Columbia River System Operations
Final Environmental Impact Statement

Appendix U, Fish and Wildlife Coordination Act

Part 1, Final Coordination Act Report

Note: The Section 508 amendment of the Rehabilitation Act of 1973 requires that the information in federal documents be accessible to individuals with disabilities. The Agency has made every effort to ensure that the information in *Appendix U: Fish and Wildlife Coordination Act, Part 1 Final Coordination Act Report* is accessible. However, if readers have any issues accessing the information in this appendix, please contact the *U.S. Army Corps of Engineers* at (800) 290-5033 or info@crso.info so additional accommodations may be provided.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
911 NE 11th Avenue
Portland, Oregon 97232-4181

In Reply Refer to:
FWS/IR09/IR12/AES

Rebecca Weiss
Program Manager, Columbia River System Operations EIS
U.S. Army Corps of Engineers, Northwestern Division
Post Office Box 2870
Portland, Oregon 97208-2870

Dear Ms. Weiss:

In accordance with the requirements of section 2(b) of the Fish and Wildlife Coordination Act of 1934 [16 USC 661 *et seq*; 48 Stat. 401], as amended, and the Scope of Work from May 2018, the U.S. Fish and Wildlife Service (Service) has completed the Fish and Wildlife Coordination Act Report (FWCAR) for Columbia River System Operations (CRSO). The Service understands that the FWCAR will be released as an appendix to the CRSO Environmental Impact Statement (EIS).

This FWCAR is the culmination of work from across Service programs and the geographic region, and it documents the Service's analysis and conclusions of how CRSO will impact fish and wildlife resources and their habitats. The FWCAR also includes conservation recommendations to benefit species impacted by dam modifications and operations. Both the analysis and conservation recommendations described in the draft Report were informed by input from experts across the Columbia River Basin.

We appreciate the opportunity to coordinate with the U.S. Army Corps of Engineers on CRSO. If you have any questions regarding the enclosed Report, please contact our CRSO FWCA Coordinator, Lee Corum (telephone: 360-753-5835; email Lee_Corum@fws.gov).

Sincerely,

Acting Regional Director

Enclosure

FINAL
FISH AND WILDLIFE COORIDNATION ACT SECTION 2(B) REPORT
COLUMBIA RIVER SYSTEM OPERATIONS

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

MAY 2020

FINAL

FISH AND WILDLIFE COORDINATION ACT SECTION 2(b) REPORT

on the

Columbia River System Operations

Prepared for:
U.S. Army Corps of Engineers – Northwestern Division

Prepared by:
U.S. Fish and Wildlife Service – Columbia-Pacific Northwest Region

May 2020

ACRONYMS AND ABBREVIATIONS

Act	Endangered Species Act
AEP	annual exceedance probability
Basin	Columbia River Basin
BCC	Bird of Conservation Concern
BCR	Bird Conservation Program
BMC	Bird of Management Concern
Bonneville	Bonneville Power Administration
CAR or report	Fish and Wildlife Coordination Act Section 2(b) Report
Cascades	Cascade Mountain Range
Corps	U.S. Army Corps of Engineers
CRS	Columbia River System
CRSO	Columbia River System Operations
DEIS	draft Environmental Impact Statement
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EVT	existing vegetation type
FCRPS	Federal Columbia River Power System
Feasibility Study	Juvenile Salmon Migration Feasibility Study
Flex Spill	Flexible Spill Operation Agreement
FRM	Flood Risk Management
FWCA	Fish and Wildlife Coordination Act
GIS	Geographic Information System
Grebes	Clark’s and Western grebes
HMU	Habitat Management Unit
H&H	Hydrology and Hydraulics
LANDFIRE	Landscape Fire and Resource Management Planning Tools database
LW	large wood
MBTA	Migratory Bird Treaty Act
MIP	Minimum Irrigation Pool
MO alternative or MOs	Multiple Objective alternative
MOP	Minimum Operating Pool
MO1	Multiple Objective Alternative 1
MO2	Multiple Objective Alternative 2
MO3	Multiple Objective Alternative 3
MO4	Multiple Objective Alternative 4
NAA	No Action Alternative
NEPA	National Environmental Policy Act
NLCD	National Land Cover Dataset
NMFS	National Marine Fisheries Service
NWHI	Northwest Habitat Institute
NWI	National Wetlands Inventory
NWR	National Wildlife Refuge

Opinion	Biological Opinion
Reclamation	U.S. Bureau of Reclamation
Rockies	Rocky Mountain Range
Service	U.S. Fish and Wildlife Service
SOW	Scope of Work
System Operation Review	Columbia River System Operation Review
TDG	total dissolved gas
VARQ	variable discharge
WMA	Wildlife Management Area
WPA	Waterfowl Production Area

MEASUREMENT ABBREVIATIONS

cm	centimeter
ft	feet
ha	hectare
kcfs	kilo cubic feet per second
km	kilometer
km^2	square kilometer
m	meter
m^3/s	cubic meter per second
mi^2	square miles
RKM	river kilometers
RM	river miles

TABLE OF CONTENTS

TABLES

FIGURES

EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (Corps) and U.S. Bureau of Reclamation (Reclamation) operate the 14 Federal projects that comprise the Columbia River System Operations (CRSO) to serve authorized project purposes including power generation, water supply, flood risk management (FRM), irrigation, navigation, recreation, and fish and wildlife resource conservation. Bonneville Power Administration (Bonneville) markets and transmits the electricity generated by the projects, and, collectively, the three agencies (co-lead agencies) are responsible for operating and maintaining the Columbia River System (CRS).

Operation of the CRS has negatively impacted important ecological and physical processes (e.g., water flow, nutrient cycling, and natural disturbance) that maintain habitat structure and function to support ecologically, socioeconomically, and culturally valuable fish and wildlife resources throughout the Columbia River Basin (Basin). Impacts on listed fish and wildlife species as threatened and endangered under the Endangered Species Act of 1973 (Act), as amended (16 U.S.C. § 1531 et. seq.), have been documented in past Biological Opinions (Opinions) (NMFS 1995, 2008, 2019; USFWS 2000) and Fish and Wildlife Coordination Act Section 2(b) Reports (CARs or reports) (USFWS 1995, 1999) written by the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (Service).

Since the CRSO has been in operation, the co-lead agencies have implemented conservation measures to protect, mitigate, and enhance fish and wildlife resources affected by project operations. However, the CRSO will continue to negatively impact fish and wildlife resources in the Basin, even with ongoing conservation measures in place.

This CAR focuses exclusively on identifying additional impacts on fish and wildlife resources from both current operations and the alternatives identified in the co-lead agencies' public scoping process for the draft Environmental Impact Statement (DEIS) for the CRSO (USACE et al. 2020, p. 1-10). The Service considered the No Action Alternative (NAA) (i.e., current operations), four Multiple Objective (MO) alternatives (Section 1.2.1) (USACE et al. 2020, pp. 2-1-80), and one additional operation in the analysis of impacts. This operation is associated with the Flexible Spill Operation Agreement (Flex Spill) (Section 6.2) (USACE et al. 2020, pp. 1-20-21, 7-33-35). While the DEIS also identified a Preferred Alternative, this alternative is largely a combination of structural and operational measures that comprise the NAA and four MOs, and, thus, the Service's conclusions regarding the NAA and MOs also apply to the Preferred Alternative (Section 1.2.1.6) (USACE et al. 2020, pp. 7-1-49).

In development of this CAR, the Service coordinated among its programs and with stakeholders, and collected relevant data to analyze impacts of current operations and potential changes in operations of the Federal CRS projects. This CAR includes the Service's evaluation of the potential short-term and long-term, and positive and negative impacts of the alternatives on the overall health of landscapes (rivers, lakes and reservoirs, riparian areas, wetlands, and uplands) in the study area (Section 3 and Appendix B). The Service used indicators of ecological and physical processes that support habitats, subhabitats, and fish and wildlife resources (Section 5) to guide their analysis. This report includes summary tables (Tables 15, 16, 17, 18) of the projected trends of overall health of landscapes at key sites under all alternative scenarios and a narrative that describes the impacts of structural and operational measures associated with each alternative (Appendix G).

The Service concluded that each of the alternatives will continue to negatively impact the overall health of landscapes present within the study area, to one degree or another. Thus, each of the alternatives will also continue to negatively impact fish and wildlife resources that depend on these landscapes. For instance, the Service identified primarily decreasing trends in the overall health of river, lakes and reservoirs, riparian, and wetland landscapes in the study area under the NAA. Most key sites characterized by certain landscapes are likely to experience further decreasing trends in overall health under MO1 and MO2, except for an unimpounded river reach in the Lower Snake River (the Clearwater River). While no alternative was projected to be wholly beneficial to fish and wildlife resources, measures associated with MO3 and MO4 could either slow decreasing trends in overall health compared to the NAA or even reverse decreasing trends in overall health at some key sites.

To enhance the resiliency of ecological and physical processes, habitats, subhabitats, and fish and wildlife resources negatively impacted by the CRSO, the Service recommends the co-lead agencies implement additional conservation measures that are likely to result in increasing trends in the overall health of landscapes. With this CAR, the Service shares with the co-lead agencies a prioritized list of conservation recommendations that identify measureable actions to mitigate, avoid, or minimize negative impacts of the alternatives on fish and wildlife resources (Section 7). Many of these proposed conservation recommendations address specific components or measures of the five alternatives presented by the co-lead agencies in the DEIS. The Service grouped these conservation recommendations into six major categories in this CAR according to the following objectives:

- restore or mimic critical components of natural hydrological systems, such as establishing functional flow regimes;
- increase habitat connectivity and improve fish passage, such as reconnecting floodplains and removing barriers;
- maintain functionality of National Wildlife Refuges (NWRs), State and Tribal Wildlife Management Areas (WMAs), and other conservation lands affected by CRSO, such as ensuring sustainability of current land and water management operations;
- maintain or enhance habitat complexity and heterogeneity, such as supporting delta-forming processes;
- reduce the spread of invasive species, and prevent future invasions, such as coordinating with interagency invasive species teams; and,

- support long-term monitoring and adaptive management approaches to future fish and wildlife resource conservation, such as improving coordination between biologists and engineers working together on dam operations.

Based on the Service's analysis, reducing negative impacts on specific processes and habitats, which characterize various landscapes, will effectively reduce associated negative impacts on fish and wildlife resources that live in and depend on those landscapes.

1 PURPOSE, SCOPE, AND AUTHORITIES

1.1 PURPOSE

The Corps – Northwestern Division, Reclamation, and Bonneville (co-lead agencies) prepared a DEIS for the CRSO in accordance with the National Environmental Policy Act (NEPA) (42 U.S.C. § 4321 et. seq.) (USACE et al. 2020). The CRSO includes the coordinated water management functions for the operations, maintenance, and configurations for, or management of, 14 Federal dam and reservoir projects located in the Basin.

This document is the Service's formal 2(b) CAR for the CRSO, and it fulfills the Service's shared responsibilities under the Fish and Wildlife Coordination Act (FWCA) of March 10, 1931, as amended (16 U.S.C. §§ 661-667e). With this report, the Service communicates the potential impacts of the proposed alternatives on trust fish and wildlife resources, highlighting the value of these resources and their significance to stakeholders (e.g., Federal and State agencies, local entities, Tribes, and the general public) in the Basin. With this report, the Service also provides conservation recommendations for the co-lead agencies to consider in developing the final Environmental Impact Statement (EIS) for the CRSO. The purpose of providing these conservation recommendations is to minimize further loss of, or damage to, fish and wildlife resources in the Basin, and to support future management and restoration of those resources (Smalley and Mueller 2004, p. I-28).

1.2 SCOPE

Between 2017 and 2018, the Service developed a Scope of Work (SOW), outlining key responsibilities and coordination strategies, and a budget request with the co-lead agencies in support of completing this report (USFWS and USACE 2018, pp. 1, 6). The SOW clarified the geographic scope of the Service's analysis, which included the Basin, the mainstem Columbia River, major Columbia River tributaries, and portions of their tributaries affected by dam modifications and operations as of March 2018, including an approximate 0.5 mile (0.8 kilometer [km]) terrestrial habitat buffer along the river and tributary banks (Section B.4).

This CAR does not address other operationally related areas and projects such as those associated with irrigation systems, power delivery, and habitat restoration and mitigation (USFWS and USACE 2018, p. 8). The information presented in Section 3 and Appendix B of this report further define areas included in, and excluded by, the Service's analysis.

On May 15, 2018, the Service and Corps, acting on behalf of the co-lead agencies, approved the final SOW (USFWS and USACE 2018, p. 1). Appendix A includes a timeline that illustrates key milestones in the Service's engagement among its programs and with stakeholders and the co-lead agencies for CAR development.

1.2.1 CRSO Alternatives

In accordance with NEPA, the co-lead agencies developed five alternatives for the operations, maintenance, and configuration of the 14 CRS projects to meet authorized project purposes and to balance competing demands for water. The Service considered these alternatives in the analysis.

The co-lead agencies defined eight objectives to guide alternatives development. The final set of alternatives included the NAA and four action MOs. The NAA describes ongoing CRS operations under current conditions, and the MOs describe modifications to one or more aspects of CRS operations.

The MOs include structural and operational measures that address future delivery of additional water for irrigation, municipal, and industrial purposes and increased water management flexibility to react to unanticipated changes in river flow and allow for refill of storage reservoirs. The MOs also include measures that address a range of spill levels for juvenile Pacific salmon, varying levels of hydropower production, and differing actions to support the needs of other migratory fishes and resident fishes (e.g., native trout, suckers [*Catostomus* spp.]).

This report includes a summary of the five alternatives while Chapter 2 of the DEIS describes them in more detail (USACE et al. 2020, pp. 2-1-80).

1.2.1.1 No Action Alternative

The NAA includes current operations and maintenance of the 14 Federal projects that comprise the CRSO. Continued operation of the projects on the Columbia and Snake Rivers would require further development and improvement of existing and future structural and operational features, many of which are intended to protect fish and wildlife resources. Under the NAA, the co-lead agencies would continue to operate the CRSO for multiple authorized purposes including FRM, power generation, water supply, irrigation, navigation, and recreation.

1.2.1.2 Multiple Objective Alternative 1

Multiple Objective Alternative 1 (MO1) is intended to benefit listed Pacific salmon and listed resident fishes. MO1 proposes implementation of a juvenile fish passage spill operational measure (Block Spill Test [Base +120/115 Percent]), which includes alternating spill at the Lower Snake and Lower Columbia River projects (USACE et al. 2020, p. 2-42). MO1 also includes changes to water management, power generation, irrigation, and navigation.

1.2.1.3 Multiple Objective Alternative 2

Multiple Objective Alternative 2 (MO2) relaxes some of the restrictions on operating ranges and ramping rates to evaluate the potential to increase hydropower production and operational flexibility at various projects to respond to changes in power demand and renewable power generation. MO2 includes an expanded juvenile fish transportation operation system and reduced spill operational measure with a spill target of 110 percent total dissolved gas (TDG), which represents the lowest end of the range of proposed juvenile fish passage spill operations (USACE et al. 2020, p. 2-51).

1.2.1.4 Multiple Objective Alternative 3

The co-lead agencies developed Multiple Objective Alternative 3 (MO3) to evaluate dam breaching on the Lower Snake River as part of the NEPA analysis. As proposed, MO3 would breach the earthen embankments at the four Lower Snake River dam locations (Ice Harbor Dam, Lower Monumental Dam, Little Goose Dam, and Lower Granite Dam). MO3 limits juvenile fish passage spill operations to no more than 120 percent TDG at the four Lower Columbia River projects (Bonneville Dam, The Dalles Dam, John Day Dam, and McNary Dam) (USACE et al. 2020, p. 2-55).

1.2.1.5 Multiple Objective Alternative 4

The co-lead agencies developed Multiple Objective Alternative 4 (MO4) to evaluate a combination of proposed changes that could be implemented within existing authorities. MO4 would benefit migratory fishes, and it includes proposed changes to water management flexibility, hydropower production, and additional water supply. MO4 would also limit juvenile fish passage spill operations to no more than 125 percent TDG, which represents the highest end of the range of proposed juvenile fish passage spill operations (USACE et al. 2020, p. 2-62).

1.2.1.6 Preferred Alternative

In the DEIS, the co-lead agencies identified a Preferred Alternative (USACE et al. 2020, pp. 7-1-49). The Preferred Alternative is comprised of a combination of measures from the five alternatives described above, with a few modifications and one additional operation associated with Flex Spill (Section 6.2) (USACE et al. 2020, pp. 1-20-21, 7-33-35).

As this CAR reflects, the Service's analysis included an evaluation of these five alternatives, considering the structural and operational measures associated with them and their impacts to fish and wildlife resources in the study area. Since the Preferred Alternative is characterized by measures that were, in some form, already analyzed, the Service did not conduct an additional evaluation of the impacts specific to the Preferred Alternative. However, the Service did evaluate the impacts of Flex Spill (Section 6.2.1), which was not included in any of the initial MOs.

1.3 AUTHORITIES

1.3.1 Fish and Wildlife Coordination Act

The FWCA authorizes the Secretaries of the Departments of Interior and Commerce to provide assistance to Federal and State agencies to protect trust fish and wildlife resources, assess possible damage to wildlife resources associated with the implementation of Federal water resource development projects like those that comprise the CRS, and define protective and enhancement means and measures for these resources.

The FWCA recognizes the importance of fish and wildlife resources and their value and significance to stakeholders. Further, the FWCA requires that fish and wildlife conservation be given equal consideration with other water resource development project and program elements through early coordination, joint planning efforts, data exchange, interagency cooperation, and the development of specific measures and project alternatives for fish and wildlife conservation and rehabilitation (Smalley and Mueller 2004, pp. 14-17).

Additionally, the FWCA authorizes the Secretary of the Interior to provide assistance to, and cooperate with, Federal agencies and other groups in developing, preserving, rearing, and stocking of fish and wildlife and to protect their habitat in the course of Federal activities, such as the modification of a body of water, natural river, or such activities proposed in the CRSO DEIS.

During any given project period, the FWCA authorizes the Service to make other investigations of fish and wildlife resources, including lands and waters, and to accept contributions of funds and donations of land to meet FWCA purposes.

To ensure fish and wildlife resources receive equal consideration, the FWCA requires the co-lead agencies to coordinate with the Service, NMFS, and other groups or cooperating agencies regarding the potential impacts of the proposed project and associated actions on fish and wildlife resources (NMFS and USFWS 2018, pp. 1-6). For this report, early coordination and interagency cooperation resulted in data-sharing and -collection, collaborative analysis, report production and review, and the Service's development of conservation recommendations. The results of this coordination are not binding. However, the co-lead agencies proposing the action should consider input received during the FWCA coordination process and incorporate conservation recommendations from the CAR in their project design and plans (Smalley and Mueller 2004, p. 160).

The Service anticipates the co-lead agencies will initiate and complete various consultations, restoration projects, and mitigation projects to address the CRSO and its impacts over time. Mitigation projects will depend on local opportunities and other factors, and those designed for one suite of habitats or species may lead to negative impacts on others. Potential conflicts and tradeoffs are not foreseeable and were not considered in this analysis, however the Service will count on future opportunities through NEPA to review and provide comments on specific project proposals and their various components (e.g., alternatives, impacts) as they arise.

1.3.2 Congressional Authority

The U.S. Congress provides the authority for the Corps and Reclamation to construct, operate, and maintain the 14 Federal CRS projects to meet multiple purposes (Table 1). Purposes include flood control (i.e., FRM), power generation, water supply, irrigation, navigation, recreation, and fish and wildlife conservation. Not every project is authorized for all of these purposes.

Bonneville has the authority to market and transmit the power generated by these coordinated operations (USACE n.d.). The co-lead agencies are responsible for managing and operating the CRSO for multiple purposes while meeting their statutory and regulatory obligations.

Table 1. Federal agencies and projects in the CRSO

Federal Agency	Federal Projects
Corps	Bonneville The Dalles John Day McNary Chief Joseph Albeni Falls Libby Ice Harbor Lower Monumental Little Goose Lower Granite Dworshak
Reclamation	Grand Coulee Hungry Horse

The co-lead agencies are reviewing and updating the long-term, coordinated management of the Federal CRS projects, including evaluating measures associated with various project alternatives to avoid, offset, or minimize potential negative impacts on resources significant to various stakeholders or user groups. The DEIS includes information on the costs, benefits, and tradeoffs of various measures and alternatives as part of reviewing and updating the management of the CRSO (USACE 2017).

1.4 COOPERATING AGENCIES AND TRIBES

Early in the NEPA process, the co-lead agencies requested cooperation from Federal and State agencies, local entities, and Tribes that have either jurisdiction by law in the study area, or special expertise on relevant environmental issues, to participate in DEIS and final EIS development (40 CFR § 1501.6). Chapter 1 of the DEIS includes a complete list of the cooperating agencies (USACE et al. 2020, pp. 1-7-8).

The co-lead agencies and several of the designated cooperating agencies and Tribes collaborated with the Service during the analysis and for this reporting effort (Table 2). Other agencies and entities, Tribes, and non-governmental partners contributed to this report, but they were not cooperating agencies (Section 1.4)

Table 2. Cooperating agencies and Tribes that also contributed to the CAR

General Affiliation	Specific Agencies and Tribes
State Agencies	Montana Department of Fish, Wildlife, and Parks Montana Department of Natural Resources and Conservation Oregon Department of Fish and Wildlife Washington State Department of Ecology Washington Department of Fish and Wildlife
Tribes	Confederated Tribes of the Grand Ronde Community of Oregon Cowlitz Indian Tribe Kalispel Tribe of Indians Kootenai Tribe of Idaho Spokane Tribe of Indians Yakama Nation

2 RELEVANT PRIOR FWCA REPORTS IN THE BASIN

In accordance with the FWCA, the Service has previously developed CARs, Planning Aid Letters, and general memos in response to Federal agency-led water resource development activities and their impacts on fish and wildlife resources in the Basin. Prior CAR reporting efforts, described below, identify the Federal Columbia River Power System (FCRPS) as the coordinated operation of 14 Federal projects in the Basin. However, these projects represent only a subset of the 31 total Federal projects that actually comprise the FCRPS (NPCC 2011, p.2). The name change (from FCRPS to CRSO in reference to the 14 CRS projects) is meant to eliminate past confusion surrounding the Federal hydropower systems. The term FCRPS is used in this section because it was also used in past CARs, however, in the analysis for this report, the Service used the term CRSO.

Past CARs for the FCRPS can be assigned to two time periods: pre-dam construction and post-dam construction. When the Federal hydropower projects or dams were first designed and constructed, CARs, letters, and memos focused on project (dams and associated infrastructure) construction and operations. In those documents, the baseline conditions used to analyze changes in the environment as a result of the Preferred Alternative did not include the impacts of dams, as the dams were not yet constructed. The Service's CARs published during that time included the only description of the environmental impacts of the FCRPS projects prior to their construction.

Congress did not enact NEPA until 1969 and did not fully implement it until the mid-1970s. Construction of the last Federal project, Lower Granite Dam, was finalized in 1975, so the design and construction of the FCRPS was not subject to NEPA. Until the 1990s, the Service issued CARs with narrow scopes for individual project structural improvements and operational changes. Few CARs addressed the entire system, yet two are notable as a result of their broader scope and more detailed analyses: the Columbia River System Operation Review (System Operation Review) and another related to fish passage in the Lower Snake River (USFWS 1995, 1999).

2.1 1995 CAR FOR THE COLUMBIA RIVER SYSTEM OPERATION REVIEW

The Service's 1995 CAR for the System Operation Review for the Corps analyzed resources affected by the FCRPS. Through a comprehensive evaluation of the FCRPS, this report included recommendations to promote the recovery of newly-listed Pacific salmon. The 1995 CAR was comprehensive and also unique in that it marked an early approach to integrate fish and wildlife mitigation, enhancement, recovery, and restoration with the existing FCRPS and the Preferred Alternative. At the time, the Service was confident that addressing these issues in a holistic ecosystem context, rather than on a project-by-project basis, would be more biologically appropriate and effective.

The Service's 1995 CAR presented a broad ecosystem planning and management approach for evaluating and addressing operational and biological impacts of the Preferred Alternative (USFWS 1995, p. 15). Rather than recommend specific actions for implementation, the Service declared that mitigation, enhancement, recovery, and restoration strategies included in the Preferred Alternative would require adaptive implementation (UFWS 1995, p. 24). This approach included identification, design, implementation, and evaluation of restoration strategies, and would have generated proposed modifications based on information obtained during the FWCA evaluation phase. This report did not suggest project-specific measures or actions for the Federal action agencies to implement; rather, it recommended a process for identifying potential measures, implementing those measures as agency budgets allow, and evaluating their efficacy over time.

2.2 1999 CAR FOR IMPROVED FISH PASSAGE IN THE LOWER SNAKE RIVER

In the proposed Lower Snake River fish passage improvements as part of the 1999 CAR, the Corps – Northwestern Division analyzed an alternative for breaching the four Lower Snake River dams: Ice Harbor Dam, Little Goose Dam, Lower Granite Dam, and Lower Monumental Dam. Federal listing of several stocks of Pacific salmon in the mid-1990s due to overharvest, habitat loss and degradation, and construction of dams and reservoirs prompted the NMFS to issue two Opinions on FCRPS operations (NMFS 1995, 2000). The Opinions outlined measures to avoid jeopardizing the continued existence of listed species affected by FCRPS operations. As a result, the Corps implemented a study of alternatives known as the Lower Snake River Juvenile Salmon Migration Feasibility Study (Feasibility Study) to analyze the impacts of Lower Snake River dams and reservoirs as barriers to migratory fishes (USACE 1992a, p. ES-2).

The Feasibility Study evaluated the technical, environmental, and economic feasibility of structural alternatives that were likely to increase survival and improve the prospects for recovery of Pacific salmon in the Snake River, thereby allowing them to pass through the four Lower Snake River dams. The study was conducted in two phases. Phase I, completed in mid-1995, included a preliminary assessment of multiple concepts such as drawdown of reservoirs, upstream collection and transport of juvenile Pacific salmon, additional reservoir storage, and more alternatives for improving conditions for fish migration. Phase II, completed in 1996, included an evaluation of the feasibility of reservoir drawdown to spillway crest elevations and below, and other improvements to existing fish passage facilities. Based on the Phase I and Phase II reports, the 1999 EIS developed four alternatives (USACE 1992b, pp. 3-2-22).

The Federal Record of Decision reflected the Corps' decision to implement the Major System Improvements (Adaptive Migration) Alternative. Over the next 10 to 15 years, the Corps and Reclamation implemented many of the measures outlined in the EIS.

3 STUDY AREA AND BASIN EXTENT

The study area considered in the Service's analysis includes the Basin, and its tributaries and infrastructure affected by the CRSO. The study area is comprised of the mainstem Columbia River, the Lower Snake River (beginning approximately 9.0 miles [14 km] below its confluence with the Salmon River, to the Snake River's confluence with the Columbia River), and all portions of tributaries affected by regular flow management, including terrestrial and aquatic habitats within an approximate 0.5 mile (0.8 km) buffer (USFWS and USACE 2018, p. 8).

The Basin covers approximately 258,000 square miles (mi^2) (668,217 square kilometers [km^2]) and includes major portions of Idaho, Oregon, Washington, and the western part of Montana; minor portions of Nevada, Utah, and Wyoming; and the southeastern part of British Columbia (Figure 1). The Columbia River, the fourth largest river in amount of discharge (i.e., 265.0 kilo cubic feet per second [kcfs] [7,504 cubic meter per second or m^3/s]) in North America, delivers more water to the Pacific Ocean than any other river in North or South America (Bloodworth and White 2008, p. 98; Kammerer 2005). It is approximately 1,270 miles (2,044 km) long and flows through the Rocky Mountain (Rockies) and Cascade Mountain Ranges (Cascades).

Where the Columbia River meets the Pacific Ocean, saltwater intrusion extends approximately 23 miles (37 km) upstream. Tidal impacts extend up to Bonneville Dam, 146 river miles (RM) (235 river kilometers [RKM]) inland (USACE et al. 2020, p. 3-15). Streamflow in the Basin typically begins to rise in April, reaching a peak during May or early June, and about 60 percent of the natural runoff occurs May through July. Regarding infrastructure, the Basin includes over 400 dams, of which 133 dams produce hydropower as their primary or secondary purpose. Other dams are primarily related to irrigation, fish hatcheries, or other purposes (USACE et al. 2020, p. 3-15).

Ecologically, the Basin includes diverse habitats, affected by several mountain-influenced precipitation patterns, differences in elevation, aspect, soils, and underlying geology and resulting hydrology. The Cascades separate the Pacific Ocean coast from the interior of the Basin, dividing the maritime climate to the west from the interior land east of the crest, leaving the interior Basin with a continental climate of cold winters and warm, dry summers (USACE et al. 2020, p. 3-15). Variability in geology, soils, and climate results in a diverse array of upland, wetland, aquatic, and riparian (i.e., relating to transitional land adjacent to bodies water such as rivers or streams) habitats.

