts	Bonneville	Power and Transmission; Climate; Hydropower Appendix Hydroregulation Appendix Air Quality Appendix
Anders Johnson	Electrical Engineer	15	B.S. Electrical Engineering M.S. Electrical Engineering	Transmission Planning, Production Cost Modeling, Power System Analysis	Bonneville	Power and Transmission
Ann Furbush, Research Analyst	Research Analyst (Consultant)	1.5	B.A. Economics	Data Analysis; economics	Industrial Economics, Inc. (IEc)	Recreation, environmental justice (for Bonneville)
Ann Miracle	Environmental Consultant	15	Ph.D. Molecular Ecology	NEPA, human health, cumulative, ecology	Pacific Northwest National Laboratory	Visual
Arun Mylvahanan	Operations Research Analyst	19	M.S. Civil Engineering, B.S. Civil Engineering, Professional Certificate in Civil Engineering (PE)	Water resource engineering, hydrology, hydraulics and environmental engineering; Hydropower modeling and planning.	Bonneville	Hydroregulation and Hydropower Appendices, Hydrology & Hydraulics Appendices
Barry Bunch	Research Civil Engineer	30	B.S., M.S. Civil Engineering, Doct of Engineering, Environmental option	Surface Water Quality Modeling	Corps, Engineering Research and Development Center, Environmental Laboratory	CE-QUAL-W2 Water Quality Modeling
Birgit G. Koehler, Ph.D.	CRSO EIS Program Manager for Power	17	Ph.D. Chemistry, A.B. Chemistry and Physics, US Global Change Distinguished Postdoctoral Fellow atmospheric	River and Hydropower operations, long-term planning, climate change, Columbia River Treaty, interdisciplinary analysis	Bonneville	Hydropower Appendix, Hydroregulation Report, Power and Transmission Appendix, Climate Change chapter, Alternatives

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Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
			chemistry, Professional Certificate in Tribal Relations			chapter, Preferred Alternative chapter
Blair Greimann	Hydraulic engineer	21	Civil engineer	River hydraulics and sediment transport; reservoir sedimentation; dam removal	Bureau of Reclamation	River mechanics supporting author; dam removal tech memo review
Brent Boehlert	Principal/Consu ltant	17	B.A. Engineering; M.S. Natural Resource Economics; Ph.D. Environmental and Water Resources Engineering	Socioeconomic analysis, water systems analysis	Industrial Economics, Inc.	Power and Transmission
Brian Krolak	Senior Modeler/Devel oper	22	B.S. Industrial Management; M.B.A.	Hydropower Operations Modeling; Data Analysis	HDR Engineering (Bonneville contractor)	Hydroregulation Appendix author
Bruce Glabau, P.E.	Physical Scientist (Power Operations Specialist)	35	M.S. Civil Engineering, Prof Certificate in Project Management, B.S. Geography and Env. Science	Water resource engineering and hydrology; Management of simulation and optimization models for reservoir operations and planning.	Bonneville	Hydroregulation and Hydropower Appendices, Hydrology & Hydraulics Appendices, Navigation Environmental Consequences Chapter; Affected Environment Chapter
Carolyn Fitzgerald	Hydrologic Engineer	23	M.S. Civil Engineering, B.S. Civil Engineering	Water Management	Corps	H&H Affected Environment and Environmental Consequences; H&H Appendix
Carolyn Foote	NWW Operations &	21	B.S. Civil Engineering	Civil Works funding and budget for O&M.	Corps	Cost analysis