The Columbia River has many tributaries, and four are of particular focus in the Preferred Alternative: Snake River, Clearwater River, Kootenai River, and Pend Oreille River. Section B.1 includes a detailed description of the focal tributaries and how the Service further defined the study area for the CAR.

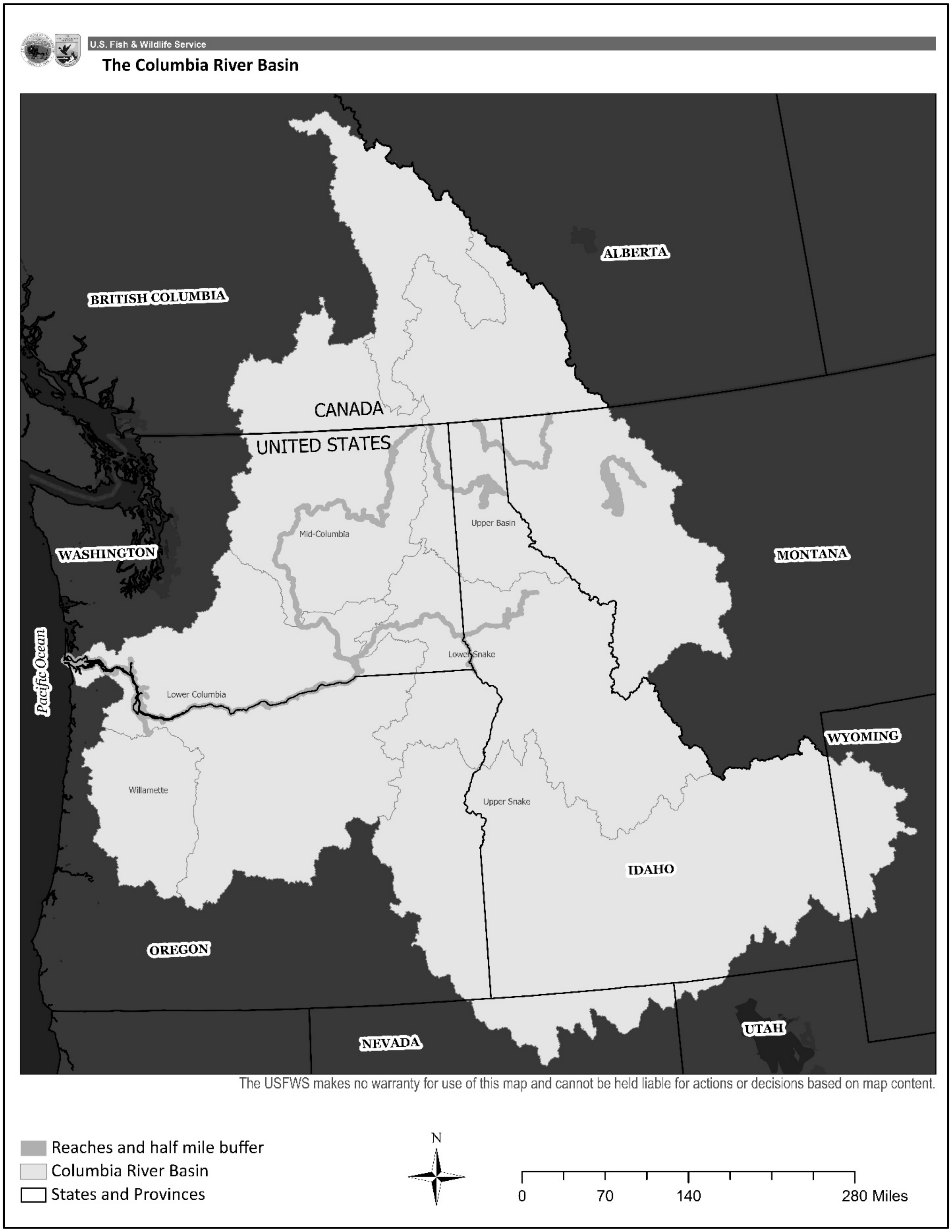

Figure 1. The Columbia River Basin, including the 0.5 mile (0.8 km) buffer

4 METHODS

This CAR includes the Service's analysis of impacts of the co-lead agencies' proposed changes to modifications, operations, and configurations of Federal CRS projects on fish and wildlife resources. The Service coordinated with other Federal and State agencies, local entities, and Tribes to define trust fish and wildlife resources to consider in the analysis of impacts (Section 6).

For the analysis, the Service identified key ecological and physical processes that support Basin landscape structure and function. Based on those landscape structures and functions, the Service identified fish and wildlife resources that depend on certain habitats and subhabitats in the study area. Finally, the Service organized the data and analysis by subbasins in the study area. The four subbasins selected were: Lower Columbia River, Mid-Columbia River, Upper Basin, and the Lower Snake River (Table 3 and Figure 2).

Table 3. Subbasins identified by the Service and associated Federal projects in the study area

Subbasin	Description	Federal Projects
Lower Columbia River	Pacific Ocean to the confluence with the Snake River	Bonneville The Dalles John Day McNary
Mid-Columbia River	Confluence of the Snake River to the Canadian border	Chief Joseph Grand Coulee
Upper Basin	Pend Oreille, Kootenai, and Clark Fork Rivers and Reservoirs	Albeni Falls Libby Hungry Horse
Lower Snake River	Confluence of the Columbia River to Dworshak Reservoir	Ice Harbor Lower Monumental Little Goose Lower Granite Dworshak

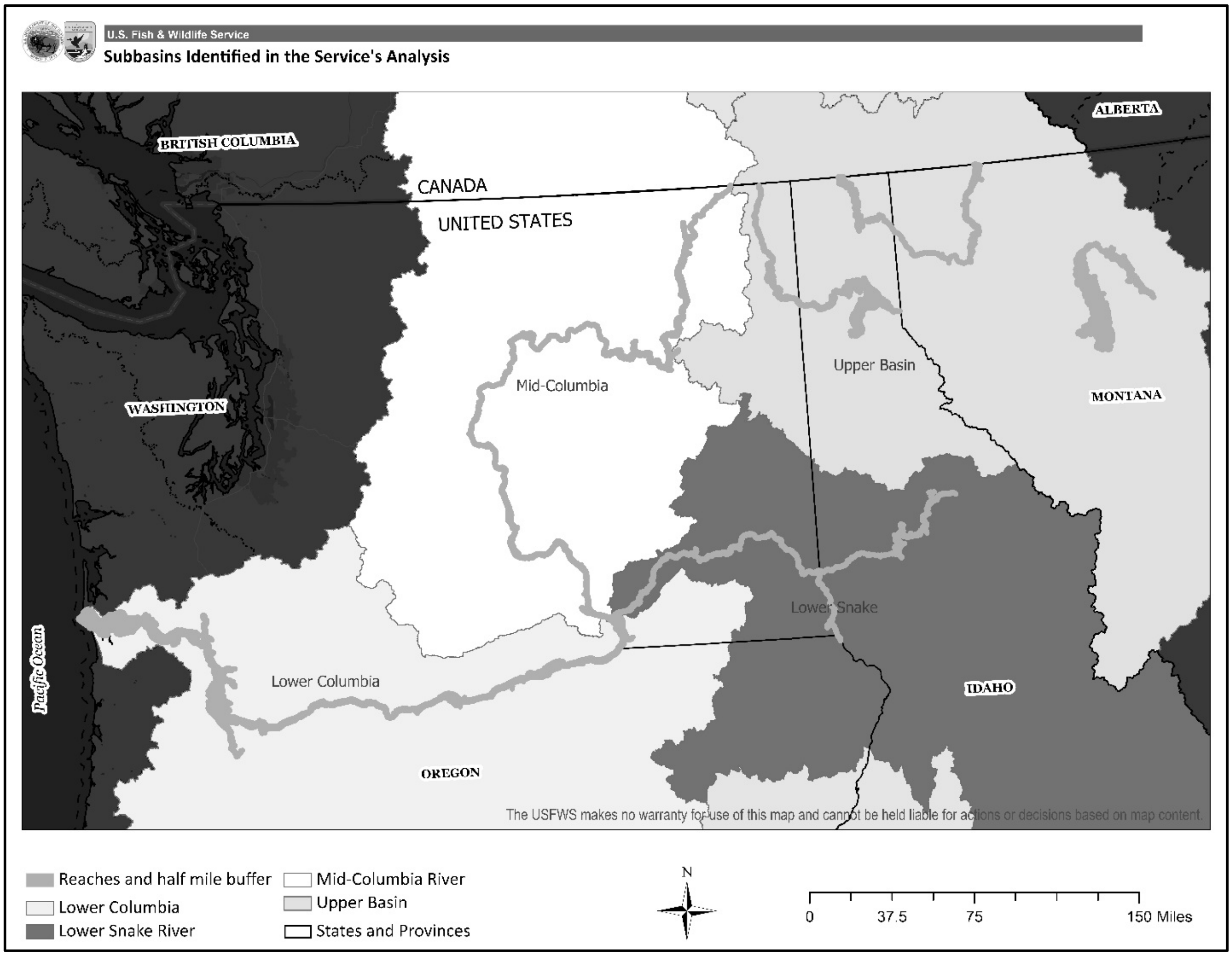

Figure 2. Subbasins identified by the Service for the CAR analysis

4.1 ECOLOGICAL AND PHYSICAL PROCESSES

The Service identified ecological and physical processes critical to support functional Basin landscapes and persistent fish and wildlife resources under current conditions. The Service also developed general indicators of processes (Table 4). For example, high ecosystem function may be a good indicator of diverse plant growth and successful animal reproduction in a specific location. For the CAR analysis, the Service considered the indicators in Table 4 to determine how changes in dam operations may affect ecological and physical processes and fish and wildlife resources that depend on them.

Table 4. Ecological and physical processes and general indicators identified by the Service for the CAR analysis

Ecological and Physical Processes	Indicators
Channelization Channel avulsion Natural disturbance Channel migration Water flow	Connectivity
Disturbance Nutrient cycling Plant and animal interactions (e.g., growth)	Ecosystem function
Channel avulsion Disturbance Forest succession Sediment bar formation Nutrient cycling Plant and animal reproduction Recruitment and transport of large wood[1/] Sediment dynamics (e.g., sediment transport) Soil formation	Habitat complexity and diversity Species diversity
Erosion (i.e., scouring)	Landforms (e.g., natural bluffs)
Natural disturbance Nutrient cycling Pollination Seasonal flooding	Native vegetation (e.g., grasslands)
Bioturbation (e.g., spawning or burrowing) Erosion (e.g., bank sloughing) Fire occurrence (i.e., frequency, intensity) Flooding Sediment dynamics (e.g., deposition) Channel migration	Natural disturbance
Precipitation Soil formation Storing water (e.g., floodwater) Water flow	Natural flood regime
Natural disturbance (e.g., storms)	Pre-dam hydrograph

Ecological and Physical Processes	Indicators
Precipitation Storing water (e.g., floodwater) Water flow (e.g., base flow, subsurface flow)	
Erosion Sediment filtration Surface water inundation	Terrain (e.g., streambanks, shorelines)
Climate variability patterns Cooling/warming of water Mixing of fresh and ocean waters Sediment dynamics (e.g., deposition) Storing/biodegrading pollutants Stratification	Water quality (in this report, total dissolved gas)
Evaporation Flooding Groundwater discharge Precipitation Water flow (e.g., subsurface flow) Water storage Water uptake (e.g., adsorption by plants)	Water quantity

[1/]Instead of the term large woody debris, this report uses large wood (LW) to imply dead but mostly intact fallen trees large enough to influence ecological and physical processes (e.g., channel avulsion or sudden channel formation by erosion).

4.2 LANDSCAPES

To address the diverse range of ecological communities in the study area and their value to fish and wildlife resources, the Service identified landscapes that could be impacted by the ecological and physical processes changed as a result of the Preferred Alternative (Section 5).

Referring to the U.S. Environmental Protection Agency (EPA) Level 3 and 4 Ecoregions in the study area, the Service selected a preliminary list of four broad aquatic and terrestrial landscapes potentially affected by the Preferred Alternative: lakes/reservoirs/rivers, riparian, wetlands, and uplands (EPA 2017). These landscapes helped the Service refine the evaluation species, habitats, subhabitats, and key sites selected for this analysis (USFWS and USACE 2018, p. 9). The uplands landscape comprises a relatively small proportion of the study area, and, thus, the Service analyzed impacts on this landscape generally, without identifying key sites or locations as with other landscapes (Section 4.6).

A given landscape may contain features similar to those that also characterize other landscapes, however this CAR limits discussion of those features as part of only one, rather than more than one, landscape. For instance, the Service analyzed riparian habitats separately from wetland and upland habitats to the extent possible, even though some riparian features were found to be closely associated with those habitats. In general, this analysis focused on relatively undeveloped lands, rather than human-populated or -developed subhabitats (i.e., residential, commercial, and industrial areas and associated infrastructure), as the undeveloped lands are more likely to support fish and wildlife resources.

4.3 EVALUATION SPECIES

For the CAR, the Service evaluated trust fish and wildlife resources including: migratory birds; migratory fishes (e.g., multiple species of fish such as Pacific lamprey [*Entosphenus tridentatus*] and white sturgeon [*Acipenser transmontanus*]) and interjurisdictional fishes; species with socioeconomic value, including consumptive (e.g., fishing, hunting) and non-consumptive (e.g., birdwatching) human use value; environmentally sensitive species; species performing key ecological roles; species affected by Federal water resource development; and species that represent guilds or communities of species that use a common environmental resource (Smalley and Mueller 2004, p. III-18).

In identifying the evaluation species, the Service reviewed documents including State Wildlife Action Plans, Priority Habitats and Species of Washington, and State Species of Concern. Based on its review, the Service identified and prioritized a preliminary list of approximately 100 evaluation species using the following criteria:

- **Indicators of ecological change**. For example, the “rivers/lakes/reservoirs” landscape includes the Pacific lamprey, an indicator of water quantity (i.e., timing and total yield of water originating from a watershed) as well as water quality and tributary substrates (Clemens et al. 2017, p. 7).
- **Likelihood to be negatively or positively impacted** by changes in ecological and physical processes affected by proposed alternatives, including dam operations and maintenance.
- **Representative of identified subbasins and landscapes in the Basin**. To understand the impacts of the CRSO basinwide, within each landscape, the Service selected representative species that inhabit landscapes occurring across the four subbasins in the study area.
- **Not listed as threatened or endangered under the Act**. Impacts on listed fishes (bull trout [*Salvelinus confluentus*], Kootenai white sturgeon [*A. transmontanus*], and 12 stocks of Pacific salmon and steelhead), wildlife, and plant species will be addressed in consultations under section 7(a)(2) of the Act and, thus, are outside the agreed upon scope of this CAR. For the Service’s analysis, species that have state listing status (e.g., endangered, threatened, candidate, of concern) and do not have Federal threatened or endangered listing status were prioritized (NMFS 2019, pp. 5-6).

- **Of interest to multiple States and Tribes**. Selected species (e.g., Pacific lamprey) that multiple States (Idaho, Montana, Oregon, and Washington), Tribes, and other stakeholders across geopolitical boundaries have identified as a priority in their respective management plans were also prioritized in the Service's analysis.

Upon request (Section C.1), Service experts, the co-lead agencies, and other State, Tribal, local, and private partners participated in a review of the prioritized species list. Based on the input received and associated review, the Service developed an initial, focused list of landscapes and evaluation species (Table 5). This initial list was approved in the SOW (USFWS and USACE 2018, p. 9).

Table 5. Initial, focused list of landscapes and evaluation species in the signed SOW

Landscapes	Evaluation Species
Rivers/Lakes/Reservoirs	Clark's grebe (*Aechmophorus clarkii*) Columbia River redband trout (*Oncorhynchus mykiss gairdnerii*) Pacific lamprey (*Entosphenus tridentatus*) Shortface lanx (*Fisherola nuttalli*) Trumpeter swan (*Cygnus buccinator*) Westslope cutthroat trout (*Oncorhynchus clarkii lewisi*)
Riparian	Townsend's big-eared bat (*Corynorhinus townsendii australis*) Ute-ladies'-tresses (*Spiranthes diluvialis*) Western bumblebee (*Bombus occidentalis*) Yellow-billed cuckoo (*Coccyzus americanus*)
Wetlands	Northern leopard frog (*Lithobates pipiens*) Western pond turtle (*Actinemys marmorata*) Western toad (*Anaxyrus boreas*)
Uplands	Ferruginous hawk (*Buteo regalis*) Washington ground squirrel (*Urocitellus washingtoni*) White bluffs bladderpod (*Physaria douglasii* spp. *tuplashensis*)

Source: USFWS and USACE 2018, p. 9

4.4 RELATING AND REFINING LANDSCAPES AND SPECIES

Following the SOW approval, the Service refined and expanded the initial, focused list based on key elements of the analysis:

- the Preferred Alternative and alternatives, and their potential impacts on the study area and fish and wildlife resources;
- important ecological and physical processes, habitats and subhabitats, and ecological features that occur in, or characterize, the study area; and,

- potential evaluation species that could serve as indicators of ecological change given the suite of potential CRSO impacts.

Thus, the Service created an interim list of five landscape groupings (rivers, lakes and reservoirs, riparian, wetlands, and uplands) and 78 evaluation species. Six of the 78 species had been included in the initial, focused list (Table 5). Next, the Service ranked potential evaluation species from this interim list according to the indicator of ecological change criterion.

The Service's refinement considered unique ecological links among the Preferred Alternative and alternatives, ecological and physical processes, habitats and subhabitats, and species life history stages and ecological niches. The Service's refinement reflected the following changes:

- **Reconsideration of landscapes**. Separation of "lakes and reservoirs" and "rivers" landscapes based on a discussion of the unique ecological and physical processes, habitats and subhabitats, and ecological features that differentiate rivers from lakes and lake-like environments such as reservoirs. For this CAR, the Service discussed impacts on Pacific lamprey primarily in association with the rivers landscape rather than the lakes and reservoirs landscape due to their strong dependence on riverine subhabitats in the study area.
- **Confirmation of evaluation species**. Pacific lamprey and Clark's grebe (*Aechmophorus clarkii*) were confirmed as evaluation species from the initial, focused list.
- **Substitution of evaluation species**. Twelve species were substituted as evaluation species because they were considered to be better indicators of potential changes in landscapes throughout the study area. For instance, the black cottonwood (*Populus trichocarpa*) substituted for the Ute-ladies'-tresses (*Spiranthes diluvialis*) because of its prevalence throughout riparian habitats and subhabitats in the Basin and likelihood to be affected by CRSO impacts.
- **Addition of two evaluation species**. The American bittern (*Botaurus lentiginosus*) and the Western grebe (*A. occidentalis*) were added as evaluation species.
- **Elimination of two evaluation species**. The White Bluffs bladderpod (*Physaria douglasii* spp. *tuplashensis*) and Townsend's big eared bat (*Corynorhinus townsendii australis*) were eliminated as evaluation species based on their limited geographic range in particular subhabitats of the study area.

Table 6 shows the resulting refined list, which received support from, and approval by, Service staff and other State, Tribal, local, and private partners. See Section 5 and Appendix F for more detailed information about landscapes, habitats and subhabitats, and their relationships to the identified ecological and physical processes. Appendix F also includes descriptions of the final evaluation species the Service selected for, and analyzed in, this CAR.

Table 6. Refined list of landscapes and evaluation species analyzed in the CAR

Landscapes	Evaluation Species
Rivers	Pacific lamprey (*Entosphenus tridentatus*) Western pearlshell (*Margaritifera falcata*) White sturgeon (*Acipenser transmonatus*)
Lakes and Reservoirs	Clark's grebe (*Aechmophorus clarkii*) Western grebe (*Aechmophorus occidentalis*) Dunlin (*Calidris alpina*) Floaters (*Anodonta* spp.)
Riparian	Black cottonwood (*Populus trichocarpa*) Viceroy butterfly (*Limenitis archippus*) Yellow warbler (*Setophaga petechia*)
Wetlands	American bittern (*Botaurus lentiginosus*) Mallard (*Anas platyrhynchos*) Western painted turtle (*Chrysemys picta*) Woodhouse's toad (*Bufo woodhousii*)
Uplands	Long-billed curlew (*Numenius americanus*) Sage thrasher (*Oreoscoptes montanus*)

4.4.1 Other Guilds, Communities, and Species

The Service identified additional species, guilds, and communities to highlight particular impacts of some of the proposed alternatives—impacts that could not be illustrated through analysis of the evaluation species. For example, the Service identified the Columbia yellowcress (*Rorippa columbiae*) in the wetlands landscape because it is uniquely reliant on specific wetland subhabitats (e.g., emergent wetlands). Similarly, along with the yellow warbler (*Setophaga petechial*), the Service highlighted Bullock's oriole (*Icterus bullockii*) and willow flycatcher (*Empidonax traillii*), as they all represent a large and diverse guild of riparian songbirds and serve as indicators of potential impacts on other wildlife (e.g., terrestrial invertebrates, amphibians, reptiles, and mammals) that use riparian habitat (Croonquist and Brooks 1991, pp. 708-709). In these ways, additional species, guilds, and communities illustrated different scales of potential impacts of the proposed alternatives.

4.5 COORDINATION AND INFORMATION-SHARING

4.5.1 Technical Workshops

The FWCA requires the Service to consult and coordinate with other groups, including the co-lead agencies, cooperating agencies, and Federal and State agencies, Tribes, private entities, and academic institutions to augment its understanding of the potential impacts of the proposed alternatives on fish and wildlife resources. Due to the size and scope of the Preferred

Alternative, the diversity of values held among stakeholders in the Basin, and the many fish and wildlife resources at risk, it was imperative that the Service effectively coordinate with participating stakeholder groups. To coordinate and gather input, the Service planned and hosted a series of multi-stakeholder technical workshops in the summer of 2019. The goal of the Service's coordination through these workshops was to enhance the information available for analysis and yield a more complete understanding of the ecological, socioeconomic, and cultural values of these resources, and their potential risk as a result of proposed changes to the CRSO. These workshops allowed the Service to maximize effort in capturing various perspectives and insights into the research and analysis presented in this CAR.

The Service designed and facilitated five technical workshops in May and June, 2019. Each workshop focused discussions on either a landscape (e.g., riparian, wetlands, lakes and reservoirs, or rivers) or a subbasin (e.g., Upper Basin) (Table 7). Each workshop was held in a different location in the Basin to allow for convenient travel and easy participation among stakeholders. The Service facilitated the first three workshops and a consulting firm, DS Consulting, located in Portland, Oregon, facilitated the last two workshops.

Table 7. The focuses, dates, and locations of the Service's technical workshops

Workshop Focus	Dates	Location
Wetlands	May 20-21	Mid-Columbia River National Wildlife Refuge Complex Office in Burbank, Washington
Upper Basin[1/]	May 28-29	Montana Department of Fish, Wildlife, and Parks Office in Kalispell, Montana
Riparian	June 5-6	Mid-Columbia River National Wildlife Refuge Complex Office in Burbank, Washington
Rivers	June 24-25	Columbia River Fish and Wildlife Conservation Office in Vancouver, Washington
Lakes and Reservoirs	June 25-26	Columbia River Fish and Wildlife Conservation Office in Vancouver, Washington

[1/]Uplands habitats and subhabitats in the Basin likely to be affected by the CRSO were discussed as part of the Upper Basin Workshop.

Section C.2 includes the Service's outreach and communications associated with these technical workshops. More than 110 stakeholders from 21 organizations participated in at least one or more of these workshops (Table 8).

Table 8. Stakeholders represented at the Service's technical workshops

General Stakeholder Group	Affiliation within General Stakeholder Group
Federal Agencies and Programs	Bureau of Reclamation U.S. Amy Corps of Engineers U.S. Fish and Wildlife Service U.S. Forest Service
State Agencies	Montana Department of Fish, Wildlife, and Parks Montana Department of Natural Resources and Conservation Oregon Department of Fish and Wildlife Washington Department of Fish and Wildlife Washington State Department of Ecology
Tribes	Confederated Tribes of the Grand Ronde Community of Oregon Cowlitz Indian Tribe Kalispel Tribe of Indians Kootenai Tribe of Idaho Yakama Nation
Private Entities	Inter-Fluve Meadow Run Environmental LLC
Academic Institutions	Eastern Washington University Oregon State University Southern Illinois University – Edwardsville University of Idaho University of Lethbridge

During each workshop, the Service provided an overview of the CRSO and the FWCA, detailed the analysis approach for the CAR, and defined the purpose and goals for the workshop. Workshop discussions centered on four to five questions designed to encourage stakeholders to share specific information on the following:

- ecological and physical processes that maintain resource health and potential impacts of changes to existing conditions;
- the status of significant fish and wildlife resources;
- key sites and locations defined by ecological and physical processes that either do, or could, support fish and wildlife resources; and,
- measurable and achievable actions to conserve, protect, and enhance the identified fish and wildlife resources.

Each technical workshop provided an opportunity for participating stakeholders to learn about the Preferred Alternative and alternatives, and contribute to, or add, technical information related to the previously identified key ecological and physical processes, landscapes, and evaluation species. The Service requested stakeholders identify and describe fish and wildlife resources and habitats, or specific locations or sites with special value to them and the agencies they represent; discuss how changes to existing conditions could potentially impact these resources; and suggest measures to conserve, protect, and enhance ecological and physical processes, habitats, and species. The Service also asked for information (e.g., data, reports from past surveys or studies, white papers, gray literature, species population assessments, expert knowledge) to fill information gaps. Appendix D includes the Service's workshop agendas and discussion questions.

4.5.2 Data and Modeling

The Service used data from different sources including modeling efforts led by the co-lead agencies, existing databases, primary literature, technical experts who participated in the technical workshops, draft and final Service and Corps reports (e.g., consultations, Biological Assessments) and gray papers, and maps and aerial photographs. The Service performed a series of quantitative and qualitative assessments using available data to examine and measure the potential impacts of the CSRO on fish and wildlife resources in the Basin. Appendix E includes the primary data sources the Service used in the analysis for this CAR.

4.6 QUANTITATIVE KEY SITE AND LOCATION SELECTION

The Service worked with stakeholder participants during the technical workshops to identify key sites or locations in the study area with specific characteristics, based on the following criteria:

- best representative of ecological and physical processes and functional habitats;
- actively managed or protected to maintain fish and wildlife resource value; and,
- greatest contributors to native species conservation (e.g. important migratory bird areas, well-connected corridors, reservoirs with water management operations that benefit important species).

Other locations (e.g., Blalock Island complex) were identified from follow-up discussions with Service staff and through communications with cooperating agencies and technical workshop participants regarding specific fish and wildlife resources (e.g., Caspian tern [*Hydroprogne caspia*]).

As part of the analysis of impacts, the Service evaluated 41 key sites and locations by landscape and subbasin. Key sites associated with four of the landscapes (rivers, lakes and reservoirs, riparian, and wetlands) are summarized in Table 9, shown in Figure 3, and discussed in more detail in Section 5. Because there is little uplands landscape in the 0.5 mile (0.8 km) buffer in comparison to the other landscapes, the Service analyzed impacts on the uplands landscape generally and did not identify key sites or locations associated with this landscape.