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Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
	Maintenance Program Manager					
Charles E. Matthews, P.E.	Supervisory Electrical Engineer	30	B.S. Electrical Engineering M.S. Electrical Engineering	Transmission Planning	Bonneville	System reliability review EIS Affected Environment sections review
Chris Bouquot	Economist	8	M.S. Natural Resource Economics; M.E.M Resource Economics and Policy	Inland Navigation	Corps	Affected Environment / Environmental Considerations / Technical Appendix
Chris Frans	Civil Engineer	9	M.S., Ph.D. Civil Engineering, B.S. Earth Sciences	Hydrology, Climate Change	Corps	Climate Chapter, H&H Appendix (Hydrology)
Chris Nygaard	Senior Hydraulic Engineer	18	B.S. Civil Engineering	Hydrology, Open Channel Hydraulics and Sediment Transport	Corps-NWP --> Bonneville	River Mechanics Technical Lead
Christopher H. Furey	Environmental Protection Specialist	15	B.S. Environmental Studies/Biology J.D. Environmental and Natural Resources Law		Bonneville	Air Quality
Christopher McCann	Economist	8	B.A. Economics	Inland Navigation, Deepdraft Navigation and Flood Risk Management	Corps	Affected Environment / SCENT Model Documentation / Technical Appendix
Cindy Boen	Senior	20	BLA Landscape Architecture and Environmental Planning; B.S. History	Alternatives Development and Evaluation, Benefits Analysis, NEPA, Land Use Planning, Recreation Planning, Mitigation	Corps	Chapter 2 primary author, Chapter 7 co-author, Plan Formulation Appendix co-author
Corey Mize	Computer Scientist	2	Masters in Computer Science	Python Visualization Expert	ERDC-ITL	

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Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
Craig Newcomb	Economist	33	B.A. Economics	Water Supply, Flood Risk Management, Hydropower, Dredging/Sedimentation, Recreation,	Corps	Navigation, Recreation
Daniel Turner	Water Quality Team Lead	18	M.S. Engineering	Water Quality	Corps	Water Quality
Dave Goodman	Environmental Protection Specialist			NEPA Policy	Bonneville; Pacific Northwest National Labs	NEPA Policy
Dave Kennedy	Executive Manager of NEPA Planning; CRSO Policy Co-Lead	30	B.A. Natural Resources Management	NEPA/ESA	Bonneville	NEPA Policy
David Gade	Limnologist	24	B.S. - Biology; M.S. - Environmental Science; Ph.D. - Environmental Science	Watershed, lake, and stream modeling; water quality analysis	Corps (CESWF-PEC-CI)	Model (CE-QUAL-W2, HEC-RAS) development, calibration, application, and conclusions.
Dean Holecek	Tribal Liaison	10	M.S. Environmental Science; B.S. Fisheries Science; B.S. Wildlife Science	Tribal Relations	Corps, Walla Walla District	Tribal Perspective section, Tribal Entities and Sovereigns, Preferred Alternative
Dennis Johnson	District Economist	7	B.S. Business Administration/Economics	Flood Risk Management	Corps	Flood Risk Management
Derek Nelson	Cost Engineer	9	B.S. Engineering	Cost Engineering	Corps	Cost analysis
Dorothy Welch	Deputy Vice President - Environment, Fish and Wildlife	19	BSFR - Wildlife Biology, M.S. Wildlife Biology	Fish and wildlife programs	Bonneville	Fish & Wildlife Programs

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Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
Dr. Eric Jessup	Consultant and Director of the Freight Policy Transportation Institute and Associate Research Professor at Washington State University, School of Economic Sciences	20	Ph.D. Agricultural Economics; M.S. Agricultural Economics; B.S. Agricultural Economics	Inland navigation; freight system efficiency; transportation economics	Consultant	Navigation and transportation (Lead Autho)
Dr. Kenneth Casavant	Consultant and Professor at the School of Economic Sciences at Washington State University	48	Ph.D. Agricultural Economics; M.S. Agricultural Economics; B.S. Agricultural Economics	Inland navigation; transportation economics	Consultant	Technical advisor on navigation and transportation
Ellen Engberg	Business Line Manager/ Asset Manager	10	M.S. Geology, B.S. Geology	Hydropower budget and business line, hydropower capital work, dam safety, asset and program management	Corps	Cost analysis
Eric Glisch	Environmental Engineer	12	B.S. Civil and Environmental Engineering	Sediment and surface water quality assessment	Corps, New Orleans District	Author: Sediment Quality Standards Reviewer: Water Temperature Assessment, Water and Sediment Quality Introduction, Water and Sediment Quality Alternatives Analysis

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Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
Eric Horsch, Senior Associate	Senior Associate (Consultant)	11	M.S. Applied Economics, B.S. Economics	Recreation Modeling and Effects Analysis	Industrial Economics, Inc. (IEc)	Recreation (Lead Author)
Eric Nielsen	Operations Research Analyst	13	B.S. Geology/Environmental Science, M.S. Geo-Hydrology	Hydropower modeling and planning. Hydropower operations	Bonneville	
Eric Novotny	Hydraulic Engineer	10	B.S. Biomedical Engineering, M.S. Civil Engineering, Ph.D. Civil Engineering	Water quality modeling, Hydraulic and Hydrologic modeling, programming, data analytics	Corps	Water Quality model data analysis
Eric Rothwell	Hydro-coordinator (or Hydrologist... whatever is preferred)	15	M.S. Hydrology; B.S. Geology	System Operations, Hydrology, Water Quality, Ecosystem Flows, Water Supply, Climate Change	Reclamation	H&H chapters and appendices, WQ chapters and appendices, parts of Climate, Water Quality, and Water Supply chapters.
Eric W. Graessley	Industry Economist	5	M.A. Applied Economics, B.S. Economics	Electric System Production Cost Modeling	Bonneville	
Erik Pytlak	Supervisory Meteorologist	30	B.S. Meteorology; M.P.A	Meteorology, hydrology and climate change science	Bonneville	Hydroregulation and hydropower sections and relevant appendices
Evan Heisman	Civil Engineer	9	M.S. Civil Engineering, Bachelors of Civil Engineering	Water Management, Hydrology, Reservoir Operations Modeling	Corps	H&H Appendix (Stage-Flow Transformation documentation, ResSim/WAT documentation)
Evan Heisman	Civil Engineer	9	M.S. Civil Engineering, Bachelors of Civil Engineering	Water Management, Hydrology, Reservoir Operations Modeling	Corps	H&H Appendix (Stage-Flow Transformation documentation,

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						ResSim/WAT documentation)
Eve James	Supervisory Physical Scientist	13	M.S. Geology (Hydrogeology focus), B.S. Geology	River and Hydropower operations, mid-term planning, interdisciplinary analysis	Bonneville	Hydropower Appendix, Hydroregulation Report, Power and Transmission Appendix, Climate Change chapter, Alternatives chapter, Preferred Alternative chapter
Hannah Dondy-Kaplan	Fish and Wildlife Project Administrator	15	M.A. Environmental Planning	Environmental planning and permitting, land acquisition and management, fish and wildlife habitat restoration project management	Bonneville	Vegetation, Wetlands, and Wildlife
Hannah Hadley	Environmental Coordinator	15	B.A. Anthrology	NEPA and environmental compliance	Corps	Chapters 1 and 8 (Author)
Hans R. Moritz	Civil / Hydraulic Engineer	25	B.S. is Civil Engineering, ME in Ocean Engineering	River Engineering and Sediment Transport	Corps - NWP	Lower Columbia River Sedimentation and Dredging
Heather Baxter	Civil Engineer/Interdisciplinary	6.5	M.S. Civil Engineering, B.S. Civil Engineering	Modeling, ResOps, Hydrology	Corps	Reservoir Operations modeling
Holly Bender	Lead Regional Economist	21	Ph.D.	Economics	Corps	Primary -- Cost Analysis; Reviewed Recreation, Power and Transmission, Navigation
Iris Maska	Economist	11	B.A.	Economics	BOR	Cost analysis
J. Paul Rinehimer	Senior Engineer	10	Ph.D.	Hydraulics, hydrology, water quality modeling	WEST Consultants, Inc.	AFD W2 modeling and results preparation. Review W2/RAS models of lower Snake River.