Table 9. Key sites and locations identified by the Service, organized by landscape and subbasin

Landscape	Subbasin	Key Sites
Rivers	Lower Columbia River	1. Columbia River Estuary 2. Mouth of the Deschutes River 3. John Day Reservoir or Pool (Lake Umatilla)
	Mid-Columbia River	4. Hanford Reach 5. Reach 21, above Grand Coulee Pool (Lake Roosevelt)
	Upper Basin	6. Kootenai River 7. Pend Oreille River
	Lower Snake River	8. Clearwater River 9. Lower Monumental Reservoir or Pool (Lake Herbert G. West)
Lakes and Reservoirs	Lower Columbia River	10. John Day River Confluence 11. Blalock Island Complex 12. Umatilla River Confluence
	Mid-Columbia River	13. Lake Roosevelt
	Upper Basin	14. Lake Pend Oreille 15. Lake Koocanusa
	Lower Snake River	16. Dworshak Reservoir
Riparian	Lower Columbia River	17. Julia Butler Hansen National Wildlife Refuge 18. Sandy River Delta 19. Umatilla National Wildlife Refuge
	Mid-Columbia River	20. Okanogan River Confluence 21. Threemile Creek to Six Mile Creek Confluences 22. Little Sheep Creek Confluence
	Upper Basin	23. Stillwater River Confluence 24. Clark Fork Delta at Lake Pend Oreille 25. Yaak River and Star Creek Confluences
	Lower Snake River	26. Catholic Creek Confluence 27. Tucannon River Confluence 28. Big Flat Recreation Area

Landscape	Subbasin	Key Sites
Wetlands	Lower Columbia River	29. Reed Island 30. Steigerwald Lake and Sauvie Island Wildlife Area 31. Sandy River Delta
Wetlands	Mid-Columbia River	32. Hanford Reach 33. Wells Wildlife Area 34. Lower Crab Creek 35. McNary National Wildlife Refuge
	Upper Basin	36. Everett Island 37. Kootenai National Wildlife Refuge 38. Pack River Delta
	Lower Snake River	39. Silcott Island 40. Snake River Delta 41. Palouse River Delta

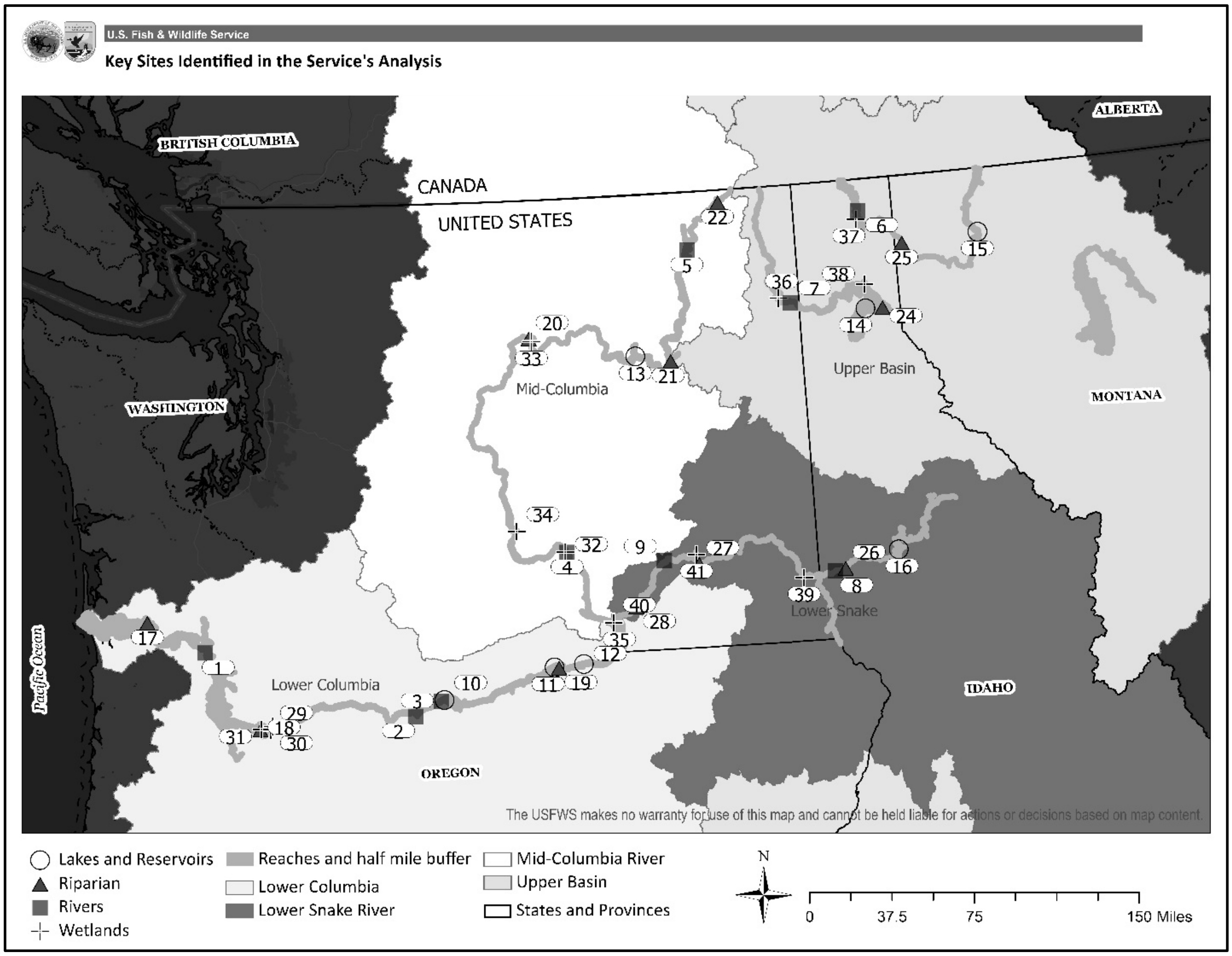

Figure 3. Key sites and locations analyzed in the CAR

5 RESOURCES

For the analysis, the Service selected aquatic and terrestrial landscapes, characterized by habitats and subhabitats, in the study area that were likely to be affected by proposed changes to the CRSO (Table 10). In this CAR, the Service identifies and describes these landscapes, the evaluation species (according to their close association with ecological and physical processes and habitats), and key sites within each landscape. Additional guilds, communities, and species are also described within relevant landscapes as they appear in this section of the report. The Service describes these resources in more detail in Appendix F.

Table 10. Landscapes, habitats, and subhabitats identified by the Service in the study area

Landscape	Habitats
Rivers	River – including banks and shorelines, floodplains, side channels, transition areas, tributary mouths, and unimpounded reach subhabitats Estuary Nearshore marine environment Barren lands Islands
Lakes and Reservoirs	Natural lakes Reservoirs Barren lands Islands
Riparian	Emergent Scrub-shrub Forest Islands
Wetlands	Palustrine – including forest, scrub-shrub, and subhabitats Lacustrine Emergent Barren lands Islands River deltas
Uplands	Forest uplands – coniferous, deciduous, and mixed subhabitats Arid uplands – agriculture, grasslands, and shrub-steppe subhabitats

5.1 RIVERS

This landscape includes river, estuary, and nearshore marine habitats, which are often characterized by streams and tributaries, edges of rivers and sloughs, and temporary impoundments. For this report, reference to common river subhabitats in the Basin includes river banks and shorelines, side channels, transition areas, and unimpounded reaches (Section F.1).

Within the regulated CRS, river subhabitats are representative of the historic free-flowing riverine environment, of which only remnants exist in the study area. These subhabitats maintain ecological and physical processes and hydrologic function that the reservoir environment cannot provide, and they support various life history stages of aquatic species. Section F.1 includes more details on river resources in the study area.

5.1.1 Trends in Rivers Landscape and Habitat Quality

Historical and recent trends in populations of biologically, socioeconomically, and culturally important aquatic species in the riverine environment throughout the Basin (e.g., Pacific lamprey, white sturgeon, freshwater mussels) have mirrored the declining trends of Pacific salmon fisheries (Nedeau et al. 2009, p. 34). In general, the factors that pose the greatest threats to many of these species come from a loss of access to, or quality of, habitat and important ecological and physical processes. These habitats and processes continue to be negatively impacted by water diversion projects for irrigation, power generation, and water supply, particularly throughout Idaho, Oregon, and Washington in the Pacific Northwest (Nedeau et al. 2009, p. 34).

The presence of the Federal projects and other dams and barriers have significantly altered the riverine environment in the Basin and all of its inhabitants, especially those species that use rivers for migratory purposes (e.g., Pacific lamprey, Pacific salmon, trout, and white sturgeon). The few remaining free-flowing and unimpounded reaches maintain important hydrologic processes that allow for habitat complexity, increased ecosystem function, and improved water quantity and quality standards required to support healthy fish and aquatic species populations at various life history stages (Beamesderfer and Anders 2013, p. 57; Ward et al. 2001, pp. 318-321; Williams et al. 2006, p. 642).

5.1.2 Evaluation Species

Evaluation species associated with the rivers landscape include Pacific lamprey, Western pearlshell mussel (*Margaritifera falcata*), and white sturgeon. For detailed descriptions of these species, see Section F.1.2.

5.1.3 Key Sites and Locations

Within the Basin, the Clearwater River in Idaho; Flathead River in Montana; Grand Ronde River, John Day River, and the Sandy River in Oregon; and Klickitat River in Washington are part of the National Wild and Scenic Rivers System (Public Law 90-542 § 1[b]; 16 U.S.C. § 1274 [1968]; NWSRS 2018). These rivers are nationally recognized as maintaining wild, scenic, and recreational areas and, thus, are worthy of preservation.

Key sites and locations, identified by the Service and characterized by river habitats and subhabitats throughout the study area, are listed in Table 11. The impacts of the CRSO alternatives on the rivers landscape and evaluation species at these key sites are described in Sections 6 and G.1.

Table 11. Key sites characterized by the rivers landscape, organized by subbasin

Subbasin	Key Sites
Lower Columbia River	Columbia River Estuary Mouth of the Deschutes River John Day Reservoir or Pool (Lake Umatilla)
Mid-Columbia River	Hanford Reach Reach 21, above Grand Coulee Pool (Lake Roosevelt)
Upper Basin	Kootenai River Pend Oreille River
Lower Snake River	Clearwater River Lower Monumental Reservoir or Pool (Lake Herbert G. West)

5.2 LAKES AND RESERVOIRS

Lakes are naturally occurring low points in the landscape that are characterized by lentic (i.e., still or slower-moving) water, predominantly in the form of year-round, open water habitat. Groundwater or surface water may constitute the inflow, outflow, or both. In contrast to rivers and tributaries, natural lakes and reservoirs store more water and usually have less flow. Reservoirs are man-made impoundments rather than natural lakes. Section F.2 includes more details on lakes and reservoir resources in the study area.

5.2.1 Trends in Lake and Reservoir Landscape and Habitat Quality

Prior to the construction of Federal and non-Federal hydropower projects, the Columbia and Snake Rivers were free-flowing. They consisted of intact and productive mainstem and side channel subhabitats in tributaries and naturally occurring lakes. The river subhabitats in the Lower Snake River, for instance, included ecological features such as gravel bars, islands, runs, pools with backwaters, side channels, and sloughs, which increased overall habitat complexity and ecosystem function.

Dam construction and related infrastructure, and continuing CRS project operations and maintenance have degraded river habitats and diminished aquatic (e.g., migratory fishes) and terrestrial species populations. Though some natural lakes (e.g., Flathead Lake, Lake Pend Oreille) and their habitats have remained functionally intact, most lake-like habitat exists today in the form of storage reservoirs behind dams. One of the most prominent changes observed in river habitat throughout the Basin over time has been the inundation of river habitat and conversion to run-of-river reservoirs.

5.2.2 Evaluation Species

Evaluation species associated with the lakes and reservoirs landscape include Clark's and Western grebes, dunlin (*Calidris alpina*), and floaters (*Anodonta* spp.). For detailed descriptions of these species, see Section F.2.2.

5.2.3 Key Sites and Locations

Key sites and locations characterized by lakes and reservoir habitats are listed in Table 12. The impacts of the proposed alternatives on the lakes and reservoirs landscape and evaluation species at these key sites are described in Sections 6 and G.2.

Table 12. Key sites characterized by the lakes and reservoirs landscape, organized by subbasin

Subbasin	Key Sites
Lower Columbia River	John Day River Confluence Blalock Island Complex Umatilla River Confluence
Mid-Columbia River	Lake Roosevelt
Upper Basin	Lake Pend Oreille Lake Koocanusa
Lower Snake River	Dworshak Reservoir

5.3 RIPARIAN

Riparian areas are transition zones between aquatic and upland habitat along rivers, streams, and other watercourses, and are typically characterized by frequent disturbances from flooding, erosion, and deposition, which create a mosaic of plant community ages and seral stages (Bentrup 2008, p. 110; Brinson et al. 1981, p. 23; Gregory et al. 1991, p. 540; USFWS 1999, pp. M4-10, M4-12, 2019a, p. 5).

In riparian areas, groundwater flows at shallower depths and the frequency of flooding is greater than in adjacent terrestrial environments or uplands. Riparian habitats have distinctly different vegetation, exhibiting more vigorous or robust growth forms, than other habitats in the study area (USFWS 2019a, p. 6).

Riparian habitat in the Basin is often a mosaic of wet to moderately wet areas), depending on topography and soil characteristics that reflect sediment deposition patterns and subsurface water depth. Riparian areas may have forests, areas of low woody vegetation, sand and gravel bars, wet meadows, flood-scoured areas, perennial and intermittent secondary channels or side channels, and other stream-related habitats and vegetation (Fischer et al. 2001, pp. 1-2). For the analysis, the Service divided the riparian landscape into three habitats (emergent, scrub-shrub, and forest) (USFWS 2019a, pp. 7-8). Section F.3 includes more details on riparian resources in the study area.

5.3.1 Trends in Riparian Landscape and Habitat Quality

Currently, riparian areas comprise especially important habitat for fish and wildlife resources. While riparian habitat makes up less than 1 percent of the land area in the western states, it hosts more species of breeding birds than any other habitat, as well as 75 percent of all terrestrial species, and also serves as an important habitat for most amphibians, fish, and other aquatic organisms (Fischer et al. 2001, p. 4). Aside from bird species that depend on riparian habitat, both riparian obligate mammals (e.g., moose, beavers, otters, mice, muskrats, and mink) and other upland mammals (e.g., woodland caribou, elk, deer, wolves, grizzly bears, and mountain lions) also depend on riparian habitat to complete critical life history stages (BOR 2016, p. 4-15; Hauer et al. 2016, pp. 6-7).

Riparian habitats provide dense cover and rich food resources, and riparian corridors help connect otherwise isolated habitats and reduce genetic isolation and extirpation of sub-populations (Everest and Reeves 2007, p. ix). Thus, they are critically important for breeding, feeding, dispersal, and migration of wildlife species.

In the Basin, hydropower development has significantly changed, either directly or indirectly, the timing, magnitude, and pattern of water levels, water velocities, sedimentation, and the ecological and physical processes that support the structure and function of riparian habitats (Hough-Snee et al. 2015, p. 1151). Loss or degradation of these ecological and physical processes have resulted in conversion of riparian forest habitat to upland habitat, which reduces structural diversity and heterogeneity (Macfarlane et al. 2016, p. 448). This homogenized landscape limits the number and type of ecological and physical processes, subhabitats, and niches that can support fish and wildlife resources (Fierke and Kauffman 2005, p. 150).

The adoption of “environmental” or “functional” flow regimes has proven to be effective in increasing the recruitment of riparian vegetation (e.g., cottonwood [*P.* spp.] and willow [*Salix* spp.]) and conserving endangered species without major negative impacts on hydropower production (Rood et al. 2005, pp. 193, 196-198). Functional flow regimes are those that mimic the most important aspects of the pre-dam hydrograph, which are responsible for driving the processes that ultimately function to maintain and regenerate riparian vegetation. During high water years, higher water volumes are released during the spring freshet, followed by an appropriate rate of recession (no more than 1.0 inch [2.5 centimeter or cm] per day), and this pattern mimics the episodic flow conditions that would naturally lead to cottonwood and willow recruitment a couple of times a decade.

These functional flows include a minimum of the important aspects of a natural flow regime to support ecological and physical processes (Foster and Rood 2017, p. 1088; Foster et al. 2018, p. 921; Rood and Mahoney 2000, p. 109; Rood et al. 1998, p. 557; Rood et al. 2003, p. 647). Similarly, variable discharge (VARQ) flood control functional flow regimes adopted in 2003 at Libby Dam in Montana to benefit the listed Kootenai River white sturgeon (*A. transmontanus*) have also resulted in anecdotal evidence of increased recruitment of riparian vegetation such as cottonwoods (Burke and Buffington 2009, p. S235; USACE 2006, pp. S-3-9; USFWS 2019b).

5.3.2 Evaluation Species

Evaluation species associated with the riparian landscape include black cottonwood, viceroy butterfly (*Limenitis archippus*), and yellow warbler. Other important guilds include cottonwood-willow communities and riparian songbirds. For detailed descriptions of these species and guilds, see Section F.3.2.

5.3.3 Key Sites and Locations

Key sites and locations, identified by the Service and characterized by riparian habitats throughout the study area, are listed in Table 13. The impacts of proposed alternatives on the riparian landscape and evaluation species at these key sites are described in Sections 6 and G.3.

Table 13. Key sites characterized by the riparian landscape, organized by subbasin

Subbasin	Key Site
Lower Columbia River	Julia Butler Hansen National Wildlife Refuge Sandy River Delta Umatilla National Wildlife Refuge
Mid-Columbia River	Okanogan River Confluence Threemile Creek to Six Mile Creek Confluences Little Sheep Creek Confluence
Upper Basin	Stillwater River Confluence Clark Fork Delta at Lake Pend Oreille Yaak River and Star Creek Confluences
Lower Snake River	Catholic Creek Confluence Tucannon River Confluence Big Flat Recreation Area

5.4 WETLANDS

Wetlands are typically "inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (40 CFR § 232.2). Water saturation (i.e., hydrology) influences soil development and determines the plant and animal communities living in and on the soil. Prolonged presence of water creates anaerobic conditions that favor the growth of specially-adapted plants and promote the development of wetland areas (e.g., river deltas and wetland subhabitats on islands).

The Service relied primarily on the National Wetlands Inventory (NWI) and the U.S. Department of Agriculture's and U.S. Department of Interior's Landscape Fire and Resource Management Planning Tools database (LANDFIRE) to identify and classify wetland habitats in the Basin for the analysis. The wetland habitats described in the analysis are either naturally occurring or managed as palustrine, lacustrine, and emergent or estuary (i.e., tidal) wetlands (Cowardin et al. 1979, pp. 3-5). Section F.4 includes more details on wetland resources in the study area.

5.4.1 Trends in Wetland Landscape and Habitat Quality

Wetland habitats and the ecological and physical processes that support their structure and function are critical in maintaining the health and status of a diversity of fish and wildlife resources throughout the Basin. Though a significant number of well-distributed water areas and wetlands exist in the study area, many of them have been lost due to water impoundment behind dams (USFWS 2019c). Specific to the Basin, a study from 1990 concluded that 56 percent, 31 percent, and 38 percent of wetlands were lost during the 1780s and 1980s in Idaho, Washington, and Oregon, respectively (Dahl 1990, p. 12).

Wetland habitats have since been created in the Basin, for example, as part of the Service's NWR System (e.g., McNary NWR). While these refuges support many valuable fish and wildlife resources (e.g., waterfowl) in wetland habitats, current fish and wildlife resources may differ from those naturally supported, historically. In some cases, Federal projects in the study area have created abnormal or more frequent fluctuations in water surface elevation that do not coincide with the optimum spring and summer conditions necessary for proper functioning and creation of new wetland habitats. However, Federal projects may also create slower-moving water conditions in general, which can support wetland habitats in discrete areas within the Basin.

5.4.2 Evaluation Species

Evaluation species associated with the wetlands landscape include American bittern, mallard (*Anas platyrhynchos*), Western painted turtle (*Chrysemys picta*), and Woodhouse's toad (*Bufo woodhousii*). Other species of interest include Columbia yellowcress and sora (*Porzana carolina*). For detailed descriptions of these species, see Section F.4.2.

5.4.3 Key Sites and Locations

The Service identified key sites characterized by wetland habitats and subhabitats in the study area (Table 14). Based on feedback from stakeholder participants in the Service's technical workshop on wetlands, key site selection focused on island and river delta habitats with distinct wetland subhabitats. These areas are heavily used by birds, amphibians, and reptiles for foraging and rearing purposes (USFWS 2019c). The impacts of proposed alternatives on the wetlands landscape and evaluation species at these key island and river delta sites are described in Sections 6 and G.4.

Table 14. Key island and river delta sites characterized by the wetlands landscape, organized by subbasin

Subbasin	Wetland Habitats	Key Island and River Delta Sites
Lower Columbia River	Islands	Reed Island Steigerwald Lake National Wildlife Refuge and Sauvie Island Wildlife Area
	River Deltas	Sandy River Delta
Mid-Columbia River	Islands	Hanford Reach Wells Wildlife Area
	River Deltas	Lower Crab Creek McNary National Wildlife Refuge
Upper Basin	Islands	Everett Island Kootenai National Wildlife Refuge
	River Deltas	Pack River Delta
Lower Snake River	Islands	Silcott Island
	River Deltas	Snake River Delta Palouse River Delta

5.5 UPLANDS

In general, upland habitats are located outside waterbodies (lakes, reservoirs, and rivers) and include areas that are not prone to inundation long enough for their soils to have anaerobic characteristics (i.e., wetlands). Flooding or high water tables do not greatly influence the function of upland habitats. Through this analysis, the Service identified two broad uplands habitats: forested uplands and arid uplands. Subhabitats within forested and arid uplands in the study area are described in Section F.5.

5.5.1 Trends in Upland Landscape and Habitat Quality

In the Basin, native habitat conversion has disconnected and deteriorated habitats (USDA et al. 1997, p. 99). Loss of grass and shrub cover coupled with the loss of structural diversity have resulted in reduced plant and insect forage, nesting habitat, and cover for many sagebrush bird species, resulting in numerous species population declines (Knick and Rotenberry 1995, p. 1069). Additionally, juniper woodlands expansion into grassland and sagebrush habitats has negatively impacted birds such as rock wren (*Salpinctes obsoletus*) and chipping sparrow (*Spizella passerina*) (Mac et al. 1998, pp. 437-964).

In the Basin, livestock grazing, the spread of non-native species (e.g., cheatgrass and cowbirds), and changes in fire intensity and frequency have resulted in the loss of native grasslands and major reductions in grassland cover. These losses have, in turn, resulted in reduced available plant and insect forage, nesting habitat, and cover for a variety of species (e.g., Columbian sharp-tailed grouse [*Tympanuchus phasianellus columbianus*], sandpiper [*Scolopacidae* spp.], and sagebrush sparrow [*Artemisiospiza nevadensis*]) (Mac et al. 1998, pp. 437-964).

Sagebrush and bunchgrass cover types have experienced greater losses than any other habitats in the Basin and will likely continue to decline with the impacts of present land uses, including increased, livestock overgrazing, fires, herbicide spraying, plowing, seeding, and conversion of land for agriculture (Saab and Groves 1992, p. 11; Saab and Rich 1997, p. 14; Bock et al. 1993, p. 304; Knick and Rotenberry 1995, p. 1069). In Washington alone, roughly 60 percent of the historical, native shrub-steppe habitat has been converted for other uses (Dobler et al. 1996, p. 10).

Changes in the structure, abundance, and distribution of shrub-steppe have also led to declines in species such as the greater sage-grouse (*Centrocercus urophasianus*), Brewer's parrow (*S. breweri*), and sagebrush sparrows (Martin and Carlson 1998; Rotenberry et al. 1999; Schroeder et al. 1999).

5.5.2 Evaluation Species

Evaluation species associated with the uplands landscape include long-billed curlew (*Numenius americanus*) and sage thrasher (*Oreoscoptes montanus*). For detailed descriptions of these species and guilds, see Section F.5.2.

5.5.3 Key Sites and Locations

Though the uplands landscape comprises a relatively small proportion of the study area, upland habitats generally occur within, and adjacent to, the designated 0.5 mile (0.8 km) buffer. Thus, the impacts of proposed alternatives on the uplands landscape and evaluation species are generally described throughout the study area rather that at key sites and locations (Sections 6 and G.5).

5.6 OTHER HABITATS

As a result of the presence of Federal projects, reservoir drawdown, and water release timing and magnitude, three landscapes (rivers, lakes and reservoirs, and wetlands) share additional habitats the Service considered to be critical for evaluation species analyzed in this CAR. These other habitats include barren lands, islands, and river deltas.

5.6.1 Barren Lands

Barren lands (i.e., drawdown zones) are so frequently inundated as to preclude vegetation growth. These lands may include reservoir drawdown zones and shorelines surrounding rivers, lakes, reservoirs, and estuaries. When reservoirs are filled with water, through inflow from precipitation or dam operations, the barren zone is not visible. In some areas, reservoir drawdowns will expose bare slopes, while, in other areas, fluctuations in water level may expose mudflats or islands. Low lake levels expose previously inundated land (NPS 2015). For instance, near the mouth of the Columbia River, the Columbia River Estuary includes extensive mudflats, numerous islands and bars, tidal marshes, and tidal swamps.

5.6.2 Islands

In the Basin, islands may be located in rivers, lakes, reservoirs, and estuaries. Thus, islands do not fit appropriately in consideration of any single, previously-identified landscape. In some cases where there are slopes, the shorelines are abrupt and, in other cases, shorelines may be less abrupt and, thus, are likely to provide for a variety of habitats such as mudflats and even emergent or estuary riparian habitats. For instance, McNary NWR contains islands situated near the east bank of the Columbia River near the confluence with the Snake River, and these islands are inhabited by nesting colonies of Caspian terns, double-crested cormorants (*Phalacrocorax auritus*), white pelicans (*Pelecanus erythrorhynchos*), and numerous waterfowl species (USFWS 2018a).

The Blalock Island complex, one of the key sites identified in the lakes and reservoirs landscape, is a cluster of islands protected by the Service and located between Boardman and Irrigon, Oregon (i.e., RM 274 to RM 276 [RKM 441 to RKM 444]). The Blalock Island complex supports several wildlife guilds in the John Day Pool such as multiple waterbird breeding colonies, including black-crowned night-herons (*Nycticorax nycticorax*), California gulls (*Larus californicus*), Caspian terns, great blue herons (*Ardea herodias*), great egrets (*A. alba*), Forster's terns (*Sterna forsteri*), and ring-billed gulls (*L. delawarensis*) (Collis et al. 2019, p. 32). The complex also provides sanctuary habitat for wintering waterfowl; staging, roosting, and foraging habitat for migratory and wintering waterfowl and shorebirds; breeding habitat for pollinators; and rare wet meadow habitat found in few other places in the Basin (Dunwiddie 2018, pp. 1-2; Healy, F., in litt. 2019).

Other examples of islands in the study area include large islands in the Lower Columbia River that are associated with Lewis and Clark and Julia Butler Hansen NWRs. The Corps has historically placed, and continues to place, dredge material on some of these islands, in hopes of maintaining open, sandy habitats for species such as streaked horned larks (*Eremophila alpestris strigata*) (USACE et al. 2018, pp. 119-135; USFWS n.d., p. 3).

5.6.3 River Deltas

River deltas occur at confluences, where a river may join the ocean (i.e., estuary), lake, reservoir, or other river. River deltas are created as a result of sediment deposition, in which sediment is carried by a river and deposited as it enters slower-moving water. Various types of river deltas (e.g., fan-deltas) exist in the study area (e.g., Sandy River Delta in the Lower Columbia River) (Liangqing and Galloway 1991, pp. 388, 391-392). River deltas represent important wetland habitat that supports diverse and ecologically high-functioning ecosystems.

6 IMPACTS ON FISH AND WILDLIFE RESOURCES

The Service's analysis of impacts of the CRSO focused on ecological and physical processes and their indicators (Table 4) that characterize the structure and function of habitats and key sites representative of the five landscapes and 16 evaluation species (Table 6). Other habitats and additional guilds, communities, and species were identified and analyzed based on whether they were most likely to experience significant ecological change under the proposed CRSO alternatives.

The Service analyzed impacts of structural and operational measures of the NAA and each MO, including ecological costs to, and benefits for, fish and wildlife resources. The Service's analysis is organized first by landscape and then by MO. Section 6.1 presents summary tables of the impacts of proposed alternatives on each landscape, characterized by specific ecological and physical processes and indicators, habitats, evaluation species, and key sites, where relevant. For a detailed description of these findings, see Appendix G. The Service did not conduct an additional evaluation of the impacts specific to the Preferred Alternative, apart from those related to Flex Spill (Section 6.2.1).

6.1 SUMMARY OF LANDSCAPE FINDINGS

The Service analyzed impacts of the proposed CRSO alternatives on the overall health of the five landscapes. Tables 15, 16, 17, 18 include a qualitative summary of the rivers, lakes and reservoirs, riparian, and wetlands landscape findings and show the trend of overall health of these landscape at key sites under the NAA as well as the projected change in the long-term trend (i.e., more than 5 years) resulting from each MO.

For key sites where change in overall health is projected to occur, the Service used varying shades (light, medium, and dark) of color (orange and blue) to indicate whether or not the projected impacts are projected to be generally negative or positive (respectively) for the landscapes in the study area. The intensity of the shading indicates the severity of the change, either positive or negative (light = least extreme, medium = average, dark = most extreme).

A detailed description of the impacts of the proposed alternatives to the different landscapes is included in Appendix G. Unlike the summaries of other landscape findings in this report, the summary of wetlands landscape findings includes a focused analysis of impacts on key island and river delta sites located in various subbasins in the study area.

The Service also analyzed impacts on critical indicators of ecological and physical processes that support the uplands landscape, habitats and subhabitats, and evaluation species. Overall, impacts on the uplands landscape in the study area were found to be insubstantial, since there is little to no uplands landscape in the designated 0.5 mile (0.8 km) buffer. Thus, the Service did not identify any key sites or develop a summary table similar to Tables 15, 16, 17, 18 to illustrate the projected impacts of the CRSO to uplands.