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Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
James Witherington	Cost Engineering Technician	5	Economics		Corps	Mitigation Cost Measures
Jane Israel	Senior Associate/Consultant	22	B.A. Math and Philosophy; M.B.A. Finance and Accounting	NEPA socioeconomic analysis, financial analysis, environmental justice	Industrial Economics, Inc.	Environmental Justice
Jason Change	Civil Engineer	9	B.S., M.S., and Ph.D. Agricultural and Biological Engineering	Hydrology and climate change	Corps	Climate Change and H&H Appendix
Jason Sweet	Supervisory Policy Analyst	19	B.S. in Fisheries Science. Minor in Wildlife Science	Analysis of the effect of hydropower operations on resident and migratory fish	Bonneville	Preferrred Alternative Chapter
Jayson Osborne	Remediation Biologist	12	M.S. Biology, B.S. Conservation Biology	Environmental Sampling and Cleanup	Corps	Sediment Quality Appendices for McNary, John Day, The Dalles, and Bonneville Reaches.
Jeanne Godaire	Geologist	20	Geosciences	Fluvial geomorphology; paleoflood hydrology; Quaternary geology	Bureau of Reclamation	River mechanics supporting author
Jeff Cavanaugh	Economist	1	B.A.	Economics	Corps	Cost analysis
Jennie Tran	Electrical Engineer	28	B.S. Electrical Engineering	Hydropower modeling, analysis, and planning	Bonneville	Hydropower Appendix, 4h10C studies, Hydro modeling support and analysis
Jennifer Bountry	Hydraulic engineer	21	Civil engineer	River hydraulics and sediment transport; reservoir sedimentation; dam removal	Bureau of Reclamation	River mechanics supporting author; dam removal tech memo review
Jennifer Gervais	Hydrologic Engineer	7	M.A.Sc. Civil Engineering; B.S. Industrial and Systems Engineering	Water Management, Hydraulics, Hydropower, Hydrology	Corps	H&H Appendix (Grand Coulee Upstream Storage Correction Method Sensitivity;

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Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
						ResSim/WAT documentation)
Jennifer Johnson	Supervisory Civil Engineer	16	Ph.D., Water Resources, M. Engr., Civil Engineering, B.S. Civil Engineering, B.S. Geophysics	Water Resources modeling, Groundwater, Water Supply, Climate Change	Bureau of Reclamation	Water Supply, Climate Change
Jennifer Kassakian	Senior Associate/Consultant	14	B.A. Biology; Master of Marine Affairs	Marine and aquatic resource management, fisheries management and policy	Industrial Economics, Inc.	Fisheries
Jennifer Miller	Chief, Environmental Engineering (Chicago District)	33	Ph.D. in Environmental Engineering, M.S. in Environmental Eng., B.S. in Civil Eng.	> 20 years of experience in civil works projects with Corps working on all project phases from planning thru design and construction; total 33 years experience in environmental engineering. Expertise in dredging, sediment management, contaminated sediment disposal, water chemistry. PE in environmental engineering.	Corps, Chicago District	Lower Snake River Sediment existing conditions; no action and alternative analyses for sediment
Jim Burton	Hydraulic Engineer	17	B.S. Civil Engineer	Hydrology & Hydraulics	Corps	Water Temperature Modeling
Jim Fodrea	Senior Project Manager	45	B.S. Civil Engineering	Hydropower, Reservoir Regulation	HDR Engineering (Bonneville contractor)	Hydropower Appendix author, Hydroregulation Appendix reviewer
John Anasis	Electrical Engineer, Transmission Operations	34	B.S. Electrical Engineering and Physics; M.P.A. Public Administration; Ph.D. System Science	Power System Operations and Modeling, Transmission Inventory Assessment, Transmission Tariffs and Scheduling.	Bonneville	Power and Transmission
John Hayes	Asset Manager	14	B.A. Geography	Asset Management, O&M	Corps	Cost analysis

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Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
John Newton	Hydraulic Engineer	14	Ph.D. Civil Engineering, B.S. Civil Engineering	Hydrology & Hydraulics	Corps-NWW	River Mechanics: Affected Environment supporting author and Snake River dredging metrics.
JR Inglis	Tribal Liaison	8	M.S. Systems Management, B.S. Math & Engineering	Tribal Relations	Northwestern Division, Corps	Co Author Tribal Perspective section 3.16, Tribal Entities and Sovereigns Sect 9.2
Julie Doumbia	Environmental Protection Specialist	8	M.S. Marine Resource Management; M.S. Environmental, Natural Resources & Energy Law	Anadromous fish and overall hydrosystem operations	Bonneville	Anadromous fish, modeled species, some resident fish
Kari Cornelius Hay	Operations Research Analyst	8	B.A. Mathematics; Graduate Certificate of Applied Statistics	Development of modeling parameters to apply desired operations in Hydsim modelling process; coordinate technical modelling team in Hydsim process; analysis, coordination and alignment of Hydsim modelling process	Bonneville	Hydroregulation and Hydropower Appendices
Kasi Whorley	Hydrologic Engineer	13	B.S. Engineering	Water Management, Hydrology, Reservoir Operations Modeling, Floodplain Management	Corps	H&H Appendix (ResSim/WAT documentation); Reservoir Operations modeling
Kathryn Tackley	Physical Scientist	23	B.S. Physical Geograhpy and Geology	water quality monitoring and technical analysis; project management	Corps	Water Quality
Keleigh Duey	Environmental Manager	3 years	B.S. Biology	Ecology and Biodiversity	Corps	Vegetation, Wetland, and Wildlife
Kelly Baxter	Economist	15	B.A. Economics, M.S. Economics	Economics	Corps	Recreation, Navigation and Transportation,

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Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
						Flood Risk, and Cost Analysis
Kent Easthouse	Physical Scientist	27	M.S. Environmental Engineering-University of Washington, B.S Environmental Sciences-University of California at Davis	Water Quality and Sediment Quality	Corps, Seattle District	Libby Dam-Lake Koocanusa and Kootenai River: Water Quality and Sediment Quality. Albeni Falls Dam-Lake Pend Oreille and Pend Oreille River: Water Quality and Sediment Quality. Chief Joseph Dam-Rufus Woods Lake and Columbia River: Water Quality and Sediment Quality
Kevin Cannell	Archaeologist	26	M.A., Anthropology	Cultural resources	Bonneville	Cultural Resources
Kieran Bunting	Principal/Consultant	3	B.A. Economics; M.S. Carbon Management	Environmental economics; energy economics; data analysis	Industrial Economics, Inc.	Power and Transmission, Air Quality and GHG Emissions
Kimberly Johnson	Environmental Engineer	31	B.S. Civil Engineering	Water Quality, Air Quality, Environmental Engineering, NEPA	Bonneville	Water Quality, Air Quality
Kristen Kerns	Toxicologist	11	M.S., Environmental Health	Sediment remediation, human health risk assessment	Corps, Seattle District	sediment quality
Kristen Shacochois-Brown		19	B.S. Forestry and Wildlife Management, M.S. Ecological Restoration	Wetland Scientist, Ecological Restoration, Wildlife Management	Corps	Vegetation, Wetland, and Wildlife
Kristian Mickelson	Hydrologic Engineer	17	M.S. Civil Engineering, B.S. Civil Engineering	Water Management, Climate Change, Hydropower	Corps	H&H Affected Environment and Environmental Consequences; H&H

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Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
						Appendix; Climate Chapter, Hydrology Appendix, Spill, Water Quality, Hydropower, Fish
Kristine Sclanfani	Environmental Specialist				Corps	Vegetation, Wetland, and Wildlife
Lance Awsumb	Regional Economist	11	B.A. Economics	Flood Risk Management	Corps	Flood Risk Management
Laurel Hamilton	P.E., Hydraulic Engineer	12	M.S. - Environmental Engineering; B.S. - Chemistry	Hydraulics and Water Quality	Corps, Omaha District	Water Quality Appendix
Leah Hauenstein	Project Manager	10	B.S. Industrial & Systems Engineering	Project & program management in Corps Civil Works	Corps	Project manager level reviewer
Leslie Genova	Principal (Consultant)	19	M.A. Environmental Studies; B.A. Environmental Science	NEPA socioeconomic analysis, environmental impact analysis, regional economic impact analysis, cost-benefit analysis	Industrial Economics, Inc. (IEc)	Review and analysis of recreation, navigation and transportation, review of flood risk [also for Bonneville, review and analysis of environmental justice, fisheries]
Logan Osgood-Zimmerman	Hydraulic Engineer	5.5	M.S. Civil Engineering, B.S. Engineering	Water Management, Reservoir Regulation, Hydrology	Corps	Reservoir Operations modeling; H&H Environmental Consequences
Margaret C. Racht	Operations Research Analyst	12	M.S. Statistics, B.S. Mathematics	Analysis, Coordination, and Post Processing Role in Hydsim Modeling Process, Conduit for Data Transfer to/from HDR and Downstream Parties	Bonneville	Hydroregulation and Hydropower Appendices
Margaret Ryan	Economist	11	B.A. Economics	Economics - Hydropower	Corps-HAC	Reviewed Power and Transmission