Table 15. Summary of projected trends of overall health of the rivers landscape under the NAA and all MOs, organized by subbasin

Subbasin	Key Site	NAA Trend	MO1 Trend	MO2 Trend	MO3 Trend	MO4 Trend
Lower Columbia River	Columbia River Estuary	Decreasing	No change	No change	No change	Faster rate of decrease
	Mouth of the Deschutes River	Decreasing	Faster rate of decrease	Faster rate of decrease	Faster rate of decrease	Increasing
	John Day Reservoir or Pool (Lake Umatilla)	Decreasing	Faster rate of decrease	Faster rate of decrease	Faster rate of decrease	Increasing
Mid-Columbia River	Hanford Reach	Decreasing	No change	No change	Increasing	No change
	Reach 21, above Grand Coulee Pool (Lake Roosevelt)	Decreasing	Faster rate of decrease	No change	Faster rate of decrease	Faster rate of decrease
Upper Basin	Kootenai River	Decreasing	Faster rate of decrease	No change	Faster rate of decrease	Faster rate of decrease
	Pend Oreille River	Decreasing	No change	No change	No change	No change
Lower Snake River	Clearwater River	Decreasing	Increasing	Increasing	Increasing	Faster rate of decrease
	Lower Monumental Pool (Lake Herbert G. West)	Decreasing	Faster rate of decrease	Faster rate of decrease	Faster rate of increase compared to MO4	Increasing

Table 16. Summary of projected trends of overall health of the lakes and reservoirs landscape under the NAA and all MOs, organized by subbasin

Subbasin	Key Site	NAA Trend	MO1 Trend	MO2 Trend	MO3 Trend	MO4 Trend
Lower Columbia River	John Day River Confluence	Decreasing	Faster rate of decrease	Fastest rate of decrease	Faster rate of decrease compared to MO1	No change
	Blalock Island Complex	Decreasing	Faster rate of decrease	Fastest rate of decrease	Faster rate of decrease compared to MO1	No change
	Umatilla River Confluence	Decreasing	Faster rate of decrease	Fastest rate of decrease	Faster rate of decrease compared to MO1	No change
Mid-Columbia River	Lake Roosevelt	Decreasing	Faster rate of decrease	Fastest rate of decrease	Faster rate of decrease compared to MO1 and MO4	Faster rate of decrease
Upper Basin	Lake Pend Oreille	Decreasing	Faster rate of decrease	Fastest rate of decrease	Faster rate of decrease compared to MO1 and MO4	Faster rate of decrease
	Lake Koocanusa	Decreasing	No change	Faster rate of decrease compared to MO3	Faster rate of decrease	No change
Lower Snake River	Dworshak Reservoir	Decreasing	Faster rate of decrease	Fastest rate of decrease	Faster rate of decrease compared to MO1 and MO4	Faster rate of decrease

Table 17. Summary of projected trends of overall health of the riparian landscape under the NAA and all MOs, organized by subbasin

Subbasin	Key Site	NAA Trend	MO1 Trend[1/]	MO2 Trend[1/]	MO3 Trend[1/]	MO4 Trend[1/]
Lower Columbia River	Julia Butler Hansen National Wildlife Refuge	Decreasing	No change	No change	No change	No change
	Sandy River Delta	Slowly increasing	Decreasing *	Decreasing *	Decreasing *	Decreasing *
	Umatilla National Wildlife Refuge	Decreasing	Fastest rate of decrease	No change	Faster rate of decrease compared to MO4	Faster rate of decrease *
Mid-Columbia River	Okanogan River Confluence	Decreasing	No change	No change	No change	No change
	Threemile Creek to Six Mile Creek Confluences	Decreasing	No change	No change	No change	Faster rate of decrease *
	Little Sheep Creek Confluence	Decreasing	No change	No change	No change	Faster rate of decrease *
Upper Basin	Stillwater River Confluence	Decreasing	No change	Faster rate of decrease	No change	No change
	Clark Fork Delta at Lake Pend Oreille	Decreasing	No change	Faster rate of decrease	No change	Faster rate of decrease compared to MO2
	Yaak River and Star Creek Confluences	Slowly increasing	Decreasing	Fastest rate of decrease	Faster rate of decrease compared to MO1	Faster rate of increase
Lower Snake River	Catholic Creek Confluence	Decreasing	No change	Faster rate of decrease	No change	No change

Subbasin	Key Site	NAA Trend	MO1 Trend[1/]	MO2 Trend[1/]	MO3 Trend[1/]	MO4 Trend[1/]
Lower Snake River	Tucannon River Confluence	Decreasing	No change	No change	Increasing	Faster rate of decrease
	Big Flat Recreation Area	Slowly increasing	No change	No change	Faster rate of increase	No change

[1/]An asterisk is used to mark opportunities for the co-lead agencies to potentially reverse negative impacts of the MOs through improved management of the potential drawdown of water surface elevation (Section 7).

Table 18. Summary of projected trends of overall health of the wetlands landscape under the NAA and all MOs, organized by subbasin

Subbasin	Key Site	NAA Trend	MO1 Trend	MO2 Trend	MO3 Trend[1/]	MO4 Trend
Lower Columbia River	Reed Island	Decreasing	Faster rate of decrease	Faster rate of decrease	Faster rate of decrease	Faster rate of decrease
	Steigerwald Lake National Wildlife Refuge and Sauvie Island Wildlife Area	Slowly decreasing	Faster rate of decrease	Faster rate of decrease	Faster rate of decrease	Faster rate of decrease
	Sandy River Delta	Decreasing	Faster rate of decrease compared to MO2, MO3, and MO4	Faster rate of decrease	Faster rate of decrease	Faster rate of decrease
Mid-Columbia River	Hanford Reach	Slowly decreasing	Faster rate of decrease	Faster rate of decrease compared to MO1	No change	No change
	Wells Wildlife Area	Slowly decreasing	No change	No change	No change	No change
	Lower Crab Creek	Decreasing	No change	No change	No change	No change
	McNary National Wildlife Refuge	Slowly decreasing	No change	No change	No change	Faster rate of decrease
Upper Basin	Everett Island	Decreasing	Faster rate of decrease	Faster rate of decrease	Slower rate of decrease	Slower rate of decrease

Subbasin	Key Site	NAA Trend	MO1 Trend	MO2 Trend	MO3 Trend[1/]	MO4 Trend
Upper Basin	Kootenai National Wildlife Refuge	Slowly decreasing	Faster rate of decrease compared to MO2	Faster rate of decrease	Slower rate of decrease	Increasing
	Pack River Delta	Decreasing	No change	Faster rate of decrease	Slower rate of decrease	Faster rate of decrease compared to MO2
Lower Snake River	Silcott Island	Decreasing	Faster rate of decrease	Faster rate of decrease	Faster rate of increase compared to MO4 *	Increasing
	Snake River Delta	Decreasing	Faster rate of decrease	Faster rate of decrease	Increasing	Faster rate of decrease
	Palouse River Delta	Decreasing	Faster rate of decrease	Faster rate of decrease	Faster rate of increasing compared to MO4 *	Increasing

[1/]An asterisk is used to mark opportunities for the co-lead agencies to potentially enhance positive impacts (e.g., increasing trends) of MO3 through the control of invasive species, planting of native vegetation in the spring and fall, and long-term monitoring (Section 7).

6.2 FLEXIBLE SPILL AGREEMENT

The Preferred Alternative outlined in the DEIS includes an operation to improve fish passage that was not initially available for analysis during the Service's development of this CAR. This operation is known as Flex Spill (USACE et al. 2020, pp. 1-20-21, 7-33-35).

Flex Spill is intended to increase the proportion of juvenile fish that pass through the spillways on their downstream migration, to improve scientific information on delayed mortality (caused by sub-lethal factors like injuries, stress, and migration delays related to passage) of downstream migrating juvenile Pacific salmon, and to provide flexibility for power generation. The concept of Flex Spill takes advantage of peak and off-peak demand for power, over a 24-hour period, while providing high levels of spill to benefit downstream passage of juvenile anadromous fish (USACE et al. 2020, p. 1-20, 7-21, 7-33-35). This operation will be implemented from April 10 to June 25 at the four Lower Columbia River projects and from April 3 to June 20 at the Lower Snake River projects.

In general, Flex Spill includes 16 hours of spill up to the 125 percent TDG limit, as measured in each project's tailrace, each day at six of the eight projects on the Lower Snake and Columbia Rivers. For the remaining eight hours, the projects will spill at a lower level (Performance Standard spill). Lower levels of spill would allow for increased power generation during periods of peak demand or high power prices. Further, since Performance Standard spill has been implemented in the past, the eight hours of reduced spill would avoid unintended consequences (e.g., upstream passage delays, gas bubble trauma) that may occur due to spill up to the 125 percent TDG limit during juvenile fish passage. Flex Spill will allow the co-lead agencies to gather important scientific information on the relationship between spill at the Federal CRS projects and delayed mortality of migrating juvenile Pacific salmon.

Flex Spill will be managed in-season through Regional Forum processes to address unexpected challenges, such as delays to adult migration, impacts to navigation, and other issues that may require operational modifications (USACE et al. 2020, p. 33, 7-34).

6.2.1 The Service's Analysis

Since Flex Spill was not fully developed when the draft CAR was published, the Service provides some analysis in this section based on the information provided in the DEIS and present understanding of the operation. However, this analysis is fairly limited due to the lack of research and monitoring at the higher spill level anticipated (i.e., 125 percent TDG).

The Service acknowledges the co-lead agencies have not voluntarily implemented the spill levels outlined by Flex Spill on the Lower Columbia River and Lower Snake River Federal projects in the past. Still, the amount of spill that occurs during involuntary spill events can meet or exceed the spill proposed by Flex Spill. Involuntary spill is a common occurrence on the Columbia and Snake Rivers, especially in years with high snowpack (i.e., 2011, 2012) or rapid runoff. As such, the co-lead agencies have considerable experience handling spill at the Federal

CRS projects that meet or exceed the levels prescribed by Flex Spill. Thus, the Service is confident the amount of proposed spill will not result in negative ecological or biological impacts that have not been experienced in the past or that the co-lead agencies cannot handle within their existing operational capabilities.

The Service notes that implementation of Flex Spill does not change the total amount of water passing through the projects. For 16 hours each day, the operation will direct more water to the spillway and less to the turbines. Conversely, during eight hours of Performance Standard spill, more water will be directed to the turbines and less to the spillway. But, in general, the amount of water moving through the projects does not change as a result of the operation. As such, the expected hourly changes in spill and power generation will only result in minor, short-term changes to reservoir, forebay, and tailwater elevations, thereby avoiding or reducing any potential negative impacts to aquatic or terrestrial habitats associated with the operation.

The Service is further encouraged by the biological monitoring and adaptive management that has been proposed by the co-lead agencies to accompany Flex Spill. If any adverse effects from the operation occur, the level of monitoring proposed should capture any potential negative impacts to non-salmonid species (e.g., Pacific lamprey) present in the Columbia River.

The Service does not anticipate any positive or negative impacts to most of the species analyzed in this CAR. However, the Service does expect some impacts to Pacific lamprey.

6.2.2 Pacific Lamprey

Adult Pacific lamprey start their upstream migration journey on the mainstem Columbia River in early May and continue through the summer. The early part of the run will experience high levels of spill from Flex Spill and any involuntary spill events that occur. The potential negative impacts as a result of Flex Spill could include delayed upstream passage, adult fallback, increased impingement, and gas bubble trauma (USACE et al. 2020, p. 7-33-34). However, Flex Spill could benefit juvenile lamprey if the additional spill directs juveniles away from the powerhouse and toward the spillway. In addition, Flex Spill may reduce the amount of lamprey impingement on screens that protect juvenile Pacific salmon from the project turbines. Each of these potential effects are discussed as follows.

<u>Delayed Upstream Passage</u>

While the Service is unaware of any research studies that suggest high levels of spill may inhibit adult Pacific lamprey from locating fish ladder entrances, which may result in delayed upstream passage, this outcome cannot be ruled out. Any potential delays would depend ultimately on the circumstances at each project site since the location of fish ladder entrances in relation to spillways and turbine outlets are unique to each project.

However, since Flex Spill ends in mid-June, the majority of adult lamprey should not experience the high levels of spill proposed. If migration delays do occur, then they would likely be observed at Bonneville Dam since it is the first CRS project adult lamprey encounter. In the DEIS, the co-lead agencies proposed to install additional adult lamprey facilities at several projects, primarily at Bonneville Dam, to facilitate upstream passage (USACE et al. 2020, pp. 7-27-30). These facilities will help reduce any migration delays that may occur due to Flex Spill.

Further, the co-lead agencies will continue to monitor the upstream passage of lamprey through the CRS) via current fish counting requirements at each project. The States and Tribes will also continue to evaluate adult lamprey conversion through the Columbia and Snake Rivers. The Service will continue to emphasize the importance of adult lamprey passage in the Regional Forum processes, particularly in the technical forums (e.g., Technical Management Team, Fish Passage Operations and Maintenance) that provide input and advice to the co-lead agencies on in-season operational issues.

Although the Service cannot predict there to be no negative impacts to adult lamprey as a result of Flex Spill, the Service is encouraged by the commitment to ensure lamprey passage at the Federal CRS projects and the continued monitoring, evaluation, and adaptive management focused on this adult form of this important anadromous fish.

Adult Fallback

Fallback occurs when a migratory fish (e.g., adult Pacific lamprey) ascends fish passage facilities, and subsequently falls back downstream past the dam, either through the spillway, the bypass system, or the turbines. The Service is unaware of any studies that have measured the survival of adult Pacific lamprey passing back downstream via the turbines, the spillway, or the juvenile bypass system. However, if this were to occur, the Service would anticipate higher levels of mortality resulting from turbine passage and lower levels of mortality resulting from moving through the spillway or bypass system.

Flex Spill may increase fallback rates slightly, but the overall impact should be minor since the operation ends prior to the time when the majority of adult Pacific lamprey begin their upstream movements. The impact will likely be greatest at Bonneville Dam since it is the first project the lamprey encounter. However, the co-lead agencies are expanding and adding facilities at Bonneville Dam to improve lamprey passage and, while these facilities cannot reduce the fallback rate, they may assist adult lamprey in re-ascending the projects in the case they do fallback.

Impingement

Most of the Lower Columbia and Lower Snake River Federal projects have screens installed just upstream of the intakes to guide juvenile Pacific salmon away from the turbines. However, these same screens can be a source of mortality for juvenile Pacific lamprey, as they often become impinged (i.e., stuck on the screen's surface). Impingement mortality on these screens is often 100 percent. Thus, the Service recommends the co-lead agencies exercise some flexibility in the timing of screen installation to optimize the conservation benefits for species beyond just Pacific salmon, including Pacific lamprey (Moser and Russon 2009, p. 2; Moser et al. 2014, pp. 106, 113). Increased spill could also provide safer routes of passage for juvenile lamprey, as it may direct lamprey toward the spillway and away from either the turbines or the screens.

The Service recognizes the co-lead agencies understand the effects of impingement on juvenile Pacific lamprey, as the Preferred Alternative includes modifying the screens at Little Goose Dam and Lower Granite Dam to reduce potential impingement. The Preferred Alternative also includes installation of improved fish passage turbines at John Day Dam, in addition to the improved turbines already being installed at Ice Harbor Dam. The intent behind these installations is to reduce turbine mortality enough so screens would no longer be necessary. However, this possibility comes with considerable monitoring and evaluation needs to assess the impacts. As such, the Service recommends evaluation of these new turbines includes juvenile Pacific lamprey, in addition to other anadromous fish.

Gas Bubble Trauma and TDG

Elevated TDG levels have the potential to lead to gas bubble trauma in both adult and juvenile Pacific lamprey as they move through the CRSO. However, the Service notes a lack of research or monitoring regarding the potential effects of increased TDG on the movements and survival of Pacific lamprey.

The Service believes both juvenile and adult Pacific lamprey are often present low in the water column during their upstream and downstream movements. As such, they may be less susceptible to elevated TDG levels, given the decrease in TDG with increasing depth. However, the lack of research and monitoring makes this assumption difficult to assess. Thus, the Service recommends the co-lead agencies include juvenile and adult Pacific lamprey in their biological monitoring associated with Flex Spill. Pacific lamprey may have a unique response to the TDG levels anticipated in Flex Spill, and this response should be investigated to assess the overall efficacy of the operation.

7 CONSERVATION RECOMMENDATIONS

The Basin supports well-documented and widely recognized ecological, socioeconomic, and cultural values, and it is home to diverse habitats, and unique ecological and physical processes and habitats that enable fish, wildlife, and plant species to thrive. The Basin provides an estimated $189.9 billion in ecosystem service benefits (i.e., contributions to human health and well-being) annually, with $11 billion accruing directly from rivers (Flores et al., 2017, p. 42).

Since the mid-1930s, construction of dams and associated infrastructure as part of the CRSO has compromised the biological integrity of the Basin and led to the degradation of important ecological and physical processes and habitats on which fish and wildlife resources depend. The Service acknowledges the multiple authorized purposes of the Federal dams and reservoirs. However, the Service's analysis found that proposed changes in dam configurations including operations and maintenance of the 14 Federal projects that comprise the CRSO will, overall, negatively impact fish, wildlife, and plants in the Basin along with the natural capital they offer.

Over the past year, the Service engaged with partners in the Basin through regionwide, multi-stakeholder technical workshops and meetings to develop specific, measurable, time-oriented conservation recommendations for the co-lead agencies to consider in the preservation of fish and wildlife resources associated with the implementation of the Preferred Alternative. The conservation recommendations address the impacts of the NAA and one or more of the proposed MOs presented in the co-lead agencies' DEIS on the CRSO, and they also represent the values and interests of multiple partners.

The Service recommends a mitigation hierarchy that seeks to first avoid, and then minimize impacts before mitigating with off-site actions, such as habitat restoration (81 FR 83440). This does not mean that off-site mitigation should be excluded from consideration, rather, the Service believes avoiding and minimizing impacts have a higher probability of success. Thus, the Service ordered the following conservation recommendations within this hierarchy, where possible. Conservation recommendations have been grouped into six categories, each defined by a goal statement that illustrates the Service's priority to support diverse ecological and physical processes, resilient habitats, and sustainable fish and wildlife resources.

The Service offers the following conservation recommendations to benefit species likely to be affected by the CRSO and to support more coordinated, systemic, and adaptive management and conservation of Basin-dependent fish and wildlife resources.

7.1 RESTORE OR MIMIC CRITICAL COMPONENTS OF NATURAL HYDROLOGICAL REGIMES

The integrity of free-flowing water systems depends largely on natural dynamics, among which the hydrological regime is centrally important (Poff et al. 1997, pp. 768-769). Natural hydrological regimes include varying environmental components (e.g., flows) characterized by seasonal timing, frequency, magnitude and other factors which drive ecosystem productivity.

The historically free-flowing Columbia and Snake Rivers are now fragmented by dams and associated infrastructure that have significantly altered the natural hydrological regimes that once characterized these water systems and supported fish and wildlife resources.

In light of the many ecological benefits of maintaining natural variability in river flows in the Basin, the Service seeks to minimize impacts associated with dam operations and reduce reservoir fluctuations, decrease ramping rates, minimize daily and seasonal flow fluctuations, and establish a hydrograph that mimics what occurred prior to the influence of dams. The Service recognizes that restoring critical components of natural hydrological regimes may not be possible every year, given the variable water supply and timing of annual runoff. Thus, the Service offers conservation recommendations that could be implemented when environmental conditions are favorable. To identify favorable conditions, the Service encourages the co-lead agencies to work with the Service, other Federal and State agencies, Tribes, and other partners collectively to understand when, where, how, and under what conditions a pre-dam hydrograph and more natural flood regime could be implemented. The following conservation recommendations aim to avoid or minimize impacts and, thus, represent the Service's highest priorities:

- Raise and maintain John Day Reservoir elevations between 264.5 feet (ft) and 266.5 ft (80.62 meters [m] to 81.23 m) to during April and May. All habitat for colonial nesting waterbirds (e.g., Caspian tern) will be inundated during typical peak nest initiation times, potentially resulting in waterbird relocation to other breeding colony sites during peak emigration times of juvenile Pacific salmon.
- Operate at the lowest reservoir levels feasible from June to September, which would potentially allow for late successful colonial nesting waterbird productivity, after most of the juvenile Pacific salmon have outmigrated.
- Establish a functional flow regime by managing river flows to mimic the pre-dam hydrograph in the following ways:
    - Allow seasonally appropriate high water events once or twice per decade (i.e., to achieve natural conditions suitable for successful riparian seedling establishment);
    - During high flow years, drawdown and ramping rates should not exceed more than 1.0 inch (2.5 cm) per day, which will promote the growth and survival of newly established riparian seedlings; and,
    - Monitor riparian vegetation recruitment and respond to years of high cottonwood and willow recruitment. This could be accomplished by limiting winter water levels to not exceed the previous peak-flow water level associated with high riparian recruitment for at least two winters following the year of high riparian recruitment.
- Constrain ramping rates at all projects to avoid large stage fluctuations, especially in June during cottonwood and willow seed dispersal and recruitment.
- Decrease ramping rates below Libby to 1.0 inch (2.5 cm) per hour per stage increase or decrease to mimic the natural water recession rate.

- Minimize stage drop of 2.6 ft (79 cm) in Lake Pend Oreille to smaller increments from June through September of dry years to maintain native vegetation.
- Operate downstream projects to maintain natural water surface elevation and avoid rapid fluctuations in Lake Pend Oreille and Flathead Lake.
- Support continuation of Montana Operations at Libby Dam (i.e., VARQ and spring pulse) that establish functional flows for white sturgeon and riparian vegetation (MFWP et al. 2017, pp. 12-14).
- Invest in energy storage infrastructure and technology to minimize flow fluctuations in response to short-term changes in power demand. If pump storage is implemented, then ensure stored water does not negatively affect the natural hydrology of river or natural lake environments.
- Work with partners to maintain or establish functional flow regimes on tributary streams wherever possible to contribute natural sediment that nourishes floodplains and backwater deltas. Where applicable, ensure water surface elevation of reservoir pools are below the elevation of tributary mouths during the fall in order to capitalize on weather events that remove accumulated sediments through scour thereby providing fish passage at tributary mouths.
- When restoring pre-dam hydrologic regimes is not feasible, mimic natural hydrology to provide flushing flows, channel maintenance flows, and sediment transport annually or biannually. Develop and implement flow and temperature recommendations to meet this objective in addition to other objectives (e.g., juvenile fish emigration), including: minimizing hourly and daily flow fluctuations; considering the timing and frequency of peaks; and providing recommendations across all water year types (e.g., deficit, normal, and abundant). Consider the approach taken on large river systems elsewhere in the western U.S. (e.g., Green River below Flaming Gorge Reservoir, Colorado River below Lake Powell).
- Regardless of MO, for the Sandy River Delta and associated riparian habitat during implementation of the first summer stage decline, time water surface elevation drops to coincide with normal peak flow recession (i.e., in early to mid-June following natural peak flood timing). The rate of recession should be gradual (i.e., no more than 1.0 inch [2.5 cm] per day) to help promote the establishment of native riparian vegetation instead of invasive species on exposed shoreline.
- Similarly, in the case of MO4, plan the timing and rate of drawdown to mimic natural peak flow recession for Umatilla NWR, Threemile Creek to Sixmile Creek Confluences, Little Sheep Creek Confluence, and other riparian habitat in the vicinity (refer to the previous conservation recommendation).

7.2 INCREASE HABITAT CONNECTIVITY AND IMPROVE FISH PASSAGE

In both terrestrial and aquatic environments, habitat connectivity is important for maintaining biodiversity and enabling fish and wildlife resources access to different habitats through all life history stages. In the last century, habitat connectivity has decreased in the Basin. Dam construction and proposed changes to continuing operations of the Federal projects either have fragmented, or threaten to further fragment intact and functional habitats. As a result, fish, wildlife, and plant species are more susceptible to population isolation and changes that affect ecological structure and function. Migratory fishes (e.g., Pacific lamprey and white sturgeon) are likely to remain blocked or lose access to critical spawning and rearing habitat. Changes to the current configuration and operation of Federal projects in the Basin present opportunities to increase habitat connectivity.

The Service's conservation recommendations to increase habitat connectivity and improve fish passage seek to minimize impacts associated with dam operations. These impacts are expected to continue as long as the CRS projects remain. Minimizing these impacts, consistent with the following conservation recommendations, will begin to address potential negative impacts associated with future operations:

- To the maximum extent practicable, reconnect rivers and tributaries to their floodplains, side channels, and associated wetlands through barrier removal (i.e., breaching).
- To the maximum extent practicable, set back or remove structures such as levees, dikes, riprap, and bank stabilization measures that constrain lateral movement of rivers, and reconnect rivers and tributaries to floodplains, associated wetlands, side channels, and oxbows to rivers and side channels.
- Revise the Section 408 process (authorized in the River and Harbors Appropriation Act of 1899 [33 U.S.C. § 14]) to allow for more efficient and less expensive levee setback and removal projects to increase habitat connectivity with floodplains and side channels. Currently, few projects are completed because of the cost and time spent per project and serious consequences (e.g., fines per project) if coordination with the Corps does not occur. Investigate and implement, if feasible, a revised, programmatic approach to undertake in future projects.
- Where appropriate, consider removing structures like dikes and revetments and purchasing floodplain properties to reconnect floodplain and side channel habitat in the Columbia River Estuary, thus creating and expanding shallow water habitat.
- Remove obsolete dams, barriers, and other infrastructure to improve habitat connectivity. Prioritize these actions according to potential ecological benefit, in locations such as tributaries with habitat that supports cold-water aquatic species (e.g., Columbia River redband trout [*Oncorhynchus mykiss gairdneriii*] and Westslope cutthroat trout [*O. clarki lewisi*]).
- Improve connectivity between the riparian habitat along mainstems and in tributaries. Maintain or improve existing riparian vegetation or establish new vegetation through functional flows or planting.
- Decrease current, and prevent additional, water withdrawals from the Columbia and Snake Rivers to build long-term resiliency in the system to benefit migratory and resident fishes.
- Improve, build, or modify Pacific lamprey passage structures at all projects in the Lower Columbia and Snake Rivers. Evaluate passage structure efficacy and make improvements, if necessary.

- Install and maintain bird wire arrays at all dam tailraces and consider additional non-lethal control methods.
- To better inform future analyses of impacts in dam operation changes in the Basin on migratory fishes, conduct studies on native aquatic species survival including white sturgeon and other non-listed aquatic species throughout all life history stages and passage routes. Focus on collecting information about migration timing, duration of migration, movements and reversals, use of habitat during migratory periods, and overall connectivity and how these variables contribute to overall survival and fitness.
- Create and implement effective reintroduction plans for native aquatic species above Federal projects with little to no access or connectivity. For instance, assist migration of white sturgeon to enhance adult population levels, as white sturgeon populations upstream of Bonneville Dam are small and have limited recruitment. Additionally, consider reintroducing Western pearlshell mussel and other aquatic invertebrates in appropriate river, lake, and reservoir landscapes, since they are limited in their own abilities to recolonize areas from which they have been extirpated.
- In regard to MO2, if the co-lead agencies modify operations for easier passage of Pacific salmon, then they should also consider developing and carrying out restoration projects that restore access to disconnected side channels and wetlands created by reductions in water surface elevation. They should also maintain the functionality of wildlife corridors that connect wetland to uplands landscapes and are important for reptiles and amphibians such as Western pond turtle and Woodhouse's toad, respectively.
- In regard to MO3, if the co-lead agencies breach the four Lower Snake River dams, then the greatest ecological benefits for all evaluation species and other migratory mainstem, migratory corridor, and localized, non-migratory species may be realized. These benefits would, in many cases, be dependent on implementation of associated restoration projects.

7.3 MAINTAIN FUNCTIONALITY OF NATIONAL WILDLIFE REFUGES AFFECTED BY CRS OPERATIONS

The Service's NWR System is a network of lands and waters that maintains ecological processes and habitat features to support fish, wildlife, and plants. NWRs are protected areas that allow for the conservation, management, and restoration of fish and wildlife resources to ensure environmental health and public enjoyment. The study area includes several NWRs: Lewis and Clark NWR, Julia Butler Hansen NWR, Ridgefield NWR, Steigerwald Lake NWR, Umatilla NWR, and Kootenai NWR. The Service also manages Waterfowl Production Areas (WPAs) (e.g., Flathead Lake WPA) under Wetland Management Districts. Further changes to the current configuration of the CRSO will likely impact the structure and function of some NWRs and other lands. The following recommendations support NWR functionality despite changing conditions resulting from the Preferred Alternative:

- Ensure sustainability of current management operations on NWRs as needed to meet system mission, goals, and refuge purposes (i.e., 601 FW 1) including, but not limited to, conservation and protection of migratory birds and the “Big Six” fish- and wildlife-dependent public uses (e.g., hunting, fishing, wildlife observation, photography, interpretation, and environmental education).
- Support the Service in monitoring impacts on habitat, natural resources, and fish- and wildlife-dependent recreational opportunities on NWRs, and mitigate impacts that constrain the ability of those lands to meet their individual mission, goals, and purposes; of particular consideration should be those impacts that compromise migratory bird use or the “Big Six” public uses of NWR lands.
- Minimize impacts of operations to existing infrastructure that maintains critical refuge system habitats. As necessary, add, replace, and modify infrastructure to ensure its long-term functionality. Infrastructure changes could include, but are not limited to, the installation of pump sites and fish screens as needed to enable NWRs to function and meet establishment purposes.
- Maintain existing waterbird (e.g., waterfowl and shorebirds) use areas and, through restoration and conservation projects or activities, enhance habitat diversity for waterfowl use, specifically, throughout all life history stages (e.g., migrating, wintering, and breeding stages).
- Support the Service in protecting and replacing any existing waterbird areas lost or rendered dysfunctional due to potential impacts associated with operational change such as sedimentation, flooding, and the invasion and establishment of non-native species.
- Support the Service in providing additional open water migratory bird sanctuaries in the Columbia River adjacent to existing refuge system habitats to mitigate for loss of open water habitat as a result of sedimentation. To be effective, new sanctuary habitat should mimic existing habitats and include particular landscape features (e.g., moist soil, shoreline and shallow water habitats for shorebirds, and open water habitat of various depths with submerged aquatic vegetation) to adequately support migratory birds.
- Support the Service’s monitoring and management of invasive species on NWRs as needed to maintain the structure and function of various habitats.
- Acquire water rights to protect the ability of NWRs to meet establishment purposes and, especially, keep intact the structure and function of certain areas on refuge lands that support migratory birds.
- Maintain NWR infrastructure (e.g., water control structures, ditches, and pumping stations) to deliver and distribute water that sustains functional wetlands, like those at Kootenai NWR. Provide sufficient resources to design and implement infrastructure modifications, as necessary, to meet refuge objectives.