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Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
						Environmental Consequences Section
Margo L. Kelly	Business System Analyst II	19	N/a	Programming, Analysis, Coordination and Post Processing of Revenue and Expense Simulation Modeling	Contractor to Bonneville	hydropower analysis
Mariah March-Garr Brumbaugh	NEPA Regional Technical Specialist	19	B.S. Biology, M.S. Biology	Wetland Ecology, Avian Biology, Aquatic Entomology, Wildlife Habitat Management	Corps	Vegetation, Wetland, and Wildlife
Marke Paske	Regional Budget Officer	14	B.A.	Accounting	BOR	Cost analysis
Matt Fraver	Hydraulic Engineer	10	M.S. Civil Engineering, B.S. Environmental Engineering	Hydraulics, Hydrology	Corps	H&H Appendix (H&H Data Analysis). Data Analysis; reviews for water supply, socioeconomics, and wildlife
Maura Flight	Principal/Consultant	17	B.S. Environmental Science; M.S. Economics	Applied economics, NEPA socioeconomic analysis, cost-benefit analysis, ecosystem service valuation	Industrial Economics, Inc.	Power and Transmission, Air Quality and GHG Emissions, Passive Use Technical Report
Max Pangborn	Operations Research Analyst	3	M.A. Economics; B.A. Economic Theory; JD	Hydropower modeling and planning	Bonneville	Hydropower Appendix, NAA modeling, MO2 modeling, Preferred Alternative modeling, Climate Change
Melissa A. Foster	Geomorphologist	12	Geology	Quaternary geology, fluvial processes, river hydraulics, sediment transport	Bureau of Reclamation	River mechanics supporting author
Michael Poulos	Hydrologist	10	Ph.D. Geosciences	Spatial Water Rights Analyses	USBR	Water Supply & appendices

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Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
Michael Ryan	Production Cost Modeling Analyst	42	B.A. Mathematics M.S. Physics	Power System Simulation; Analysis and Programming; Risk Management Analytics; Market Analysis	Bonneville	Power and Transmission
Michelle Eraut	CRSO EIS Policy Co-Lead	25	B.S., MPA/NEPA	NEPA Policy	Bonneville	NEPA Policy
Millie Chennell	Operations Research Analyst	7	Water Resources Management (Master of Environmental Science and Management)	Hydroregulation, Water Quality, Power Planning, Analysis, Communications	Bonneville	Water Quality, Power
Mitch Price	Senior Hydraulic Engineer	25	M.S. Civil Engineering, B.S. Civil Engineering	River Engineering, Sediment Transport and Ecosystem Restoration	Corps-NWW	River Mechanics Technical Lead.
Nancy Stephan	Management and Program Analyst	35	B.S. Atmo	Meteorology, Climate Change, River Operations	Bonneville (retired)	climate change analysis
Norman Buccola	Hydraulic Engineer	10	M.S. Civil and Environmental Engineering	Hydrology, water quality, statistics, water management	Corps	Water Quality Appendices
Pam Druliner	Natural Resource Specialist				BOR	NEPA Compliance, Resident Fish, Vegetation/Wetlands/ Wildlife
Patrick R. Rochelle, P.E.	Electrical Engineer	28	B.S. Electrical Engineering M.S. Electrical Engineering	Transmission Planning Distribution Planning Generation Engineering	Bonneville	System reliability review EIS Affected Environment sections review
Paula Engel	Economist	27	M.S. Agricultural Economics	Economics	BOR	Water Supply
Peter Stiffler	Public Utilities Specialist	15	Ph.D. Economics, M.A. Urban and Regional	Power Rates Analyst	Bonneville	Rate impacts and socioeconomic analysis