7.4 MAINTAIN OR ENHANCE HABITAT COMPLEXITY AND HETEROGENEITY

Habitat complexity and habitat heterogeneity greatly influence the function of ecological communities. Ecological communities with high habitat complexity and heterogeneity often contain greater species richness and abundance, and thus, increase the chance of species survival through all life- history stages. In the Basin, the presence of dams and associated infrastructure in and along mainstems, tributaries, riparian zones, and wetlands have reduced habitat complexity and led to homogenization of habitats, thereby decreasing overall ecological function (Hauer et al. 2016, p. 1; Macfarlane et al. 2016, p. 455; Moyle and Mount 2007, pp. 5711-5712; Poff et al. 2007, p. 5732; Utzig and Schmidt 2011, pp. i, 33; Williams et al. 2006, p. 646). Further changes to the current configuration of Federal projects in the Basin may pose additional threats to remaining complex and diverse habitats.

The following recommendations are intended to maintain or enhance habitat complexity and heterogeneity throughout the Basin. Some recommendations are intended to compensate for impacts on habitat that can neither be avoided nor minimized. These recommendations could be implemented offsite, without a direct connection to the CRSO. The Service recommends that these off-site recommendations be implemented after actions intended to avoid and minimize have been fully considered.

- Maintain, enhance, and restore habitat complexity and heterogeneity, and implement identified measures to increase habitat complexity and heterogeneity. Design and implement actions that increase LW in the system and maintain vital ecological processes such as sediment transport and tributary delta formation.
- Evaluate potential for improvements in habitat functionality at a landscape scale, and prioritize conservation and restoration projects at sites likely to be responsive to project actions and activities aimed at making such improvements.
- Provide sufficient resources and support to acquire or enhance lost or diminished habitats, landscape features, and ecological niches to maintain habitat mosaics that support riparian and wetland species and waterbirds.
- Acquire, maintain, and support maintenance of emergent wetland vegetation, shallow water habitat, meadows, and moist foraging areas for waterbirds and shorebirds, frogs, and painted turtles that inhabit the Lower Columbia River and Lower Snake River.
- Protect mudflats, including foraging and roosting habitat, for migratory shorebirds. Avoid changes in water levels that reduce mudflats downstream near the Columbia River Estuary and Julia Butler Hansen NWR.
- Restore channel complexity in mainstems, tributaries, and side channels of rivers and implement identified measures to increase side channel complexity. Additional restoration activities should include the removal of structures like dikes and riprap to soften banks and shorelines, thereby improving connectivity and habitat complexity.

- Reintroduce beaver in areas where beaver were either historically located or can be properly supported to enhance habitat complexity in aquatic and semi-aquatic environments. Cooperate with, and support, beaver reintroduction efforts, such as those piloted by State agencies in the Basin.
- Work with partners to exclude livestock from riparian areas wherever possible, especially in years following high riparian vegetation recruitment. Other than non-functional flow regimes, livestock grazing is the most immediate threat to riparian habitat, so exclusion is essential to retain riparian restoration progress made by establishing functional flows.
- Promote and fund stream restoration and address operational inefficiencies in irrigation, municipal use, and voluntary water actions to minimize negative impacts associated with water withdrawal from rivers and tributaries.
- Support monitoring of cottonwood and seedling mortality and implement the Winter Stage for Riparian operational measure at Libby Dam and Hungry Horse Dam and at other if cottonwood seedling mortality is observed due to rising winter ice.
- Create and maintain cold-water refugia (i.e., areas in water bodies that are persistently cooler than other areas) as follows (EPA 2019, pp. 2-4):
    - Review and consider recommendations developed by the EPA in their Columbia River Coldwater Refugia Plan (EPA 2019, pp. 158-162);
    - Identify existing cold-water refugia in the study area and propose and implement restoration actions such as installing riparian shading to reduce solar heating, restoring streamflows to increase resiliency of tributary subhabitats, and exploring opportunities to coordinate with partners to release cooler water from upstream dams;
    - Protect cold-water refugia where there is an emergence of groundwater; and,
    - Opportunistically purchase instream water rights in cold water tributaries to restore late-summer instream flows.
- Restore sediment dynamics in prioritized river reaches (e.g., through gravel augmentation or the installation of LW to better retain sediment).
- Manage flows and reservoir elevations, and use other appropriate management techniques to create or mimic natural sediment transport and depositional regimes. Support fish passage and alleviate issues at tributary deltas where increased sedimentation impedes habitat development and reduces or eliminates connectivity.
- Conserve colonial nesting waterbird populations in historical numbers within historical range, and supplement breeding habitat (at a 2:1 ratio) in the event colonies are displaced or destroyed.
- Reduce the likelihood of land bridge exposure to islands in preservation of waterbird nesting habitat to reduce predation and disturbance during nesting seasons.
- Install signage and develop and enforce regulations (e.g., no wake zones and closures) to protect essential waterbird breeding and nesting habitat.

- Develop and implement restoration projects at the Pack River Delta that aim to minimize wave action created by recreational boating on Lake Pend Oreille.
- Continue Kootenai River and Lake Kootenay nutrient-enhancement efforts.
- Post-implementation of barrier removal or breaching measures:
  - Evaluate changes in abundance and diversity of native aquatic invertebrates in wetland habitats. Determine and implement restoration activities that preserve remaining wetlands, and promote natural establishment of wetland habitats and associated aquatic invertebrate abundance and diversity.
  - Promote establishment and survival of native riparian vegetation:
    - Adopt functional flow regimes at Dworshak Dam. Work with partners to establish functional flows at other upstream dams.
    - Time the initial stage decrease (i.e., following barrier removal or breaching) to coincide with natural peak flow recession. This would promote the establishment of native riparian vegetation for which seed dispersal and normal springtime peak flows occur contemporaneously in an unregulated system.
    - Maintain, and potentially increase, invasive species prevention and control efforts to prevent the invasion and establishment of non-native species in newly exposed shorelines during the first few years until riparian species have established.
    - Support Operational Loss Mitigation Plan activities to protect and restore riparian habitat on the Flathead River (Bergeron et al. 2018).
  - Plant native wetland vegetation, which establishes quickly in response to new sediment deposition, in the McNary Reservoir.
  - If reestablishment of functional flow regimes is not feasible, then apply native seeds or plantings, and support non-native species management in newly exposed persistent terrestrial habitats (e.g., riparian, wetland, and upland habitats).
- In regard to MO3 and MO4, restore wetland habitat on recently exposed islands resulting from breaching the four Lower Snake River dams or when land is exposed as a result of reservoir drawdown.

7.5 REDUCE THE SPREAD OF INVASIVE SPECIES, AND PREVENT FUTURE INVASIONS

Invasive species are non-native animal and plant species that pose harm to native fish and wildlife resources. Invaders often thrive in new environments as they have few, if any, natural predators but plenty of resources, allowing them to outcompete native species. Invaders can also introduce new pathogens (which are also invasive species) to ecosystems. Similar to what has occurred in other systems (i.e., the Laurentian Great Lakes), non-native species like northern pike (*Esox lucius*) in Lake Roosevelt above Grand Coulee Dam, and reed canary grass (*Phalaris arundinacea*) in the Basin have invaded lake, reservoir, and wetland habitats, preying upon or outcompeting native species. Proposed changes to the configuration and operations of the Federal projects, especially Grand Coulee, and their features (e.g., turbines) may contribute to the spread of invasive species and even exacerbate future invasions.

The Service recognizes CRS operations are not solely responsible for introducing invasive species to the Basin, and those operations are not likely to lead to future introductions. However, because of the Federal dam operations and project reservoirs, there is the potential to spread invasive species throughout the basin. If left unaddressed, then invasive species can lead to additional negative environmental and economic impacts (e.g., higher costs for prevention of their establishment and control). In the interest of controlling invasive species, reducing their spread, and preventing future invasions, the Service offers the following recommendations:

- Reduce the impacts of non-native fish in the study area, and support northern pike removal program efforts.
- Provide support and resources for additional boat cleaning stations to prevent invasion and establishment of non-native species.
- Support research to determine potential impacts (i.e., including directly or indirectly influencing predation of native species) of American shad (*Alosa sapidissima*) in the Lower Columbia and Snake Rivers to understand their potential impact on native aquatic species.
- Coordinate with, and implement prioritized actions identified by, interagency invasive species teams. The Aquatic Invasive Species Network and the Western Regional Panel can provide direction in regard to aquatic invasive species. Each state in the study area (i.e., Idaho, Montana, Oregon, and Washington) has an invasive species council that can also provide direction on focused actions to eradicate and reduce the spread of invasive species.

7.6 SUPPORT LONG-TERM MONITORING AND ADAPTIVE APPROACHES TO FUTURE MANAGEMENT

In the Basin, maintaining ecological processes, restoring habitat, and preserving fish, wildlife, and plants are essential to the future sustainability of our biologically, socioeconomically, and culturally valuable natural resources. Predicting how water resource and infrastructure development or changing conditions such as climate change will impact the environment is exceedingly difficult. In the face of such uncertainty, Federal, State, Tribal, academic, and private partners should inform and support science-based policy decisions that advocate for more research, long-term monitoring and evaluation, and adaptive approaches to managing fish and wildlife resources. To maintain ecosystem resiliency in the face of uncertainty and future threats, the Service offers the following recommendations:

- Monitor water quality (temperature, TDG, pH) to ensure that operations do not result in significant, long-term changes to standards or benchmarks that serve as important environmental cues for successful growth and reproduction of migratory and resident fishes and other aquatic and semi-aquatic species.

- Monitor Caspian tern breeding colony abundance at the inland Basin system-level (i.e., the Columbia River Plateau Region). This should include monitoring colony abundance at Goose Island and other islands in the Potholes Reservoir, Crescent Island, the ten "at-risk" islands identified in the Inland Avian Predation Management Plan, and the unnamed islands in Lenore Lake (USACE 2014a, pp. 28-29).
- Provide support and resources for monitoring the John Day and McNary Dam operations impacts on Umatilla NWR and priority public uses identified in the Comprehensive Conservation Plan (USFWS 2007, p. B-2). These monitoring data can inform future adaptive management at this site.
- Monitor occupancy of riparian birds in restored riparian habitats as measures of efficacy of restoration efforts.
- Monitor and catalog wetland and riparian vegetation at reference locations following manipulation of water surface elevation. This monitoring should include various losses and gains in terms of wetland habitat. Monitor long-term plant and animal responses to drawdown to increase understanding of physical changes to habitats and fish and wildlife resources.
- Develop education and outreach materials to illustrate and explain the mutual ecological and social-economic benefits associated with overland flow. Share these materials with various entities or stakeholders (e.g., landowners) to help inform them about potential positive impacts (e.g., more fertile soil) resulting from more dynamic flows and changes in water elevation.
- Coordinate with The Xerces Society, State fish and wildlife agencies, land trusts, and citizen science initiatives to monitor native terrestrial invertebrates (i.e., distribution, habitat, life-history needs) and implement restoration and conservation actions or activities in locations where they may be affected by proposed changes in dam operations.
- Work with the Service's Pacific Lamprey Conservation Initiative to implement restoration and conservation actions that address the impacts of the Lower Columbia River and Lower Snake River operations. Additionally, work with the initiative to support new and ongoing field studies aimed to fill gaps in existing information and knowledge about Pacific lamprey biological and life-history requirements.
- Incorporate juvenile and adult Pacific lamprey into research, monitoring, and evaluation of Flex Spill to the extent practicable. The Service can provide technical assistance in developing study design, determining sampling protocols, and conducting statistical analyses to ensure impacts to Pacific lamprey are understood and given full consideration in operational decisions related to Flex Spill.
- Incorporate juvenile Pacific lamprey into the research, monitoring, and evaluation of the improved fish passage turbines, to the extent practicable, at Federal CRS projects receiving new turbines.
- In proposing future restoration activities in the mainstem Columbia and Snake Rivers, use the Service's, Bureau of Land Management's, and U.S. Forest Service's joint Best Management Practices to minimize impacts on Pacific lamprey.

- Monitor and evaluate operational impacts on species other than listed Pacific salmon and anadromous fishes. Establish an interagency fish and wildlife adaptive management group, or task and support existing interagency forums to consider the impacts of hydropower operations on all species. Provide support and resources to facilitate the interagency groups' or forums' conservation efforts.
- Improve coordination efforts between biologists and engineers working together on short-term (i.e., daily) dam operations to identify flexibility in operations and, in turn, capitalize on opportunities to restore and conserve habitat that yields environmental benefits to fish and wildlife resources.
- Consider climate change impacts on fish and wildlife resources and develop a climate change adaptive management plan to ensure conservation of fish and wildlife resources and their habitat.
- In regard to proposed structural and operational measures under MO3 (Breach Snake Embankments, Lower Snake Infrastructure Drawdown, Drawdown Operating Procedures, and Drawdown Contingency Plans), monitor native aquatic invertebrates affected by hydropower operations, and coordinate with the Pacific Northwest Native Freshwater Mussel workgroup to identify restoration and conservation actions for mitigation purposes.

A APPENDIX A: TIMELINE

The timeline in this appendix highlights key milestone activities in the Service's engagement in CRSO CAR development from spring 2017 through summer 2020.

A.1 TIMELINE OF ACTIVITIES RELATED TO CRSO CAR DEVELOPMENT

Date of Activity	Activity Description
2017	
October 17	The Service committed to develop a SOW, including budget request, for the Corps to potentially develop a CAR for the CRSO
2018	
March 21	The Service sought input on landscapes and evaluation species from Service Program staff and co-lead agencies for the CAR
April 23	The Corps formally requested a CAR for the CRSO and asked the Service to finalize the SOW
April 25	The Service delivered the SOW to the Corps
May 15	The Service and Corps approved the SOW
August 8	The Service and co-lead agencies jointly held a CRSO Kick-Off Meeting in Portland, Oregon
September 25	The Service considered landscapes and an initial, focused evaluation species list for the CRSO CAR
October 3	Service staff participated in a half-day FWCA training webinar
October 25	Secretaries of the U.S. Departments of Interior, Commerce, and Energy, and the Assistant Secretary of the Army (Civil Works) received a Presidential Memorandum, “Promoting the Reliable Supply and Delivery of Water in the West” (83 FR 53961), directing co-lead agencies to develop a schedule to complete the CRSO DEIS and final EIS, Opinions, and CAR in 2020
November 2	The Service refined the landscapes and evaluation species list
December 22	U.S. Department of the Interior Federal agencies, including the Service, shut down due to a lapse of appropriated funds, and work paused for 21 working days
2019	
January 25	The partial Federal Government shutdown ended, and work resumed
February 25	Based on the Presidential Memorandum (83 FR 53961), the Corps revised the schedule for the following deliverables and deadlines: • CRSO DEIS due February 2020 and final EIS due June 2020; • associated Opinions due June 2020; • CRSO CAR due June 2020; and, • the Record of Decision in September 2020.
May 20 to 22	The Service hosted the “Wetlands” technical workshop in Burbank, Washington

Date of Activity	Activity Description
May 28 to 29	The Service hosted the “Upper Basin” technical workshop and “Uplands” discussion in Kalispell, Montana
June 5 to 7	The Service hosted the “Riparian” technical workshop in Burbank, Washington
June 24 to 26	The Service hosted the “Rivers” and “Lakes and Reservoirs” technical workshops in Vancouver, Washington
August	Service staff analyzed the CRSO alternatives
September 9	Service staff finalized conservation recommendations and mitigation strategies
September 30	Service staff briefed regional leadership on the status of the draft CRSO CAR and upcoming review opportunities
October 1	The Service began internal review of the draft CRSO CAR
October 9	The Service submitted a Planning Aid Letter to the Corps including the Service’s draft conservation recommendations
2020	
January 14	The Service delivered the draft CRSO CAR to the Corps
February 28	The co-lead agencies released the CRSO DEIS and the draft CRSO CAR, attached as an appendix, and began the review and comment period
April 13	The co-lead agencies’ review and comment period closed
April 16 to May 5	The Service coordinated with Federal, State, and Tribal partner agencies and stakeholders to obtain additional biological information to consider for the final CRSO CAR
April 24 to May 6	The Service reviewed biological information received from partner agencies and stakeholders
May 14	The Service began internal review of the final report
May 27	The Service delivered the final CRSO CAR to the Corps

B APPENDIX B: CRSO STUDY AREA, FURTHER DEFINED

This appendix includes additional information the Service used to further define the study area for the CAR.

B.1 FOCAL TRIBUTARIES

The Snake, Clearwater, Kootenai, and Pend Oreille Rivers represent the focal tributaries in the Preferred Alternative.

B.1.1 Snake River

At approximately 1,040 miles (1,674 km) long, the Snake River is the largest tributary of the Columbia River (Kammerer 2005). The Snake River drainage basin comprises 41 percent of the entire Basin and includes parts of seven states (Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming). The Snake River has an average annual discharge of 57.00 kcfs (1,614 m^3/s) or 21 percent of the Columbia River's discharge. The Service's analysis considered only the lower portion of the Snake River affected by the CRSO (i.e., beginning approximately 9.0 miles [14 km] below its confluence with the Salmon River, to the Snake River's confluence with the Columbia River).

B.1.2 Clearwater River

The Clearwater River in north-central Idaho flows west along the Idaho-Montana border and joins the Snake River at Lewiston, which marks the head of navigation on the Snake River. The Dworshak Reservoir (created by Dworshak Dam on the North Fork of the Clearwater River) is the only major lake on the Clearwater system. The Clearwater River is the largest tributary of the Snake River, and its average annual discharge is approximately 15.0 kcfs (425 m^3/s).

B.1.3 Kootenai River

The Kootenay or Kootenai River Basin contains approximately 16,180 mi^2 (41,906 km^2) of southeastern British Columbia, northern Idaho, and western Montana. The Kootenai River originates just north of Kootenay National Park and flows 485 miles (781 km) through Montana and Idaho, back into Canada, and finally into Kootenay Lake (Kootenai and Montana FWP 2004, p. 5; Kootenai River Network, Inc. n.d., p. 1). The topography of the Kootenai River Basin is dominated by steep mountainous country, 90 percent of which is forested or above the tree-line. Rainfall is relatively plentiful throughout this basin, making it the second largest tributary of the Columbia River in terms of run-off volume (27.6 kcfs [782 m^3/s]), though it is only the third largest in terms of drainage area. Only the Snake River contributes more volume, and it does so from a much larger watershed area (Knudson 1994, p. 6).

B.1.4 Pend Oreille River and Tributaries

The Pend Oreille River, which drains portions of northeastern Washington, northern Idaho, and southeastern British Columbia, is approximately 130 miles (209 km) long and, below Box Canyon Dam, has a discharge averaging approximately 26.0 kcfs (736 m^3/s) (USGS 2019a). Lake Pend Oreille is the largest and deepest natural lake in Idaho (Idaho DEQ 2001, p. 1). The Clark Fork River, Flathead River, Flathead Lake, Blackfoot River, Bitterroot River, Lake Pend Oreille, and Pend Oreille River are among the main bodies of water in the basin (MTDEQ et al. 2007, p. 16). The Pend Oreille River drains an area of almost 26,000 mi^2 (67,340 km^2), mostly through the Clark Fork River and its tributaries in western Montana, including a portion of the Flathead River in southeastern British Columbia (BC Hydro 2006, p. 7; MTDEQ et al. 2007, p. 3). The total area of the Pend Oreille Basin is just under 10 percent of the entire 258,000-mi^2 (668,217-km^2) Basin.

B.1.4.1 Clark Fork River

The Clark Fork River or the Clark Fork of the Columbia River, drains most of Montana's west slope, and flows approximately 300 miles (483 km) from the headwaters, a few miles northwest of Butte, Montana to Lake Pend Oreille in North Idaho (MTDEQ et al. 2007, pp. 16, 20). Over the last 22 years, the discharge of the Clark Fork River below Cabinet Gorge Dam has averaged over 20.0 kcfs (566 m^3/s), draining over 22,000 mi^2 (56,980 km^2) (USGS 2019b).

B.1.4.2 Flathead River

The Flathead River begins in the Canadian Rockies and flows 158 miles (254 km) into the Clark Fork River near Paradise, Montana. All headwater forks are either entirely (e.g., Middle and North Fork) or in part (e.g., South Fork located above Hungry Horse Dam) designated as National Wild and Scenic Rivers (Flathead Watershed Sourcebook 2016). Below Hungry Horse Dam, the Flathead River flows into the broad alluvial Flathead Valley (Smith et al. 2000, p. 41). The Flathead River has an average discharge of just under 12.0 kcfs (340 m^3/s) and contributes over half of the Clark Fork River's flow (Confederated Salish and Kootenai Tribes and Montana FWP 2004, pp. 5-6).

B.2 COLUMBIA RIVER SYSTEM OF FEDERAL PROJECTS

The study area considered in the Service's analysis includes the 14 Federal dams or projects managed as part of a single, larger system of operations, the CRSO (Table B1 and Figure B1) (USFWS and USACE 2018, pp. 1, 8).

Table B1. Columbia River System and notable tributaries in which operating agencies coordinate and manage Federal CRS projects

River System and Tributaries	Operating Agency	Federal Project
Columbia River Mainstem	Corps	Bonneville The Dalles John Day McNary Chief Joseph
Columbia River Mainstem	Reclamation	Grand Coulee
Snake River	Corps	Ice Harbor

River System and Tributaries	Operating Agency	Federal Project
		Lower Monumental Little Goose Lower Granite
Clearwater River	Corps	Dworshak
Kootenai River	Corps	Libby
Pend Oreille River	Corps	Albeni Falls
Flathead River	Reclamation	Hungry Horse

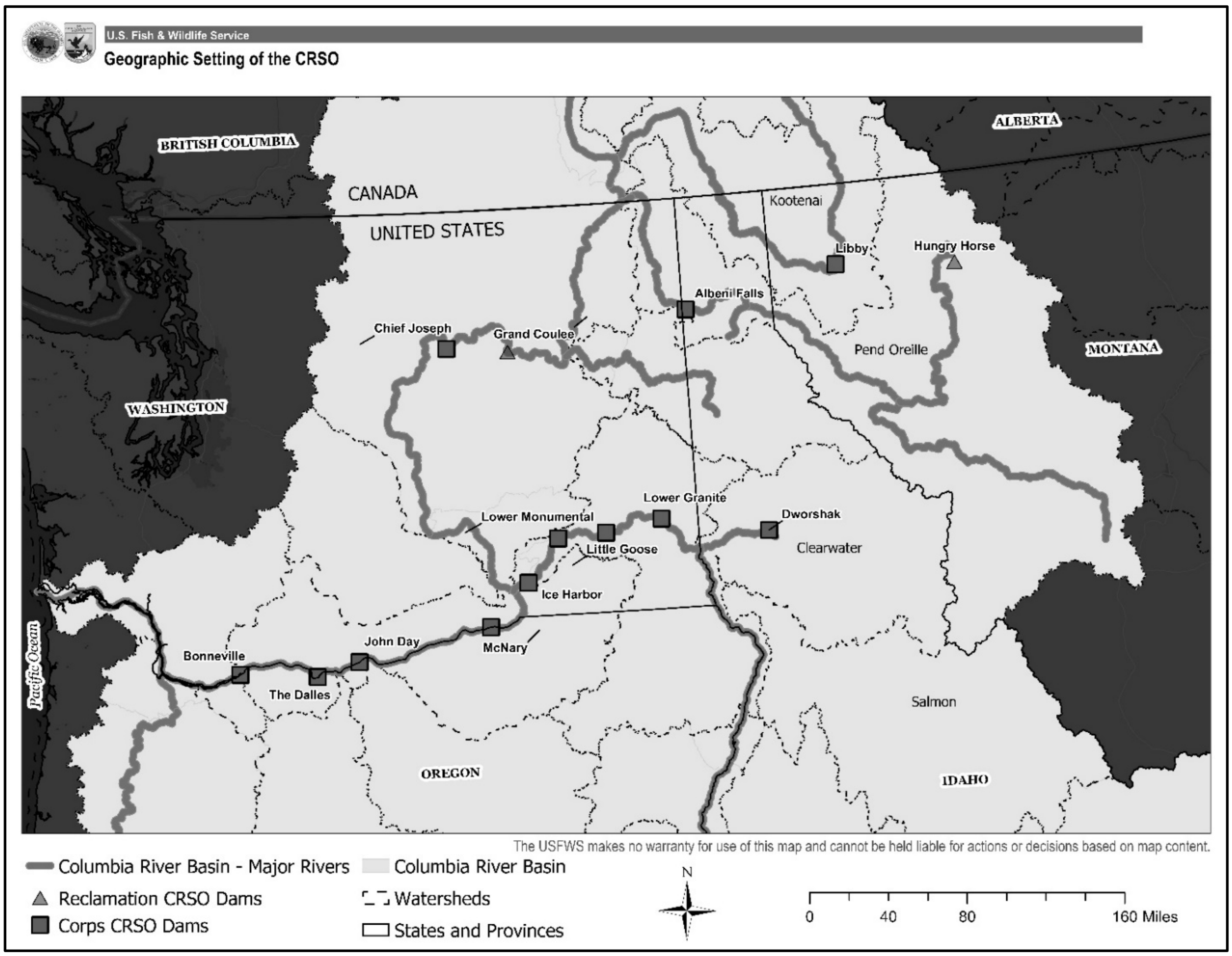

Figure B1. Geographic setting of the CRSO (USACE n.d.)

The co-lead agencies coordinate operation of these 14 Federal projects with Canadian reservoir projects pursuant to the Columbia River Treaty and several non-Federal, private and public utility district dams (Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids) throughout the Basin (BPA et al. 2001, pp. 18-19; Columbia River Basin Treaty 1961).

The Service's analysis of the potential impacts of the CRSO and its alternatives on fish and wildlife resources included the operational response to the removal of water for seven Federal irrigation projects: Columbia Basin Project, The Dalles, Chief Joseph, Umatilla, Yakima, Crooked River, and the Deschutes Projects. Certain areas and operations related to these projects were excluded (Section B.5) from the Service's analysis.

B.3 RIVER SEGMENTS (OR REACHES)

The study area includes the extent of the projected upstream inundation in the mainstem Columbia River and tributaries, as well as downstream impacts of modified flows from the 14 Federal projects to the point where such flow modification no longer has measurable impacts (USFWS and USACE 2018, p. 8). Within that scope, the Service's analysis of the impacts of Federal CRS project proposed alternatives was confined by the following regional boundaries:

- the mainstem Columbia River, from the uppermost extent of river affected by Lake Roosevelt, down to and including the Columbia River Estuary and plume (i.e., nearshore ocean adjacent to the mouth);
- the Snake River, beginning approximately 9.0 miles (14 km) below its confluence with the Salmon River, to the Snake River's confluence with the Columbia River;
- Dworshak Reservoir and the North Fork Clearwater River downstream of Dworshak, flowing into the Clearwater River to its confluence with the Lower Snake River;
- Libby Reservoir (i.e., Lake Koocanusa) and the Kootenai River downstream of Libby Dam to its confluence with the Columbia River;
- Lake Pend Oreille and the Pend Oreille River, including Albeni Falls Dam, to its confluence with the Columbia River;
- Hungry Horse Reservoir and the South Fork Flathead River, downstream of Hungry Horse Dam to the confluence with the mainstem Flathead River and Flathead Lake;
- stream reaches and land areas permanently or seasonally inundated (i.e., as determined by 200-year water level events) by currently permitted and legal operations of the Federal CRS projects; and,
- landscapes, habitats, and sites within a 0.5 mile (0.8 km) distance (i.e., buffer) of the above listed areas.

The study area includes distinct river segments or reaches that range from the reservoirs upstream of Federal dams, such as Hungry Horse Reservoir above Hungry Horse Dam on the South Fork of the Flathead River, to downstream of Bonneville Dam as far as the nearshore marine environment beyond the mouth of the Columbia River (i.e., within 0.5 mile [0.8 km] of the terminus of the banks). Table B2 lists these reaches in order from the Pacific Ocean to headwater stream segments.

Table B2. River reaches included in the CAR analysis

Rivers and Focal Tributaries	Number related to Figure B2	Reach Name	From River Mile	To River Mile	Length (miles [km])	Area (acres [km^2])[1/]
Columbia River	0	Ocean to Quinn Island	-0.5	30	79 [127]	144,441 [585]
	1	Quinn Island to Bonneville Dam	30	146	429 [690]	348,935 [1412]
	2	Bonneville Dam to The Dalles Dam	146	191	103 [166]	55,805 [226]
	3	The Dalles Dam to John Day Dam	191	217	54 [87]	27,884 [113]
	4	John Day Dam to McNary Dam	217	291	188 [303]	121,892 [493]
	5	McNary Dam to Priest Rapids Dam	291	397 (Columbia River) and 9 (Snake River)	255 [410]	146,463 [593]
Snake River	6	Ice Harbor Dam to Lower Monumental Dam	9	41	64 [103]	29,508 [119]
	7	Lower Monumental Dam to Little Goose Dam	41	69	68 [109]	28,653 [116]

Rivers and Focal Tributaries	Number related to Figure B2	Reach Name	From River Mile	To River Mile	Length (miles [km])	Area (acres [km²])1/
	8	Little Goose Dam to Lower Granite Dam	69	106	79 [127]	35,495 [144]
	9	Upstream of Lower Granite Dam to Dworshak Dam	107	178 (Snake River), 7 (Grand Ronde River), 45 (Clearwater River)	238 [383]	94,506 [382]
Columbia River	15	Priest Rapids Dam to Wanapum Dam	397	415	43 [69]	22,321 [90]
	32	Upstream of Dworshak Dam	1 (North Fork Clearwater River)	55 (North Fork Clearwater River)	55 [89]	69,192 [280]
	16	Wanapum Dam to Rock Island Dam	415	454	80 [129]	40,718 [165]
	17	Rock Island Dam to Rocky Reach Dam	454	475	47 [76]	19,706 [80]
	18	Rocky Reach Dam to Wells Dam	475	515	88 [142]	37,316 [151]

Rivers and Focal Tributaries	Number related to Figure B2	Reach Name	From River Mile	To River Mile	Length (miles [km])	Area (acres [km^2])1/
	19	Wells Dam to Chief Joseph Dam	515	546	58 [93]	29,367 [119]
	20	Chief Joseph Dam to Grand Coulee Dam	546	597	107 [172]	42,603 [172]
	21	Grand Coulee Dam to U.S. – Canada Border	597	748	153 [246]	199,793 [809]
Pend Oreille River	22	Boundary Dam to Box Canyon Dam	16 (Pend Oreille River)	33 (Pend Oreille River)	37 [60]	13,437 [54]
	23	Box Canyon Dam to Albeni Falls Dam	33	89	119 [192]	66,915 [271]
	24	Albeni Falls to Cabinet Gorge Dam	89	156, 2 (Pack River) and 15 (Clark Fork River)	189 [304]	172,539 [698]

Rivers and Focal Tributaries	Number related to Figure B2	Reach Name	From River Mile	To River Mile	Length (miles [km])	Area (acres [km^2])[1/]
Flathead River	28	Southern end of Flathead Lake to Hungry Horse Dam	79 (Flathead River)	156 (Flathead River, 6 (Stillwater River), 11 (Whitefish River), and 5 (South Fork Flathead River)	172 [277]	244,639 [990]
	30	Upstream of Hungry Horse Dam	5 (South Fork Flathead River)	41 (South Fork Flathead River)	37 [60]	57,571 [233]
Kootenai River	29	U.S. – Canada Border to Libby Dam	104 (Kootenai River)	220 (Kootenai River)	246 [396]	102,100 [413]
	31	Upstream of Libby Dam	220 (Kootenai River)	220 (Kootenai River)	48 [77]	67,058 [271]

[1/]The acres and km^2 listed are rounded to the nearest whole number.
Source: USGS n.d.

B.4 0.5 MILE (0.8 KM) BUFFER

The Service designated a 0.5 mile (0.8 km) buffer around the mainstem Columbia and Snake Rivers as an outer boundary to constrain the analysis (Figure B2). To define the buffer, the Service referenced the 200-year Annual Exceedance Probability (AEP) layer from the NAA and reviewed the co-lead agencies' Hydrology and Hydraulics (H&H) model outputs (USACE et al. 2020).

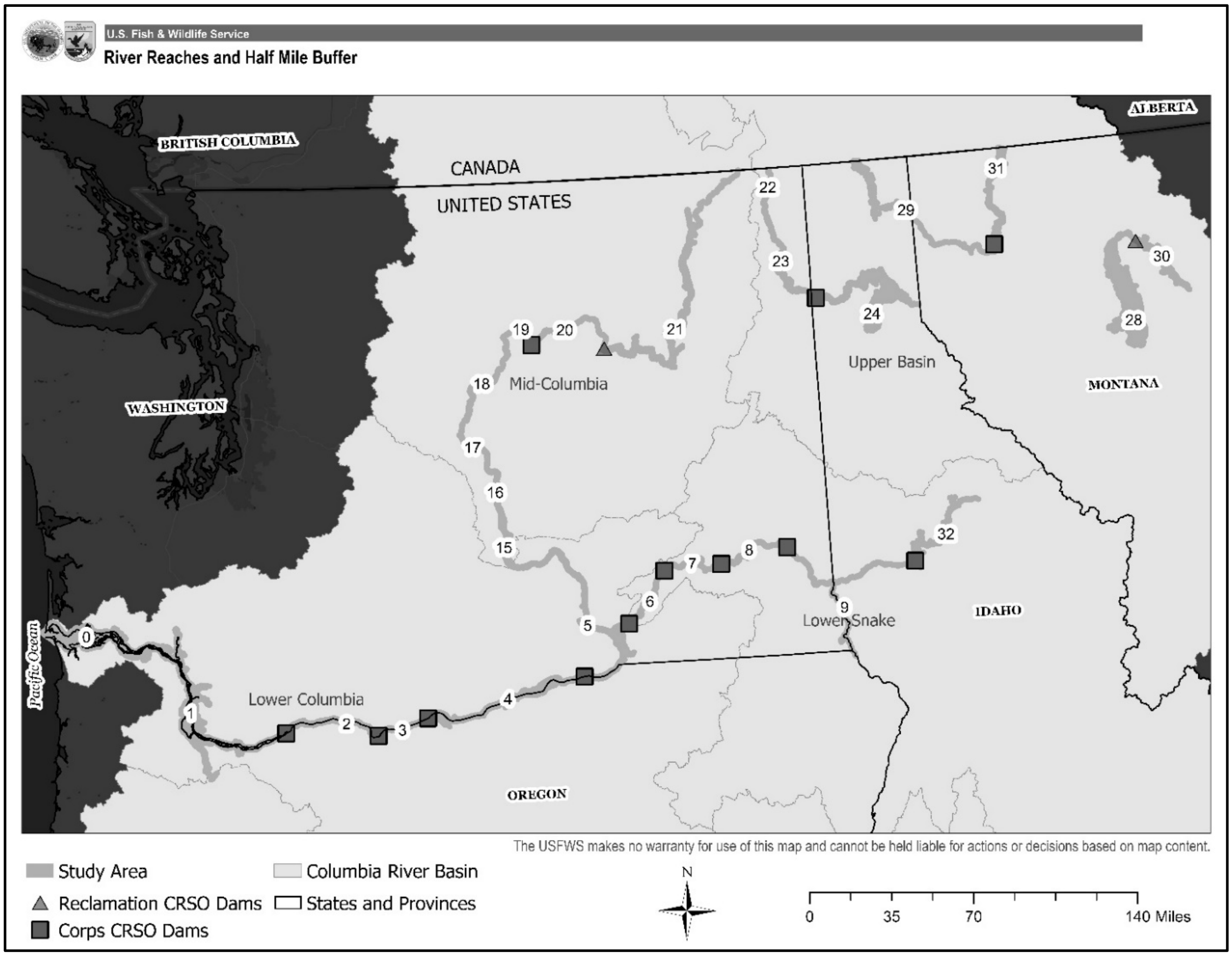

Figure B2. River reaches included in the CAR analysis and 0.5 mile (0.8 km) buffer

B.5 EXCLUDED AREAS

The study area does not include reaches located in Canada or upper portions of the Basin watersheds beyond the 0.5 mile (0.8 km) buffer. While the study area includes river reaches influenced by dams operated by non-Federal entities (e.g., Wanapum Dam, Rock Island Dam), the Service analyzed impacts of changes in configuration, maintenance, and operations of only those Federal projects that comprise the CRSO. The Service excluded lands associated with the transmission of electricity and irrigation on private lands from the analysis because they are outside the approved scope of this CAR.

C APPENDIX C: SERVICE OUTREACH AND COMMUNICATIONS

The following documents represent the Service's outreach to stakeholders during the analysis. Outreach materials included briefing memos and e-mails to Service programs' leadership, staff from other fish and wildlife resource agencies, Tribes, private groups, and academic institutions.

C.1 REQUEST FOR STAKEHOLDER INPUT

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Washington Fish and Wildlife Office
510 Desmond Dr. SE, Suite 102
Lacey, Washington 98503

February 22, 2019

To: R1 ES Project Leaders, Columbia Basin
Project Leader, Montana Field Office, R-6

From: acting State Supervisor, Washington Fish and Wildlife Office
Lacey, Washington

Subject: Opportunities for Input on USFWS Analysis of Federal Dam Effects

Background

The co-lead agencies of the Corps of Engineers (Corps), Bonneville Power Administration (BPA), and Bureau of Reclamation (BOR) are preparing and Environmental Impact Statement (EIS) on the operations of fourteen large federal dams in the Columbia Basin (Columbia Basin System Operations or CRSO). The Corps has provided funding to the USFWS to produce a Fish and Wildlife Coordination Act Report (FWCAR) that will be an appendix to the Environmental Impact Statement for CRSO.

Mission

The mission of the CRSO FWCAR is to:

"Promote conservation of ecological processes and diverse ecological communities affected by dam modifications and operations in the Columbia River basin by providing technical assistance and recommendations to the co-lead agencies."

A main objective of the FWCAR is to document the effects of dam operations on landscapes or aspects of landscapes that will not receive as much attention through ESA consultation. To that end, the USFWS team has identified five priority landscapes to analyze: Arid Uplands, Riparian, Wetlands, Rivers, and Lakes/Reservoirs.

Focusing the analysis

Given the number of ecological processes, communities, and species that could be affected by the dams, the USFWS narrowed the focus of their analysis by selecting species to illustrate the effects of changing dam operations. Species were selected through two phases. In the first phase, USFWS staff from the Washington Fish and Wildlife Office identified species that:

- were likely to be impacted,
- were good indicators of ecological change,
- represented the different parts of the basin, and
- occupy multiple states.

The first phase also prioritized species with special status under state law, but are not listed under the Endangered Species Act since the effects of dam operations to ESA-listed species will be analyzed through consultations with USFWS and NOAA. The co-lead agencies and Washington Department of Fish and Wildlife provided feedback on the list.

To prepare the FWCAR, the USFWS assembled a team from different programs across the region led by the USFWS office in Lacey, Washington. After the USFWS CRSO FWCAR team was assembled, the team revisited the list during a second phase of identifying illustrative species.

During the second phase USFWS staff across four programs edited the initial species list focusing on whether other species would be better indicators of ecological change while retaining the previous criteria. The second phase of selecting species resulted in the following list:

Priority Landscapes and Focal Species for the USFWS CRSO FWCAR

Priority Landscape	Focal Species
Arid Uplands	Long-billed curlew
	Sage thrasher
Riparian	Black cottonwood
	Viceroy butterfly
	Yellow warbler
Wetlands	American bittern
	Mallard
	Western painted turtle
	Woodhouse's toad
Rivers	Western pearlshell mussel
	White sturgeon
Rivers / Lakes/Reservoirs	Pacific lamprey
Lakes/Reservoirs	Clark's/Western grebe
	Dunlin
	Floaters

While the team's analysis of dam operations will focus on those sixteen species, they will welcome information about other species that will help explain the effects of dam operations on ecosystems.

Input from others

The USFWS CRSO FWCAR team will gather input from other stakeholders through a series of workshops in the spring and summer of 2019. The workshops will provide opportunities for state fish and wildlife agencies, tribes, and other organizations to contribute their expertise to the USFWS CRSO FWCAR. The workshops will cover the status of landscapes and species, how dam operations will affect them, and recommendations to increase conservation of species and their habitats.

We will appreciate input from professionals with knowledge about the species we have selected or other species that can help illustrate how dam operations affect the landscape. There will be one workshop on each of our priority landscapes, and each workshop will be one or two days. Workshop locations to be determined.

The USFWS will also accept comment letters as input for the FWCAR.

For more information, contact the USFWS CRSO FWCAR Coordinator Lee Corum at Lee_Corum@fws.gov or (360) 753-5835

C.2 REQUEST FOR STAKEHOLDER PARTICIPATION IN TECHNICAL WORKSHOPS

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Washington Fish and Wildlife Office
510 Desmond Dr. SE, Suite 102
Lacey, Washington 98503

Memorandum April 9, 2019

To: Columbia Basin ES Project Leaders (Idaho, Montana, and Oregon)

From: State Supervisor, Washington Fish and Wildlife Office
Lacey, Washington

Subject: Workshops for Technical Input on the Columbia River System Operations Fish & Wildlife Coordination Act Report

The USFWS Columbia River System Operations Fish and Wildlife Coordination Act Report (CRSO FWCAR) team (herein referred to as "the team") is ready to reach out to stakeholders and begin inviting experts to workshops. Please coordinate with the USFWS CRSO FWCAR Coordinator about what role, if any, you would like to have in introducing the project to your partners and asking for their participation in the workshops. Feel free to share this memo with your partners.

Background

The co-lead agencies of the Corps of Engineers (Corps), Bonneville Power Administration, and Bureau of Reclamation are preparing an Environmental Impact Statement (EIS) on the operations of fourteen large federal dams in the Columbia Basin. The Corps has provided funding to the USFWS to produce a formal 2(b) FWCAR that will be included as an appendix to the CRSO EIS. We will deliver the final FWCAR to the co-lead agencies before the final CRSO EIS is published in June 2020.

The mission of the USFWS CRSO FWCAR is to:
"Promote conservation of ecological processes and diverse ecological communities affected by dam modifications and operations in the Columbia River basin by providing technical assistance and recommendations to the co-lead agencies."

Related to that mission, a main objective of the FWCAR is to document the effects of dam operations on landscapes defined by ecological processes and communities that will not be prioritized through Endangered Species Act (ESA) Section 7 consultation. Consultation under the ESA will thoroughly analyze effects to ESA-listed species and their habitats, but dam operations may affect ecological processes and communities not linked to an ESA-listed species. The team has identified five broad priority landscapes within the Columbia River basin to analyze: Arid Uplands, Riparian, Wetlands, Rivers, and Lakes/Reservoirs to structure the FWCAR.

Workshops for technical input

We are soliciting input from stakeholders about the status of ecological processes, communities, and landscapes as well as how dam operations affect priority landscapes and associated communities. The team will gather input for their analysis and FWCAR from stakeholders through a series of workshops in May and June of 2019. The workshops will provide opportunities for stakeholders to share their diverse perspectives as they contribute technical information to the USFWS description of processes, landscapes, communities, species, and habitat statuses that will contribute to the USFWS analyses of dam modification/operation alternatives. Information from stakeholders could include, but is not limited to, reports from surveys or studies, white papers, gray literature, species population assessments or expert knowledge about ecological processes, species and their habitats, communities, and landscapes.

During the workshops, it would be helpful to the team for stakeholders to:

1. Identify and describe resources/areas that have special importance to stakeholders
2. Offer information to fill information gaps identified during the workshops
3. Suggest measures to conserve, protect, and enhance ecological processes, communities, and landscapes

We expect that stakeholders with technical knowledge about the status of ecological processes, communities, and landscapes, and existing impacts of dam operations could include, but is not limited to, representatives from:

- Federal agencies
- State natural resource agencies/departments
- Tribal natural resource agencies/departments
- Utility districts and local government (cities/counties)
- Non-government organizations
- Academia

There are five workshops scheduled for the team to receive input from stakeholders. Each workshop focuses on a different priority landscape or geographic area, we welcome stakeholders to attend any workshops that they can contribute to.

Workshop Focus	Dates	Location
Wetlands	May 20-21, 2019	Mid-Columbia River NWR Complex Office, Burbank, WA
Upper Basin	May 28-29, 2019	To be determined
Riparian	June 5-6, 2019	Mid-Columbia River NWR Complex Office, Burbank, WA
Rivers	June 24-25, 2019	Columbia River Fish and Wildlife Conservation Office, Vancouver, WA
Lakes/Reservoirs	June 25-26, 2019	Columbia River Fish and Wildlife Conservation Office, Vancouver, WA

The one- to two-day workshops provide an efficient method for the team to receive and discuss information from stakeholders. The team will also accept comment letters as input for the FWCAR.

For more information please contact the USFWS CRSO FWCAR Coordinator: Lee Corum at (360) 753-5835 or by email at Lee_Corum@fws.gov.

D APPENDIX D: SERVICE WORKSHOP AGENDAS

The following documents are the agendas for the Service's technical workshops. For each workshop, there were four or five questions designed to encourage stakeholders to share information about fish and wildlife resources in the Basin for the Service's analysis.

D.1 AGENDA FOR THE WETLANDS TECHNICAL WORKSHOP

USFWS CRSO FWCA Workshop – Wetlands

May 20 – 21, 2019
Mid-Columbia River National Wildlife Refuge Complex Office
Burbank, Washington

Workshop Goals

- Identify significant resources (e.g., processes, landscapes, habitat components, and species) in specific areas within the study area that are of special value to workshop participants
- Discuss how modifications to existing conditions related to water quality and quantity could potentially impact significant resources
- Compile a list of potential actions to conserve, protect, and enhance significant resources
- Obtain valuable data (e.g., from white papers, grey literature, technical reports, survey assessments) to fill existing information gaps

AGENDA

Monday, May 20, 2019

	Introduction to the USFWS CRSO FWCA	
1:00 pm	**Welcome and introductions**	Lee Corum
1:30 pm	**Introduction to the Columbia River System Operations (CRSO)** National Environmental Policy Act (NEPA) context General scope of proposed action and alternatives USFWS CRSO mission Team structure and organization Geographic scope	Lee Corum Michael Carlson
2:00 pm	**Overview of the Fish and Wildlife Coordination Act (FWCA)** Purpose and goals FWCA versus the Endangered Species Act Unique qualities and strengths of the FWCA Deliverables	Molly Good
2:15 pm	**Approach to USFWS CRSO FWCA Report** Priority landscapes Evaluation species	Molly Good
2:30 pm	**Workshops** Purpose and goals Exercises and questions Expectations for workshop participants	Lee Corum
2:50 pm	**BREAK**	

Orientation to Wetlands		
3:00 pm	**"What we know so far…"** Characterization of priority landscape Significant resources Use of landscape and habitat components Critical processes or features	Robert Haltner

Exercise I		
3:30 pm	**"What is it, and what's its status?"** Large group discussion: *Given the study area, comment on significant resources (e.g., processes, landscapes, habitat components, and species) of special value to you and their current statuses and trends (e.g., specific location, population [increasing, stable, decreasing], niches).*	Lee Corum
4:30 pm	**Announcements**	Lee Corum
5:00 pm	**Adjourn for the day**	

Tuesday, May 21, 2019

Exercise I, Continued		
9:00 am	**Discussion, continued**	Lee Corum

Exercise II		
9:30 am	**"What is critical, how will it change, and what are the impacts?** Small group discussion: *What processes (e.g., erosion) and landscape or habitat components (e.g., native wetland vegetation) are most critical to the health and well-being of the significant resources you identified? And, why?*	Lee Corum
11:00 am	**Report out**	Lee Corum
12:00 pm	**LUNCH**	
1:00 pm	**Discussion, continued** Small group discussion: *How would modifications to existing conditions (e.g., water elevation or depth) in the study area alter processes and landscape or habitat components you just identified? Be specific.*	Lee Corum
	Small group discussion: *List the impacts of these potential alterations in processes and landscape or habitat components on significant resources.*	Lee Corum
2:00 pm	**Report out**	Lee Corum
2:50 pm	**BREAK**	

Exercise III		
3:00 pm	**"If we could save it all…"** Small group discussion: *In light of your previous answers, list TEN measurable and achievable actions to conserve, protect, and enhance the significant resources you identified.*	Lee Corum
4:00 pm	**Report out**	Lee Corum
4:50 pm	**Announcements**	Lee Corum
5:00 pm	**Adjourn the workshop**	

Reminder

If you have access to, or are aware of, data that is related to the geographic areas or significant resources we discussed during this workshop, then please contact Lee Corum at lee_corum@fws.gov or (360) 753-5835.

Upcoming Meetings

Date	**Workshop**	**Location**
May 29	Upper Basin	Montana Fish, Wildlife, and Parks, Kalispell, Montana
June 5 – 6	Riparian	Mid-Columbia River NWR Complex Office, Burbank, Washington
June 24 – 25	Rivers	Columbia River Fish and Wildlife Conservation Office, Vancouver, Washington
June 25 – 26	Lakes/Reservoirs	Columbia River Fish and Wildlife Conservation Office, Vancouver, Washington

D.2 AGENDA FOR THE RIPARIAN TECHNICAL WORKSHOP

USFWS CRSO FWCA Workshop – Riparian

June 5 – 6, 2019
Mid-Columbia River National Wildlife Refuge Complex Office
Burbank, Washington

Workshop Goals

- Identify significant resources (e.g., processes, landscapes, habitat components, and species) in specific areas within the study area that are of special value to workshop participants
- Discuss how modifications to existing conditions related to water quality and quantity could potentially impact significant resources
- Compile a list of potential actions to conserve, protect, and enhance significant resources
- Obtain valuable data (e.g., from white papers, grey literature, technical reports, survey assessments) to fill existing information gaps

AGENDA

Wednesday, June 5, 2019

Introduction to the USFWS CRSO FWCA		
1:00 pm	**Welcome and introductions**	Lee Corum
1:10 pm	**Introduction to the Columbia River Systems Operation (CRSO)** National Environmental Policy Act (NEPA) context General scope of proposed action, alternatives, and operations USFWS CRSO mission Team structure and organization Workshop goals and expectations	Lee Corum Mark Bagdovitz Lee Corum
2:00 pm	**Fish and Wildlife Coordination Act (FWCA)** Purpose and goals Approach to USFWS CRSO FWCA Report	Molly Good
2:15 pm	**Geographic Scope** Study area	Michael Carlson
2:30 pm	**BREAK**	

Orientation to Riparian		
2:45 pm	**"What WE know so far…"** Characterization of priority landscape Significant resources Use of landscape and habitat components Critical processes or features	Gabrielle Robinson

Exercise I		
3:00 pm	**"What is riparian, to YOU?"** Discussion: *Given your knowledge of riparian landscape structure and function, please identify different classes or types of riparian habitat likely to exist within the study area.*	Lee Corum

Exercise II		
3:30 pm	**"Where do we prioritize?** Discussion: *Given your previous response, please identify high priority sites with riparian habitat in the study area, and explain why they are of interest or value to your agency.*	Lee Corum
4:50 pm	**Announcements**	Lee Corum
5:00 pm	**Adjourn for the day**	

Thursday, June 6, 2019

Exercise III		
9:00 am	**Summary of morning session and next steps**	Lee Corum
9:10 am	**"What must we maintain?"** Discussion: *In these high priority sites, what are the unique processes, landscape features, or time periods (e.g., growing season) necessary to maintain existing conditions that support significant resources?*	Lee Corum
10:20 am	**BREAK**	

Exercise IV		
10:30 am	**"How could it all change?"** Discussion: *Considering how current dam operations occur, how will changes involving higher or lower water flows affect these high priority sites?*	Lee Corum
12:00 pm	**LUNCH**	
1:00 pm	**Discussion, continued**	Lee Corum
3:20 pm	**BREAK**	

Exercise V		
3:30 pm	**"What can we do?"** Discussion: *In light of your previous answers, please identify TEN measureable and achievable actions to conserve, protect, and enhance the sites you identified and significant resources you discussed.*	Lee Corum
4:50 pm	**Announcements**	Lee Corum
5:00 pm	**Adjourn the workshop**	

Reminder

If you have access to, or are aware of, data that is related to the geographic areas or significant resources we discussed during this workshop, then please contact Lee Corum at lee_corum@fws.gov or (360) 753-5835.

Upcoming Workshops

Date	Workshop	Location
June 24 – 25	Rivers	Columbia River Fish and Wildlife Conservation Office, Vancouver, Washington
June 25 – 26	Lakes/Reservoirs	Columbia River Fish and Wildlife Conservation Office, Vancouver, Washington

D.3 AGENDA FOR UPPER BASIN TECHNICAL WORKSHOP

USFWS CRSO FWCA Workshop – Upper Basin

May 29, 2019
Montana Fish, Wildlife, and Parks Office
Kalispell, Montana

Workshop Goals

- Identify significant resources (e.g., processes, landscapes, habitat components, and species) in specific areas within the study area that are of special value to workshop participants
- Discuss how modifications to existing conditions related to water quality and quantity could potentially impact significant resources
- Compile a list of potential actions to conserve, protect, and enhance significant resources
- Obtain valuable data (e.g., from white papers, grey literature, technical reports, survey assessments) to fill existing information gaps

AGENDA

Wednesday, May 29, 2019

Introduction to the USFWS CRSO FWCA		
9:00 am	**Welcome and introductions**	Lee Corum
9:10 am	**Introduction to the Columbia River Systems Operation (CRSO)** National Environmental Policy Act (NEPA) context General scope of proposed action, alternatives, and operations USFWS CRSO mission Team structure and organization Workshop goals and expectations	Lee Corum Mark Bagdovitz Lee Corum
9:40 am	**Fish and Wildlife Coordination Act (FWCA)** Purpose and goals Approach to USFWS CRSO FWCA Report	Molly Good
9:50 am	**Geographic Scope** Study area Orientation to the Upper Basin	Michael Carlson Erin Kuttel

Exercise I		
10:00 am	**"Where do we prioritize?** <u>Discussion</u>: *Given the study area, please identify high priority sites and explain why they are of interest or value to your agency.*	Lee Corum
10:50 am	**BREAK**	

Exercise II		
11:00 am	**"What must we maintain?"** Discussion: *In these high priority sites, what are the unique processes, landscape features, or time periods (e.g., growing season) necessary to maintain existing conditions that support significant resources?*	Lee Corum
12:00 pm	**LUNCH**	

Exercise III		
1:00 pm	**"How could it all change?"** Discussion: *Considering how current dam operations occur, how will changes involving higher or lower water flows affect these high priority sites?*	Lee Corum
2:30 pm	**BREAK**	

Exercise IV		
4:00 pm	**"What can we do?"** Discussion: *In light of your previous answers, please identify TEN measureable and achievable actions to conserve, protect, and enhance the sites you identified and significant resources you discussed.*	Lee Corum
4:50 pm	**Announcements**	Lee Corum
5:00 pm	**Adjourn the workshop**	

Reminder

If you have access to, or are aware of, data that is related to the geographic areas or significant resources we discussed during this workshop, then please contact Lee Corum at lee_corum@fws.gov or (360) 753-5835.