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Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
			Planning, B.A. Economics			
Peter Williams	Operations Research Analyst	9	Ph.D. Economics, B.S. Economics/Math	Hydropower modeling, quantitative analysis	Bonneville	Hydropower Appendix, MO4 modeling
Rafael Molano	Project Manager	15	B.S. Electrical Engineering M.S. Economics M.B.A. Finance	Transmission and generation planning; load forecasting models; production cost modeling; renewables development	Bonneville	Power and Transmission
Ray Walton	Lead Water Resources Engineer	45	Ph.D.	Hydraulics, hydrology, water quality modeling	WEST Consultants, Inc.	AFD W2 modeling and results preparation. Review W2/RAS models of lower Snake River.
Rebecca Weiss	Columbia River Basin Environmental Coordinator	19 at the corps	B.A. Anthropology, M.S. Genetics	Planning, Environmental Analysis, Environmental Compliance, Federal Water Resources Policy	Corps	Policy level Reviewer
Robert Diffely	Economist	30	M.S. Economics; B.S. Economics	Resource Adequacy, power operations and planning	Bonneville	Hydropower Appendix, Hydroregulation Report, Power and Transmission Appendix, Climate Change, Water Supply, Socioeconomics
Robert Petty	Manager, Power Operations and Planning	22	M.S. Economics, B.S. Business Management	Power operations and planning, rates, business operations, market analysis and trading	Bonneville	Alternatives chapter, Preferred Alternative chapter, Executive Summary
Ron Thomasson	Hydrologic Engineer	30	B.S. Civil Engineering	Hydrology, Reservoir Regulation, Water Management	Corps	H&H Appendix (Grand Coulee Upstream Storage Correction Method Sensitivity)

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Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
Ross Wickham	Hydraulic Engineer	6	M.S. Civil and Environmental Engineering, B.S. Environmental Resources Engineering	Hydrology, Hydraulics, Reservoir Regulation	Corps	Spill; Water Quality; Geomorphology, Sediment Transport, Geology, and Soils
Ryan Laughery	Hydraulic Engineer	16	Civil Engineer	Fish Passage Engineering and Design	Corps	Fish/Econ
Sara Marxen	Hydraulic Engineer	20	M.S. Civil Engineering	Water Management, Hydraulics, Hydropower, Hydrology	Corps	H&H and FRM Affected Environment and Environmental Consequences; H&H Appendix (Spill Analysis, Grand Coulee Upstream Storage Correction Method Sensitivity, Hydrology)
Sarah Delavan	Civil (Hydraulic) Engineer	19	Ph.D., Civil Engineering	Hydraulic and Hydrologic modeling, Technical Writing	Corps	H&H Appendix (Hydrologic Data Development, Extended Observed Flows)
Scott Wells	Professor of Civil and Environmental Engineering	35	Ph.D., Civil and Environmental Engineering, Cornell; M.S. MIT, B.S. Tenn Tech Univ	Water quality and hydrodynamic modeling	Portland State University	
Selisa F. Rollins	General Engineer	2	M.S. Chemical Engineering; B.S. Chemical Engineering	Hydropower modeling and planning	Bonneville	Hydropower Appendix, MO3 modeling, Climate Change
Stacy Wachob	NWW Operations Division Program Analyst	11	B.A. Sociology; AAS Accounting	Budget and program analysis for NWW.	Corps	Cost analysis

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Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
Stan Williams	Public Utilities Specialist	15	B.S. Forest Science M.S. Industrial Engineering	Resource and Transmission Planning; Production Cost Modeling; Linear Programming	Bonneville	Power and Transmission
Stanford Gibson	Senior Hydraulic Engineer	20	Ph.D. Civil & Environmental Engineering (Hydraulics), M.S. Civil & Environmental Engineering, M.S. Ecology	National, Corps, subject matter expert on sediment transport and mobile boundary modeling.	Corps-HEC	River Mechanics: Snake River dam removal modeling and Dam Removal tech memo supporting author.
Steve Bellcoff	Public Utilities Specialist	12	Civil Engineering Technology, AAS	Loads and Resources, Power Rates	Bonneville	Power Loads and Resources, Power Rates
Steve Juul	Water Quality Lead	27	Ph.D. Civil Engineering, M.S. Environmental Science, B.S. Wildlife Science	Limnology, sediment chemistry, aquatic ecosystem restoration, watershed management	Corps	Water and sediment quality, benthic macroinvertebrates
Steven Hollenback	Physical Scientist	5	M.S. Hydrology, M.S. Environmental Science, B.S. Chemistry, B.S. Biology	Physical Science	Bureau of Reclamation	Lake Roosevelt and Hungry Horse, Appendix 7 and 9.
Tammy Threadgill	Research Physical Scientist; Water Quality and Contaminant Modeling Branch	12	M.S. Computational Engineering; B.S. Mathematics (Analytical)	Water Quality Modeling; Data Analysis	ERDC, Vicksburg, M.S.	Water Quality Model Calibration Report; MO3 Report; Automation Tool Report; Visualization Report
Tanis Toland	Environmental Compliance Regional Specialist	29	M.S. Wildland Resource Science B.A. Biology	Ecology	Corps	Vegetation, Wetland, and Wildlife