Upcoming Workshops

Date	**Workshop**	**Location**
June 5 – 6	Riparian	Mid-Columbia River NWR Complex Office, Burbank, Washington
June 24 – 25	Rivers	Columbia River Fish and Wildlife Conservation Office, Vancouver, Washington
June 25 – 26	Lakes/Reservoirs	Columbia River Fish and Wildlife Conservation Office, Vancouver, Washington

D.4 AGENDA FOR RIVERS TECHNICAL WORKSHOP

USFWS CRSO FWCA Workshop – Rivers

June 24 – 25, 2019
Columbia River Fish and Wildlife Conservation Office
Vancouver, WA

Workshop Goals

- Identify significant resources (e.g., processes, landscapes, habitat components, and species) in specific areas within the study area that are of special value to workshop participants
- Discuss how modifications to existing conditions related to water quality and quantity could potentially impact significant resources
- Compile a list of potential actions to conserve, protect, and enhance significant resources
- Obtain valuable data (e.g., from white papers, grey literature, technical reports, survey assessments) to fill existing information gaps

AGENDA

Monday, June 24, 2019

Introduction to the USFWS CRSO FWCA		
9:00 am	**Welcome and introductions**	Lee Corum
9:10 am	**Introduction to the Columbia River Systems Operation (CRSO)** National Environmental Policy Act (NEPA) context General scope of proposed action, alternatives, and operations USFWS CRSO mission Team structure and organization Workshop goals and expectations	Lee Corum Mark Bagdovitz Lee Corum
10:00 am	**Fish and Wildlife Coordination Act (FWCA)** Purpose and goals Approach to USFWS CRSO FWCA Report	Molly Good
10:15 am	**Geographic Scope** Study area Rivers versus lakes/reservoirs	Michael Carlson
10:30 am	**BREAK**	

Orientation to Rivers		
10:45 am	**"What WE know so far…"** Characterization of priority landscape Significant resources Use of landscape and habitat components Critical processes or features	Mike Hudson

Exercise I		
11:00 am	**"What are rivers, to YOU?"** Discussion: *Given your knowledge of riverine landscape structure and function, please identify different classes or types of riverine habitat likely to exist within the study area.*	Facilitator
12:00 pm	**LUNCH**	

Exercise II		
1:00 pm	**"Where do we prioritize?** Discussion: *Given your previous response, please identify high priority sites with riverine habitat in the study area, and explain why they are of interest or value to your agency.*	Facilitator

Exercise III		
2:00 pm	**"What must we maintain?"** Discussion: *In these high priority sites, what are the unique processes, landscape features, or time periods (e.g., growing season) necessary to maintain existing conditions that support significant resources?*	Facilitator
3:00 pm	**BREAK**	

Exercise IV		
3:10 pm	**"How could it all change?"** Discussion: *Considering how current dam operations occur, how will changes involving higher or lower water flows affect these high priority sites?*	Facilitator
4:50 pm	**Announcements**	Lee Corum
5:00 pm	**Adjourn for the day**	

Tuesday, June 25, 2019

Exercise IV, continued		
9:00 am	**Summary of prior sessions and next steps**	Facilitator
9:10 am	**Discussion, continued**	Facilitator

Exercise V		
10:20 am	**BREAK**	
10:30 am	**"What can we do?"** Discussion: *In light of your previous answers, please identify TEN measureable and achievable actions to conserve, protect, and enhance the sites you identified and significant resources you discussed.*	Facilitator

11:50 am	**Announcements**	Lee Corum
12:00 pm	**Adjourn the workshop**	

Reminder

If you have access to, or are aware of, data that is related to the geographic areas or significant resources we discussed during this workshop, then please contact Lee Corum at lee_corum@fws.gov or (360) 753-5835.

Upcoming Workshops

Date	Workshop	Location
June 25 – 26	Lakes/Reservoirs	Columbia River Fish and Wildlife Conservation Office, Vancouver, Washington

D.5 AGENDA FOR LAKES AND RESERVOIRS TECHNICAL WORKSHOP

USFWS CRSO FWCA Workshop – Lakes/Reservoirs

June 25 – 26, 2019
Columbia River Fish and Wildlife Conservation Office
Vancouver, WA

Workshop Goals

- Identify significant resources (e.g., processes, landscapes, habitat components, and species) in specific areas within the study area that are of special value to workshop participants
- Discuss how modifications to existing conditions related to water quality and quantity could potentially impact significant resources
- Compile a list of potential actions to conserve, protect, and enhance significant resources
- Obtain valuable data (e.g., from white papers, grey literature, technical reports, survey assessments) to fill existing information gaps

AGENDA

Tuesday, June 25, 2019

Introduction to the USFWS CRSO FWCA		
1:00 pm	**Welcome and introductions**	Lee Corum
1:10 pm	**Introduction to the Columbia River Systems Operation (CRSO)** National Environmental Policy Act (NEPA) context General scope of proposed action, alternatives, and operations USFWS CRSO mission Team structure and organization Workshop goals and expectations	Lee Corum Mark Bagdovitz Lee Corum
2:00 pm	**Fish and Wildlife Coordination Act (FWCA)** Purpose and goals Approach to USFWS CRSO FWCA Report	Molly Good
2:15 pm	**Geographic Scope** Study area Lakes/reservoirs versus rivers	Michael Carlson
2:30 pm	**BREAK**	

Orientation to Lakes/Reservoirs		
2:45 pm	**"What WE know so far…"** Characterization of priority landscape Significant resources Use of landscape and habitat components Critical processes or features	Katie Powell

Exercise I		
3:00 pm	**"What are lakes/reservoirs, to YOU?"** Discussion: *Given your knowledge of lake/reservoir landscape structure and function, please identify different classes or types of lake/reservoir habitat likely to exist within the study area.*	Facilitator

Exercise II		
3:30 pm	**"Where do we prioritize?** Discussion: *Given your previous response, please identify high priority sites with lake/reservoir habitat in the study area, and explain why they are of interest or value to your agency.*	Facilitator
4:50 pm	**Announcements**	Lee Corum
5:00 pm	**Adjourn for the day**	

Wednesday, June 26, 2019

Exercise III		
9:00 am	**Summary of morning session and next steps**	Lee Corum
9:10 am	**"What must we maintain?"** Discussion: *In these high priority sites, what are the unique processes, landscape features, or time periods (e.g., growing season) necessary to maintain existing conditions that support significant resources?*	Facilitator
10:20 am	**BREAK**	

Exercise IV		
10:30 am	**"How could it all change?"** Discussion: *Considering how current dam operations occur, how will changes involving higher or lower water flows affect these high priority sites?*	Facilitator
12:00 pm	**LUNCH**	
1:00 pm	**Discussion, continued**	Facilitator
3:20 pm	**BREAK**	

Exercise V		
3:30 pm	**"What can we do?"** Discussion: *In light of your previous answers, please identify TEN measureable and achievable actions to conserve, protect, and enhance the sites you identified and significant resources you discussed.*	Facilitator
4:50 pm	**Announcements**	Lee Corum
5:00 pm	**Adjourn the workshop**	

Reminder

If you have access to, or are aware of, data that is related to the geographic areas or significant resources we discussed during this workshop, then please contact Lee Corum at lee_corum@fws.gov or (360) 753-5835.

E APPENDIX E: DATA SOURCES

The Service used the following data sources to conduct quantitative and qualitative assessments of the suite of potential CRSO impacts on fish and wildlife resources for this report.

E.1 WATER HYDROLOGY AND HYDRAULICS MODELS

The Service referred to outputs from the co-lead agencies H&H modeling efforts to conduct the analysis (USACE et al. 2020). The Service focused on reviewing summary hydrographs for each alternative (Section 1.2.1) to compare discharge over time at various locations, in identified reaches, in the study area (USACE et al. 2020, p. B-1-4).

The Service relied on the co-lead agencies' to conduct H&H modeling analyses and share results. Service staff and modelers communicated regularly through conference calls and webinars to acquire and better understand modeling outputs. The co-lead agencies provided outputs from H&H modeling, which is a combination of two hydro regulation models or software, Hydro System Simulator (HydSim) and the Hydrologic Engineering Center Reservoir System Simulation (HEC-ResSim) (USACE et al. 2020). The Service converted the outputs and associated AEP to GIS- (Geographic Information System-) format to better visualize summary hydrographs for each alternative for multiple AEPs. The modeling outputs included information specific to each of the Federal dams that comprise the CRS, each dam reservoir and dam outflow, and a small number of intermediate points between dams. The modeling outputs also had summary information displayed in chart format. Summary categories are defined in the following list:

- **Peak discharge frequency analysis, performed for each of three time-windows: annual (October 1 to September 30), spring (April 1 to July 31), and winter (November 1 to March 31).** This is the probability of maximum daily mean discharge exceedance within each time window, based on 5,000 simulated years. That is, for any given value of discharge in the model output list or summary chart, the corresponding probability is the chance that, in any given year, the maximum daily discharge for that time window will equal or exceed this given discharge.
- **Discharge duration analysis, performed for time windows representing each calendar month and for the entire year**. The word "duration" means average proportion of time during which a given discharge is exceeded.
- **Frequency of floods or droughts, number of floods above a threshold flow or water level, by month**. This is the number of 7-day low flow events above and below a threshold flow or water level, by month. For "threshold," one could use the 75th percentile for maximum or peak flows and the 25th percentile for low flow events.
- **Duration of floods or droughts, mean duration (i.e., total days between beginning and end) of flow events, by month and for the year (annual).** This is defined as high flow events (flood conditions) above a threshold and 7-day low flow events (drought conditions) below a threshold.

- **Rate of change of flow or water level, mean difference between daily values of flow or water level during the rising water leading up to a peak flow and mean difference between daily values of flow or water level during the receding water after a peak flow.** This mean could be an average of all the flood events above a threshold value of flow or water level, such as the 75th percentile. Mean differences between high and low flow or water levels during 3-day periods could also be due to changes in spill or power generation during otherwise stable hydrological conditions.

E.2 GIS DATA

The Service also used GIS data related to vegetative cover, landscapes and habitats, and species occurrences throughout the study area. The Service collected and mapped GIS data from readily accessible natural resources databases and coordinated with the co-lead agencies to request additional GIS data, as needed.

E.2.1 Vegetation Type and Cover

The Service characterized and classified various habitats and subhabitats throughout the study area using data primarily from NWI and LANDFIRE (Cowardin et al. 1979, pp. 4-5; LANDFIRE 2016; USFWS 2019a, p. 8, 2019d).

The Service used the 0.5 mile (0.8 km) buffer to combine NWI and LANDFIRE datasets. The Service used the NWI data as a base layer and, for areas not covered by the NWI, the Service added LANDFIRE data to illustrate wetland and riparian habitats. The Service also conducted qualitative assessments of habitats at specific sites in the study area to focus the analysis on impacts of proposed alternatives.

For areas outside of the NWI data and within the 0.5 mile (0.8 km) buffer, the Service used LANDFIRE data. Other GIS datasets were considered for this analysis, such as the Northwest Habitat Institute (NWHI) dataset and National Land Cover Dataset (NLCD) (MRLC n.d.). The scale and resolution of these datasets were either coarser (NLCD has 30-m [98-ft] resolution) or more generally characterized (NWHI habitat categories, for instance, were considered too generalized for the analysis). For all data sources, mapped features may have changed since the date of the layers and are, at best, an approximation of habitats present in the study area and described in this report.

E.2.2 National Wetlands Inventory

The NWI is a useful tool for determining the location, type, and size of wetlands and deep-water habitats (Cowardin et al. 1979, p. 4). NWI is prepared from analysis of high-altitude imagery based on vegetation, visible hydrology, and geography. In 2006, the NWI added the riparian data layer for mapping purposes based on the development of a new system for mapping riparian areas. The Service described a new system and updated the document in

2009 and 2019 (USFWS 2019a, pp. 7-8). Beyond the system level, the codes become more detailed and specialized for each habitat.

E.2.3 Landscape Fire and Resource Management Planning Tools Database

LANDFIRE was originally developed to support wildland fire management. LANDFIRE uses predictive landscape models from field satellite imagery, biophysical gradient layers, reference data, and classification and regression trees to create existing vegetation type (EVT) layers. The LANDFIRE vegetation layers describe the vegetation type, canopy cover, and height, and the database catalogs these differences into detailed habitat categories. The EVT data layer also corresponds to the terrestrial ecological systems classification created by NatureServe (n.d.). Additional descriptions of the data, including the data themselves, plus descriptions of EVT are available (LANDFIRE 2016).

E.2.4 Species Occurrence Data

Species occurrence GIS data is a foundation of the Service's analysis and was gathered through many sources. The co-lead and cooperating agencies supplied much of the data used by the Service through the coordination process, as previously described. Additionally, the Service documented critical information from technical experts and other participants during the technical workshop period. Much of the species occurrence data originated from State Natural Heritage Programs or surrogate datasets, such as the Washington Department of Fish and Wildlife's Priority Habitats and Species and Wildlife Survey Data Management System.

For the analysis, the Service used other data such as the Butterflies and Moths of North America citizen science project, the Cornell Lab of Ornithology Birds of North America online database, Forest Inventory Analysis data from U.S. Department of Agriculture Forest Service, and the Xerces Society for Invertebrate Conservation (Lotts and Naberhaus 2017; Rodewald 2015; USFS 2019; Xerces Society 2019).

The Service also referred to species occurrence data from eBird, which is managed by the Cornell Lab of Ornithology. eBird is a community science-driven tool that collects, stores, and manages millions of bird records collected by birders worldwide (Sullivan et al. 2009). While there is bias in the collected and compiled data toward observation locations that are easily accessible and frequently visited, models have been developed that correct for that bias and have since described habitat associations, densities and abundances, and population trends for many species since the mid-2000s (Johnston et al. 2019, pp. 1-2).

F APPENDIX F: DETAILED DESCRIPTION OF LANDSCAPES AND EVALUATION SPECIES AND STATUSES

This appendix includes detailed descriptions, organized by landscape, of habitats and evaluation species the Service analyzed in the CAR.

F.1 RIVERS

F.1.1 Landscape, Habitats, and Subhabitats

This landscape includes river, estuary, and nearshore marine habitats, which are often characterized by streams and tributaries, edges of rivers and sloughs, and temporary impoundments. For this report, reference to common river subhabitats in the Basin includes river banks and shorelines, side channels, transition areas, and unimpounded reaches (Table F1).

Within the regulated CRSO, river subhabitats are representative of the historic free-flowing riverine environment, of which only remnants exist in the study area. These subhabitats maintain ecological and physical processes and hydrologic function that the reservoir environment cannot provide, and they support various life history stages of aquatic species.

Table F1. The rivers landscape, characterized by its habitats and subhabitats in the study area

Habitats	Subhabitats	Description
River	Mainstem	Primary downstream segment of a river
	Banks and shorelines	Terrain along the bed of a river or the perimeter of reservoirs, where water meets land
	Floodplain	Area adjacent to stream channel, formed by periodic inundation and deposition of suspended sediment
	Side channels	Off-channel areas characterized by flowing water with identifiable upstream and downstream connections to the main channel; often define the boundaries of islands
	Transition areas (e.g., tailwater-to-reservoir)	Areas defined by flowing water that are variable in size; specific to run-of-river reservoirs, areas between the outflow of a dam and the pool formed by the next dam downstream
	Tributary	A stream that flows into a larger stream, mainstem, or lake

Habitats	Subhabitats	Description
	Tributary mouths (i.e., confluence zones)	Confluence where a stream flows into a larger body of water, often characterized by a delta where deposition of sediment from a smaller incoming stream occurs
	Unimpounded reaches	Free-flowing stretch of river not affected by downstream dams
Estuary		Transition zone of river and marine environments
Nearshore marine environment		Waters outside the mouth of the river (e.g., Columbia River) that are still influenced by riverine processes and dynamics

F.1.1.1 Rivers

In rivers and other lotic (i.e., fast-moving) environments, water flows at a relatively rapid rate compared that of lentic environments such as ponds, lakes, and reservoirs. The velocity of a river depends on many factors including channel shape, gradient, volume of discharge, and friction with riverbed (Ames 2018). Flow regimes, landscape geology, and longitudinal slope are other important variables, and they operate dynamically at both the watershed and reach-scale (Imhof et al. 1996, pp. 313-315).

Free-flowing river reaches represent portions of the river not strongly influenced by the Federal project operations. Due to the extensive system of dams in the Basin, remaining free-flowing reaches are critically important for native fish and wildlife resources. Notable free-flowing reaches in the study area include the Columbia River downstream of Bonneville Dam, the Hanford Reach downstream of Priest Rapids Dam, the Pend Oreille River between Albeni Falls Dam and Box Canyon Reservoir, the Flathead River downstream of Hungry Horse Dam, the Clearwater River, and the Kootenai River between Libby Dam and Bonners Ferry, Idaho.

Even free-flowing reaches experience some effects of altered hydrology from project operations, and these alterations can negatively impact floodplain connectivity, river morphology, and sediment transport capacity (Hadley, H., in litt. 2019).

For the Service's analysis, the eight major Federal reservoirs on the Lower Columbia River and the Lower Snake River were considered as part of the rivers landscape because these projects operate as run-of-river. Thus, while the reservoirs are impounded, there is flow through the reservoirs that varies in velocity depending on operations and location in the reservoir. The Service excluded related structures, such as canals and sloughs, from the analysis.

F.1.1.2 Estuaries

Estuaries are transition zones that separate one or more rivers from the nearshore marine environment. These areas are tidally influenced and are often characterized by brackish, slower-moving water. The Service's analysis of impacts on estuary habitat was limited to the Lower Columbia River below the confluence with the Cowlitz River. This area provides for an abundance of waterfowl in the winter and some breeding waterfowl populations (e.g., mallard and Canada geese [*Branta* Canadensis]) in the summer. Water levels in the Columbia River are influenced by tides upstream to Bonneville Dam.

F.1.1.3 Nearshore Marine

The nearshore marine environment includes waters beyond the mouth of the river, but still influenced by the river, and features ranging from submerged, high-relief, rocky reefs to broad expanses of intertidal mudflats, soft muddy bottoms, and broad expanses of sandy beaches interspersed with rocky headlands (Oregon Conservation Strategy 2016a). Environmental conditions in adjacent estuarine, terrestrial, and freshwater habitats greatly influence the nearshore ocean ecology.

F.1.2 Evaluation Species

F.1.2.1 Pacific Lamprey (E. tridentatus)

Pacific lamprey are a Service trust species and are important to the agency's Federal, State, and Tribal partners. Though Pacific lamprey is not currently listed under the Act, the Service has implemented conservation actions under a conservation agreement to achieve long-term persistence of Pacific lamprey and support traditional Tribal cultural use of Pacific lamprey throughout their historic range in the Basin and beyond (USFWS 2012, p. 1).

Pacific lamprey are anadromous (i.e., migrate to the ocean as juveniles and return to freshwater as adults to spawn), and they are native to the Pacific Coast of North America and northern Asia, including the Basin. In the study area, Pacific lamprey use different parts of the rivers landscape and some estuary and nearshore marine environment habitat to complete all life history stages (i.e., summarized in Clemens et al. 2010, pp. 582-585 and Kostow 2002, p. 8). For instance, larval and juvenile lamprey migrate downstream from natal tributaries, through the Columbia River Estuary, and out to the nearshore marine environment of the Pacific Ocean to feed and mature. Additionally, adult Pacific lamprey use river habitat, including side channel subhabitat, as important migratory corridors when they leave the nearshore marine environment and return to tributaries in which they spawn.

Generally, Pacific lamprey ammocoetes (i.e., lamprey in larval stage of development) remain in tributaries for 4 to 6 years and then undergo metamorphosis (Close et al. 2002, p. 20). Ammocoetes are known to use slow depositional areas along streambanks and burrow into fine sediments mixed with organic matter and detritus during important rearing periods (Graham and Brun 2005, p. 11; Lee et al. 1980, p. 34; Pletcher 1963, p. 54; Torgerson and Close 2004, p. 622). Ammocoetes have been observed residing in sediments up to 16 m deep in the mainstem Columbia and Willamette Rivers (Jolley et al. 2010, p. 20; Jolley et al. 2011, p. 12). When ammocoetes transform to macrophthalmia (i.e., lamprey juvenile stage of development), they move from slower-moving waters with fine substrate to faster-moving waters with silt covered gravel. From there, after they have fully metamorphosed, Pacific lamprey move into even faster-moving rivers with gravel or boulder substrate (Beamish 1980, p. 1914; Potter 1980, p. 1650; Richards and Beamish 1981, p. 74).

Historically, the only real measure of adult lamprey abundance in the Basin was based on visual counts at the fishways at dams (Moser and Close 2003, p. 116). As a result, Pacific lamprey have been observed throughout the Basin, from the mouth of the Columbia River upstream to the headwaters of the mainstem Columbia River in Canada, to Shoshone Falls in the Snake River, and in the tributaries of each of these rivers (USFWS 1999, p. M5-20; Ward et al. 2012, p. 352). Currently, Pacific lamprey populations are located in most major tributaries and some smaller tributaries in the Columbia River up to Chief Joseph Dam and, in the Snake River, up to Hells Canyon Dam (Luzier et al. 2011, pp. 118, 136, 154, 172).

Pacific lamprey, like Pacific salmon, face considerable threats in the Basin (e.g., reduced access to high quality habitat, degradation of spawning and rearing areas, loss of emigrating juveniles to turbine entrainment, predation by non-native predators, pollution) (Moser and Close 2003, p. 116). Continued operations and maintenance, and changes in overall configuration of the CRSO, will likely negatively impact the rivers landscape that supports the Pacific lamprey and all of its life history stages. Potential negative impacts reflect various threats including: barriers to effective passage, dewatering and streamflow management, channel maintenance activities, and predation (Close et al. 1995, pp. 4, 8, 18; Dauble et al. 2006, p. 170; Devine Tarbell and Associates 2006, p. 16; King et al. 2008, p. 29; Luzier et al. 2011, pp. 22, 24, 117, 137; Moser et al. 2002, p. 51; Moursund et al. 2001, p. 4.1; Moyle 2002, p. 97).

F.1.2.2 Western Pearlshell Mussel (M. falcata)

The Western pearlshell mussel is not listed under the Act, however it is monitored by the Pacific Northwest Freshwater Mussel Workgroup, of which the Service and State and Tribal partners are members.

Western pearlshell mussel are able to complete all of their life history stages in clear, cold water throughout the study area (Jepsen et al. 2012, p. 7). They are normally located at depths between 1.5 ft and 5.0 ft (46 cm and 1.8 m), and they tend to congregate in aquatic habitats with a specific substrate type such as gravel and boulders, with some sand, silt, and clay (Stone et al. 2004, p. 341). Like other freshwater mussels, Western pearlshell require river habitats with slower-moving water and low shear stress (Howard and Cuffey 2003, p. 73; Stone et al. 2004; p. 341; Vannote and Minshall 1982, p. 4104;). They can inhabit headwater streams but are more commonly found in larger rivers (Nedeau et al. 2009, p. 33).

Freshwater mussels, including Western pearlshell, require certain host fishes to reproduce and disperse. The majority of documented and potential host fishes for this mussel include salmon (e.g., Chinook salmon [*O. tshawytscha*], Coho salmon [*O. kisutch*], kokanee [*O. nerka*]), trout (the migratory form of rainbow trout or steelhead [*O. mykiss*], Columbia River redband trout, cutthroat trout [*O. clarkia*], bull trout), and other fishes (e.g., three-spined stickleback [*Gasterosteus aculeatus*]) (Frest and Johannes 1997, p. 127; Nedeau et al. 2009, p. 33). Thus, any potential negative impacts on habitats and processes that support these host fishes also adversely affect the Western pearlshell and other freshwater mussels. The average lifespan for the Western pearlshell mussel is approximately 60 years or 70 years, with some individuals living more than 100 years, making this one of the longest-lived animal species (Nedeau et al. 2009, p. 33).

Historically, Western pearlshell mussels were distributed in the Basin from the mouth of the Columbia River upstream to the headwaters in the Columbia and Snake Rivers, and in the tributaries of each of these rivers (Jepsen et al. 2012, p. 7). Western pearlshell mussels have since become extirpated throughout much of the mainstem Columbia and Snake Rivers in Oregon and Washington (Nedeau et al. 2009, p. 35). Currently, they occupy river habitats in low numbers in the Hanford Reach of the Columbia River and the Hells Canyon Reach of the Snake River (Helmstetler and Cowles 2008, p. 212; Montana Field Guide 2019). Their distribution has been further constrained by continued dam operations and maintenance and poor water quality as a result of activities implemented for the conservation of other aquatic species.

F.1.2.3 White Sturgeon (A. transmontanus)

White sturgeon is a large river species that once thrived throughout the study area (Figure F1) (USFWS 1999, p. M4-8). The most robust population of white sturgeon is found downstream of Bonneville Dam, where the Lower Columbia River, Columbia River Estuary, and nearshore marine environment habitat provide critical resources for juvenile and adult white sturgeon that are unavailable elsewhere in the Basin (Beamesderfer and Anders 2013, p. 57).

In the Basin, white sturgeon generally spawn in the spring when water temperatures are between 10 °C and 18 °C (50 °F and 64 °F), and there is high turbidity (Hanson et al. 1992, p. 14; Parsley et al. 1993, p. 220; Perrin et al. 2003, p. 154). White sturgeon are broadcast spawners and release eggs and milt into the river over gravel, cobble, and boulder substrate for fertilization purposes (Parsley et al. 1993, pp. 223-224). Average spawning depths can exceed

19 ft (5.8 m) and water velocities near the bottom of the water column average approximately 4.6 feet per second (1.4 meters per second) (Parsley et al. 1993, p. 220).

Currently, CRS operations reduce or eliminate connectivity among populations and decrease or eliminate processes and habitats necessary to support all life history stages of white sturgeon (Beamesderfer and Anders 2013, pp. 76-77). As proposed, changes in the operations and maintenance of the CRSO will likely continue to negatively impact both juvenile and adult white sturgeon.

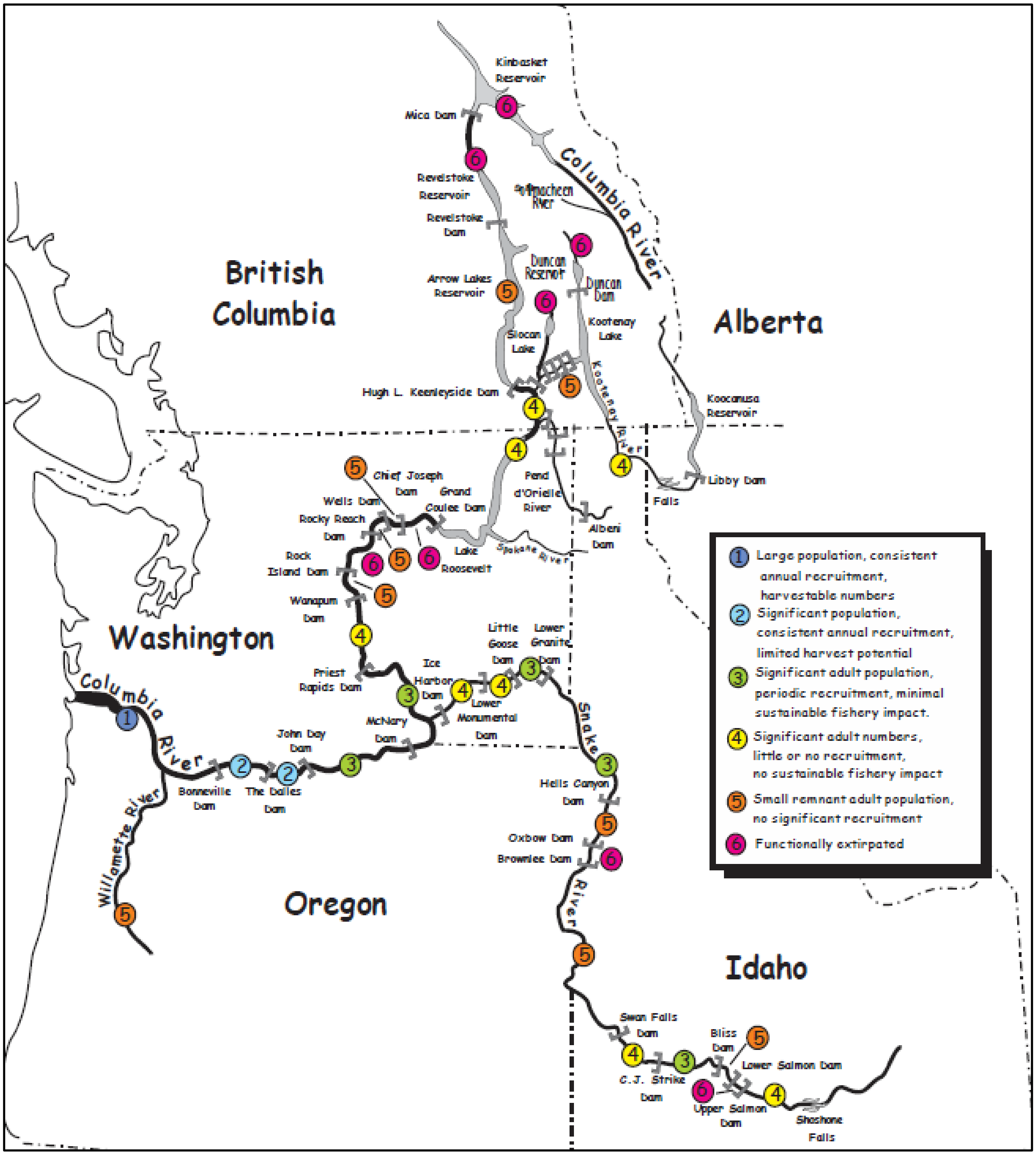

Figure F1. Distribution of white sturgeon subpopulations in the Columbia and Snake Rivers

Source: Beamesderfer and Anders 2013, p. 58

F.2 LAKES AND RESERVOIRS

F.2.1 Landscape and Habitats

Lakes are naturally occurring low points in the landscape that are characterized by lentic water, predominantly in the form of year-round, open water habitat. Groundwater or surface water may constitute the inflow, outflow, or both. In contrast to rivers and tributaries, natural lakes and reservoirs store more water and usually have less flow. Reservoirs are man-made impoundments rather than natural lakes.