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Name	Title	Years of Experience	Degree	Experience/Expertise	Agency	EIS Areas Authored
Tilak Gamage	Civil Engineer	25	M.S. in Civil Engineering	Hydraulic/Water quality modeling (15years+)	Corps - Seattle	Mid Columbia water quality models and associated report contents
Timothy Randle	Hydraulic engineer	40	Civil engineer	River hydraulics and sediment transport; reservoir sedimentation; dam removal	Bureau of Reclamation	River mechanics peer review
Tina Teed	Senior Planner	17	B.S. Ecology and Systematic Biology, M.S. Biology	Alternatives Development, Reservoir Regulation, NEPA Lead, Mitigation Compliance, Professional Wetland Scientist	Corps	Chapter 2 primary author, Plan Formulation Appendix primary author
Todd Steissberg	Research Environmental Engineer; Water Quality and Contaminant Modeling Branch	19	B.S., M.S., and Ph.D. in Civil and Environmental Engineering	Water Quality Modeling, Software Development, Data Analysis	ERDC, Davis, CA	Water quality modeling software development and support
Travis Ball	Hydraulic Engineer	12	M.Eng Civil Engineering	Hydraulics	Corps	H&H Appendix (Stage-Flow Transformation documentation), River Mechanics Affected Environment
Travis Foster	Hydraulic Engineer	14	M.S. Civil Engineering, B.S. Civil Engineering	Hydrology & Hydraulics	Corps-NWW	River Mechanics: Hydraulic model support.
Tyler Llewellyn	Operations Research Analyst	10	B.S and M.S. Environmental Science	Hydropower operations, loss-of-load probability, valuing hydropower	Bonneville	Hydroregulation and hydropower
Zac Corum	Senior Hydraulic Engineer	23	B.S. Civil Engineering	River Mechanics, Ecosystem Restoration, Sediment Transport & Geomorphology	Corps-NWS	River Mechanics: Affected Environment supporting author (Kootenai)

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Zachary Jelenek		4	Bachelors	Water Quality	Corps	MO3 Water Quality Model
Zhong Zhang	Research Professor	25	Ph.D.	Riverine and reservoir water quality modeling development and application	Portland State University / ERDC-EL	TDG capability development in RAS and W2 and tech note for W2 TDG version/Water quality modeling review
Michael Sackschewsky	Environmental Consultant	25	Ph.D. Environmental Studies	NEPA, ecology, botany, human health	Pacific Northwest National Laboratory	Noise
Philip Meyer	Hydrologist	10	Ph.D. Hydrology	Hydrologic processes, flow and transport modeling	Pacific Northwest National Laboratory	Floodplains
Eve Skillman	Regional Outdoor Recreation Planner	22	B.S., Natural Science, Mathematics, & Biology; M.S., Zoology & Physiology		Bureau of Reclamation	Visual

8 Note: Bonneville = Bonneville Power Administration; Corps = U.S. Army Corps of Engineers; EIS = environmental impact statement; GHG = greenhouse gas; HEC
9 = Hydrologic Engineering Center; MFWP = Montana Fish, Wildlife and Parks; NEPA = National Environmental Policy Act; NMFS = National Marine Fisheries
10 Service; Reclamation = U.S. Bureau of Reclamation; TDG = total dissolved gas.

1 **CHAPTER 11 - REFERENCES**

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