F.2.1.1 Natural Lakes

There are two prominent natural lakes in the study area, Lake Pend Oreille in northern Idaho and Flathead Lake in northwest Montana. While both are large and deep, they have been subject to changing water levels and impacts (e.g., bank erosion) as a result of operations and maintenance of CRS projects that regulate their outflow. For example, Albeni Falls Dam controls the outflow of Lake Pend Oreille. The Confederated Salish and Kootenai Tribes' Seli'š Ksanka Qlispe' Dam regulates the outlet of Flathead Lake, but this non-Federal project is outside the scope of this CAR.

F.2.1.2 Reservoirs

Reservoirs or man-made impoundments are prevalent in the Basin. In comparison to rivers, reservoirs typically store large volumes of water, have large operating ranges (hydraulic heads) and long water retention times (hydraulic residence). Reservoirs are formed as a result of the damming of a river and conversion of lotic to lentic environments. Reservoirs may flood and convert back to lentic environments if they were once adjacent to the river. In some cases, reservoirs have flooded natural lakes (e.g., Lake Pend Oreille) that were once a part of the mainstem river system. Reservoirs tend to have a larger catchment to surface area ratio and, thus, they have greater retention of runoff and snowmelt than natural lakes. In the Basin, reservoir water surface elevation levels and flow depend on inflow and dam operations, and water temperatures are influenced by factors including depth of water that is released from dams.

Dams create reservoirs, and the size and shape of the reservoir can vary considerably depending on inflow and project operations. Thus, there may be overlap in habitats and features of rivers, natural lakes, and reservoirs in this report. Table F2 includes the natural lakes and reservoirs landscape considered in the Service's analysis of impacts.

Table F2. The lakes and reservoirs landscape, characterized by its habitats in the study area

Habitats	Description
Natural lakes	Large areas filled with freshwater, usually localized in a basin, surrounded by land and separated from other water
Reservoirs	Artificial or man-made freshwater lakes that store and supply water for naturally occurring waterbodies

There are two types of reservoirs in the CRS, storage (Table F3) and run-of-river reservoirs (Table F4) (BPA et al. 2001, pp. 9-13; USACE et al. 2020, 1-27-30). Storage reservoirs hold water and reshape river flow to meet project purposes including local and system-wide FRM, power generation, irrigation, navigation, and recreation.

Table F3. Major Federal storage reservoirs in the Basin

Storage Reservoirs and Lakes	Federal Project
Lake Koocanusa	Libby
Hungry Horse Reservoir	Hungry Horse
Lake Pend Oreille	Albeni Falls
Lake Roosevelt	Grand Coulee
Dworshak Reservoir	Dworshak

Table F4. Major Federal run-of-river reservoirs in the Basin

Run-of-River Reservoirs and Lakes	Federal Project
Rufus Woods Lake	Chief Joseph
Lower Granite Lake	Lower Granite
Lake Bryan	Little Goose
Lower Monumental Reservoir or Pool (Lake Herbert G. West)	Lower Monumental
Lake Sacajawea	Ice Harbor
Lake Wallula	McNary
John Day Reservoir or Pool (Lake Umatilla)	John Day
Lake Celilo	The Dalles
Lake Bonneville	Bonneville

Run-of-river reservoirs have relatively limited storage capacity and allow water to pass dams at approximately the same rate as inflow. Most run-of-river reservoirs, and those storage reservoirs with limited storage ability that function as run-of-river reservoirs (e.g., John Day Reservoir or Pool [Lake Umatilla]), were not addressed in the Service's analysis as part of the lakes and reservoirs landscape. Rather, they were considered as part of the rivers landscape.

Rivers, lakes, and reservoirs share some characteristics. At low water levels, extensive areas may be exposed that are normally underwater at higher water levels. Islands and exposed barren lands share similar issues within the Basin system as a result of the CRSO, and they are considered separate from the water bodies in which they occur in this report (Section 5.6).

F.2.2 Evaluation Species

F.2.2.1 Clark's Grebe (A. clarkia) and Western Grebe (A. occidentalis)

Clark's and Western grebes (grebes) are protected under the Migratory Bird Treaty Act (MBTA), a statute enforced by the Service (16 U.S.C. §§ 703-712 [1918]). Under this authority, it is "illegal to take, possess, import, export, transport, sell, purchase, barter, or offer for sale, purchase, barter, any migratory bird, or the parts, nests, or eggs of such a bird except under the terms of a valid Federal permit." In particular, the Western grebe is also a focal species of the Service as a Bird of Conservation Concern (BCC). As part of the BCC list, the Western grebe represents one of the Service's highest conservation priorities regarding migratory and non-migratory bird species (USFWS 2015a).

Historically, grebes were considered to be the same species, though they exhibit subtle differences (LaPorte et al. 2013). Both species are ubiquitous throughout the Basin, however Western grebes are more frequently detected and found in higher numbers compared to Clark's grebes (LaPorte et al. 2013; Sauer et al. 2017). Grebes are almost exclusively dependent upon water for their life history stages. Grebes construct floating nests on emergent and submergent vegetation located in nearshore of natural lakes or lake-like habitats (i.e., reservoirs) or near the water's surface. Grebes also use the open water to forage for, and consume, a variety of fish, which comprise 80 percent of their diet, along with other aquatic species (Riensche et al. 2009, pp. 8-9).

Grebe nesting occurs from April through July, and its success is critically dependent upon the availability of stable water, with a depth of roughly 12 inches (30 cm), in lake and reservoirs habitats with persistent emergent vegetation (Feerer and Garrett 1977, p. 87). Fluctuations in water surface elevation, especially during the nesting season, isolate individuals from their nests and young (La Porte et al. 2013).

In the Basin, the grebe nesting season coincides with the boating and water recreation season and, as a result, disturbance due to sound, wave action, and increased crowds poses threats to the survival and reproductive success of grebes that inhabit the same areas. This disturbance could, and often does, result in the destruction of fragile-floating nest colonies, general disruptions during breeding periods when the birds are flightless and resting on the water, and mortality among new chicks (Ivey and Herziger 2006, p. 22). Grebes may still be at high risk, due to disturbance, in post-breeding areas where they come together in large groups, often with young that are too little to escape on their own successfully (LaPorte et al. 2013).

Systematic surveys of grebe breeding and reproductive success have not been conducted in the Basin, but the available data suggest potential declines in both species (WDFW 2013, pp. 189-190). Data from the U.S. Geological Survey's North American Breeding Bird Survey data suggest declines in the numbers of grebes in Washington, although declines are not statistically reliable due to limited sample sizes (Sauer et al. 2017). Trends in grebe population abundance in Oregon and the western North American survey area, which have been observed from larger sample sizes, also show sizable declines (yet some recent stability) in population abundance since about 1990 as a result of pesticides, habitat destruction, and human disturbance (Sauer et al. 2017; WDFW 2013, p. 191).

F.2.2.2 Dunlin (C. alpina)

Dunlin are protected under the MBTA, and they are a Service focal species as a Bird of Management Concern (BMC). In contrast to grebes and other birds, dunlin are tundra-breeding shorebirds and typically nest in or along bays, estuaries, and coastlines. During the nonbreeding season in winter months, dunlin are the most widespread of the North American shorebirds, and they are abundant in most coastal areas. In other seasons, they prefer mudflats, but can also be observed on sandy beaches and coastal grasslands (Warnock and Gill 1996).

Dunlin flocks are often impressive in number as they display coordinated aerial maneuvers to escape predation by small falcons such as kestrels (*Falco sparverius*) and merlins (*F. columbarius*). When foraging, which they do on their own, they rummage through exposed mud or in shallow water, either probing in the mud for food or picking from the water's surface. On their breeding grounds, dunlin primarily feast on insects and insect larvae and, in coastal habitats, they eat small crustaceans, marine worms, mollusks, and small fishes. In both environments, dunlin are limited in forage hours, dependent significantly on tidal fluctuation.

The total dunlin population that migrates in and out of, and winters in, the Basin is estimated to include approximately 550,000 individuals (Andres et al. 2012, p. 187). Though dunlin are commonly observed shorebirds throughout the study area, their abundance has declined in the Pacific Northwest throughout recent decades (Andres et al. 2012, pp. 187-188, 189-190; Warnock and Gill 1996). There has been little habitat destruction or disturbance on their breeding grounds, but various activities (e.g., recreation, navigation, infrastructure and associated changes in water levels) continue to threaten dunlin's migratory habitat and overwintering areas in the study area (i.e., mudflats, sandy beaches, rocky shores) and breeding areas that are outside of the study area (i.e., wet tundra, low ridges). No reliable information about dunlin population abundance or trends exists within their range or this study area. However, dunlin remain key indicators for assessing the health of and status of natural lake habitats and some river habitats (i.e., estuary and nearshore marine environment) in the Pacific Northwest (Warnock and Gill 1996).

F.2.2.3 Floaters (Anodonta spp.)

Floaters are freshwater mussels and habitat generalists, yet grow best in stable, nutrient-rich water bodies such as lakes and reservoirs (Nedeau et al. 2009, p. 19-22). Of all freshwater mussels located throughout the study area, *Anodonta* spp. are most tolerant of lower oxygen, lentic or lake-like conditions and, thus, are most commonly located in natural lakes, reservoirs, and in downstream, low-gradient reaches of rivers in depositional habitats. Floaters are short-lived, fast growing mussels that rely on hosts to complete their life history stages. While some freshwater mussels require use of specific host fishes, floaters are not highly host-specific, meaning they can likely use native fish like Westslope cutthroat trout, sculpin, stickleback, or others as hosts (Nedeau et al. 2009, p. 22).

In western North America, floaters are widely distributed from southern California to Canada. Most species are located west of the Continental Divide: winged floater (*A. nuttalliana*), Oregon floater (*A. oregonensis*), Yukon floater (*A. beringiana*), California floater (*A. californiensis*), and the Western floater (*A. kennerlyi*). All of these floaters, except for the Yukon floater, exist throughout the study area (Nedeau et al. 2009, pp. 17, 23-28). Other freshwater mussels, like the Western pearlshell and the Western ridged mussel (*Gonidea angulate*) also occur in the study area (Nedeau et al. 2009, pp. 33, 38). Most species are not located in high elevation waters in the Rockies or Cascades and, thus, are more commonly found in watersheds at lower elevations (Nedeau et al. 2009, p. 20).

In general, floaters have declined in abundance, and continue to decline, in many parts of western North America. Floater populations have become extirpated from many historic sites, especially in Arizona, California, Oregon, Utah, and Washington (Nedeau et al. 2009, pp. 23-25). In the study area, the main threats to floater reproduction and survival include changes in water level, water diversion for irrigation, water supply, and power generation (Nedeau et al. 2009, p. 22). Though floaters can tolerate reservoir-like conditions, many reservoirs experience severe annual, and often daily, monthly, or even hourly, water level fluctuations that negatively impact freshwater mussel abundance in several areas. For example, a 1992 study of a quick drawdown of the Lower Granite Reservoir, revealed one mass floater mortality event, which included California and Western floaters and Western ridged mussels (Nedeau et al. 2009, p. 23).

Reservoir drawdowns similar to the one that occurred in 1992 can lead to dry periods, which expose freshwater mussels to barren lands, causing them to dry out or desiccate and overheat. During these dry periods, floaters and other aquatic resources can become extremely susceptible to predators like raccoons, muskrats, and other scavengers. Additionally, due to their thin and fragile shells, floaters are vulnerable to damage resulting from erosion and pollution (Nedeau et al. 2009, p. 21).

F.2.3 Other Guilds and Communities

F.2.3.1 Colonial Nesting Waterbirds

The lakes and reservoirs landscape supports many waterbird species including terns, gulls, herons, egrets, and cormorants throughout the study area.

The Pacific Flyway (i.e., major flyway for migratory birds) breeding population of Caspian tern, for example, has shown a decline in the numbers of breeding pairs, from approximately 18,872 pairs in 2009 to a minimum census estimate of 10,580 pairs in 2018 (Peterson et al. 2017a, p. 8; Peck-Richardson et al. 2019, p. 1). Two management plans have been implemented to minimize predation on juvenile Pacific salmon by reducing available nesting habitat and therefore the size of breeding colonies in the Columbia River Estuary and in the Columbia River Plateau Region (USACE 2014a; 2015). In 2020, the second largest Caspian tern colony site will likely experience severe removal of nesting habitat due to human health and safety concerns (Lawrence, M., in litt. 2019). If so, an additional 1,100 breeding pairs will be left, searching and competing for limited nesting locations throughout the Pacific Flyway, effectively reducing the size of this breeding population if the terns do not relocate.

The latest version of a Caspian tern population model was developed to predict population trajectories under multiple scenarios of varying management and environmental breeding conditions (Suzuki et al. 2018, p. 1). The model population trajectories indicate resiliency of the Pacific Flyway population of Caspian terns under most of the analyzed management scenarios, including the scenario that reduces available nesting habitat in the Columbia River Plateau Region (Suzuki et al. 2018, p. 5). Long-term population declines were predicted with the management scenario of reductions in nesting habitat in the Columbia River Estuary and the Columbia Plateau Region, coupled with the less favorable environmental conditions for breeding in the Columbia River Estuary persisting into the future.

Less favorable breeding conditions for Caspian tern have been observed in recent years. The scenarios that reflected less favorable environmental conditions for nesting Caspian terns in the Columbia River Estuary alone predicted a stable population trend, however they were not analyzed in concert with reducing the available nesting habitat in the Columbia Plateau Region or with reduced nesting habitat in the Salish Sea (Suzuki et al. 2018, p. 4).

In the Basin, an average of 422 Caspian tern breeding pairs (average peak colony size) has been recorded on the Blalock Island complex since implementation of the Inland Avian Predation Plan at Crescent Island began (Collis et al. 2019, pp. 32-35). After implementation of tern management actions at Crescent Island, above McNary Dam, there was an increase in colony size at the Blalock Island complex. In 2018, the peak colony size was 313 breeding pairs (Collis et al. 2019, p. 34).

F.3 RIPARIAN

F.3.1 Landscape, Habitats, and Subhabitats

In riparian areas, groundwater flows at shallower depths and the frequency of flooding is greater than in adjacent terrestrial environments or uplands. Riparian habitats have distinctly different vegetation, exhibiting more vigorous or robust growth forms, than other habitats in the study area (USFWS 2019a, p. 6).

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Riparian habitat in the Basin is often a mosaic of wet to moderately wet areas), depending on topography and soil characteristics that reflect sediment deposition patterns and subsurface water depth. Riparian areas may have forests, areas of low woody vegetation, sand and gravel bars, wet meadows, flood-scoured areas, perennial and intermittent secondary channels or side channels, and other stream-related habitats and vegetation (Fischer et al. 2001, pp. 1-2). For the analysis, the Service divided the riparian landscape into three habitats (emergent, scrub-shrub, and forest) (Table F5) (USFWS 2019a, pp. 7-8).

Table F5. The riparian landscape, characterized by its habitats and subhabitats in the study area

Habitats	Description
Emergent	Zones with erect, rooted herbaceous vegetation present during most of the spring and summer (from March through September)
Scrub-shrub	Zones with more than 30 percent canopy cover of woody riparian vegetation (e.g., tree saplings and shrubs) less than 20 feet (6 meters) tall
Forest	Zones with more than 30 percent canopy cover of woody riparian vegetation greater than 20 feet (6 meters) tall

Descriptions of other habitats within riparian zones (e.g., wetland subhabitats) are included in the other landscape descriptions in this report.

F.3.2 Evaluation Species

F.3.2.1 Black Cottonwood (P. trichocarpa)

Black cottonwood is a keystone species in riparian zones, and it is common along the mainstem Columbia River and its tributaries (Figure F2) (Fierke and Kauffman 2005, p. 150). Black cottonwood is often the only large tree found in the more arid portions of the study area.

Black cottonwoods are phreatophytes (i.e., trees that rely on water from the riparian water table rather than from precipitation) and, thus, are dependent upon a connection to a constant source of water (Mahoney and Rood 1993, p. 228). Forming a major component of the canopy of riparian gallery (i.e., corridor) forests east of the Cascades, and in wetter portions of the floodplain west of the Cascades, the black cottonwood provides shade, leaf litter, soil rooting matrix, and LW associated with riparian and river interactions. The riparian gallery also serves as foraging and nesting habitat and cover for numerous bird species, many of which use the cotton from the trees' fruiting bodies in constructing their nests. Insects also feed on their leaves (DeBell 1990, pp. 570-573).

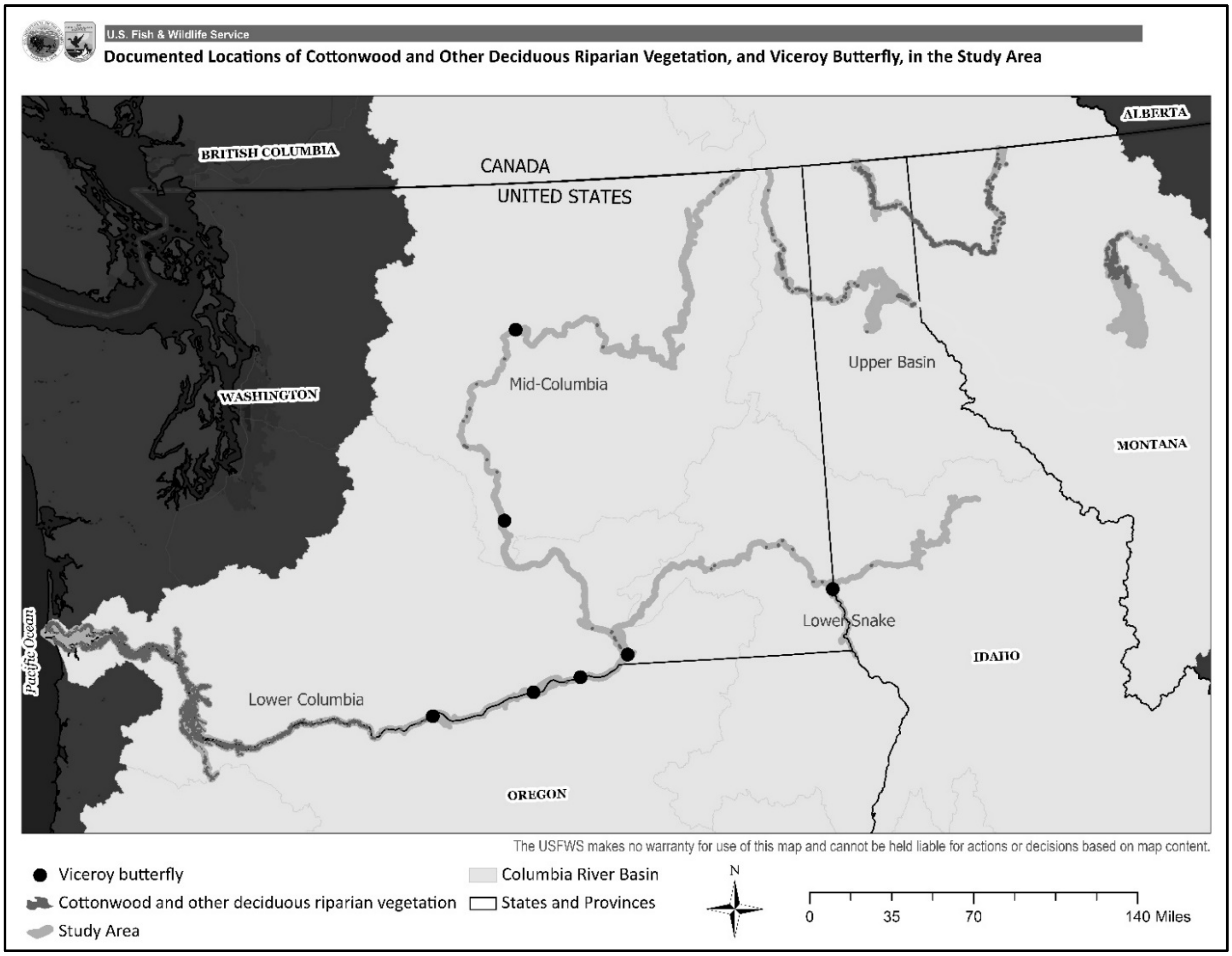

Figure F2. Documented presence of black cottonwoods, other deciduous riparian vegetation, and viceroy butterflies in the study area

Black cottonwood regeneration is dependent upon a natural hydrologic pattern; cottonwoods have evolved to release seeds following a peak flow (flood), which historically occurred in early June. Peak flows scour river banks creating barren, moist habitat for cottonwoods. Wind and water disperse seeds, which are then deposited along recently-exposed, moist shorelines as flood waters slowly begin to recede. To successfully establish, seeds must sprout while the soil is moist and at the proper elevation above base water level, and then the post-flood water level recession rate must not exceed the elongation rate of the seedling roots, so seedlings can be sufficiently irrigated. For newly-established seedlings to survive and grow, they must not be exposed to excessive scour and deposition during the first few years of life, as well as long-term inundation during the spring and summer. Conditions for successful cottonwood regeneration in natural, uncompromised system, occur approximately once every five to ten years (Mahoney and Rood 1998, pp. 635-642).

Historically, common riparian vegetation such as black cottonwood was widespread along the Columbia River and its tributaries, especially in alluvial (i.e., river-deposited) valley segments. However, after construction of the Federal dams in the Basin, a sharp decline in cottonwood recruitment was observed at many tributaries of the Columbia River as well as along other rivers throughout the Pacific Northwest, including the Kootenai River; Snake River; Yakima River; Willamette River; Waterton River; and the St. Mary's River as a result of altered hydrologic regimes (Benjankar et al. 2012, p. 88; Braatne et al. 2007a, p. 247; Burke et al. 2009, p. S224; Dykaar and Wigington 2000, p. 101; Fierke and Kauffman 2005, p. 149; Foster and Rood 2017, p. 1088; Hauer and Lorang 2004, p. 394). Currently, due to continuing Federal CRS project operations, black cottonwood are negatively impacted by alterations in hydrologic regimes including permanent inundation of formerly productive substrate and disruption of flood-mediated processes, which deprive cottonwood seedlings of moisture and render some habitats unsuitable for black cottonwood growth and survival.

As riparian obligate species, black cottonwoods are indicators of riparian health, and the loss of these specialized resources from the riparian forest often indicates habitat degradation (Braatne et al. 1996, p. 76; Macfarlane et al. 2016, p. 448). Cottonwood-dominated forests, especially later-seral mixed riparian forests, have greater biomass and structural diversity than forests dominated by later-successional tree species (Fierke and Kauffman 2005, pp. 160-161). When natural flooding and river meandering is inhibited, the flood-adapted pioneer component of a riparian forest (e.g., cottonwood, willow species) is lost and may be replaced by later-successional riparian species, resulting in a long-term net loss of habitat and landscape biomass and diversity (Fierke and Kauffmann 2005, p. 160; Johnson et al. 1976, p. 81). In addition, riparian obligate vegetation interacts with streamflow and, thus, contributes more to diversifying streambed morphology, which, in turn, benefits the overall aquatic ecosystem (Castro and Thorne 2019, p. 319).

F.3.2.2 Viceroy Butterfly (L. archippus)

The viceroy butterfly is a riparian obligate species, considered to be an ecological indicator species of riparian forest health and ecosystem function (Nelson 2003, p. 203). Due to its association with cottonwood and willow trees, upon which the larvae feed, overwinter, and complete metamorphosis, viceroy butterfly may be found in the study area where cottonwoods or willows are found; in moist areas most often along the edge of water (Figure F2).

The viceroy butterfly ranges from the Northwest Territories in Canada south to central Mexico, and from the eastern slopes of the Cascades and Sierra Nevada Mountain Range east throughout the rest of the U.S. (Lotts and Naberhaus 2017). Viceroy butterflies require trees and shrubs of the willow family (cottonwoods, willows, and poplars) as host plants for their larvae (Nelson and Anderson 1994, p. 142). Female viceroys lay their eggs from May through September on the tips of leaves and plants of cottonwoods, willows, and poplars (Sourakov 2009). In riparian habitats, viceroys rely on subsurface water flows to provide humidity and a high water table for food plant nectar production, and periodic flooding to create bare and moist substrate for puddling (i.e., extracting amino acids and essential minerals from mud and other damp sediments) (Nelson 2003, p. 210).

Adult viceroys are diurnal, and early generations will feed on a variety of food items such as carrion, dung, and decaying fungi early in the season when flowers are not yet available. Later generations will nectar on flowers, favoring composite flowers including milkweed (*Asclepias* spp.), thistle (*Cirsium* spp.), aster (*Symphyotrichum* spp.), goldenrod (*Solidago* spp.), shepherd's-needle (*Scandix pectin-veneris*), and others (Lotts and Naberhaus 2017). Viceroy butterflies are unlikely to travel outside of mesic areas, but they can travel distances along riparian corridors, suggesting that riparian habitat access and connectivity are important for dispersal and locating potential mates (Nelson 2003, p. 210). Viceroy butterflies do not migrate and, instead, use riparian habitats year-round during larval and adult stages, the winter period of dormancy (diapause), and the adult flight period.

There is very little information in the peer-reviewed literature regarding the status of viceroy butterflies in the study area. As part of the analysis, the Service found few data on the occupancy and abundance of viceroy butterflies in the study area. However, one citizen science resource included reports of verified observations of viceroy butterflies throughout the Pacific Northwest as follows: 20 in Idaho, 48 in Montana, 13 in Oregon, and 24 in Washington from unknown dates prior to 2004 to as recently as June 2014 (Idaho), July 2017 (Montana), July 2018 (Oregon), and September 2018 (Washington) (Lotts and Naberhaus 2017). Other, historical observations from unknown dates prior to 2004 are located in various counties in Idaho, Montana, Oregon, and Washington.

F.3.2.3 Yellow Warbler (S. petechia)

Protected under the MBTA, the yellow warbler is a neotropical migrant with one of the widest distributions of any North American warbler, breeding coast-to-coast across northern states, Canada and Alaska, and across the southwest. Non-migratory yellow warbler populations occur in Mexico, the West Indies, and South America. With few exceptions, across their range, they show an affinity for cottonwood, willow, and other riparian shrubs for feeding and breeding purposes and during migration (Humple and Burnett 2010, pp. 355-356; Lowther et al. 1999; Rich 2002, pp. 1130-1134).

Yellow warblers breed across the entirety of the study area. Because of their strong association with riparian habitats, particularly sub-canopy and tall shrub foliage, yellow warblers are also focal species as part of the conservation strategies for landbirds in the lowlands and valleys of western Oregon and Washington and in the Columbia Plateau of eastern Oregon and Washington (Altman 2000, pp. v, 19, 32, 91; Altman and Holmes 2000, pp. v, 14, 26, 73-75). Yellow warblers feed on insects and other arthropods anywhere within the canopy, but most commonly between 16 ft and 33 ft (4.9 m and 10 m) from the ground (Lowther et al. 1999). Yellow warblers begin breeding in May and June and, within they study area, they breed most often in wet, deciduous thickets dominated by willow. Yellow warblers build small cup nests typically between 6.0 ft and 10 ft (1.8 m to 3.0 m) (ranging from 0.0 ft to 50 ft [0.0 cm to 15 m]) from the ground in willows or other small shrubs or trees in riparian landscapes (Lowther et al. 1999).

Yellow warblers are closely associated with willows throughout the breeding season and also, typically, during migration (Lowther et al. 1999). Studies show that the presence of willow shrubs and certain stream characteristics (i.e., flow direction, channel shape) conducive to willow growth are the best predictors of yellow warbler presence (Strusis-Timmer 2009, p. 31). During the breeding season, yellow warblers have been observed in every river reach of the study area, though there are fewer observation reports from river reaches with less riparian vegetation (eBird Basic Dataset, Version: EBD_relMar-2019). Yellow warblers have experienced significant regional population declines, largely associated with the loss or degradation of riparian habitat (Lowther et al. 1999). For instance, survey data from 1966 through 2015 shows a negative trend in population abundance for the yellow warbler in various regions including the Great Basin, Northern Pacific Rainforest, and Northern Rockies; and statewide, including Idaho, Montana, Oregon, and Washington (Ballard et al. 2003, p. 742; Sauer et al. 2017).

F.3.3 Other Guilds and Communities

F.3.3.1 Cottonwood-Willow Communities

There has been less of a focus on willows relative to cottonwoods in documenting the impacts of altered hydrologic flow regimes and decline of riparian habitats throughout the study area. However willows are in the same family (Salicaceae) as cottonwoods and share similar characteristics (e.g., regeneration) and flood-tolerant adaptations (e.g., adventitious roots, rapid root growth following germination, dispersal of seeds largely by water) that allow them to thrive in riparian habitats (Torrez 2014, pp. 18-21). Willows are even more sensitive than cottonwoods to a rapid decline in the water table following germination; specifically, while cottonwoods can tolerate a stream stage decrease of about 1.0 inch (2.5 cm) per day, willows can only tolerate a decline of about 0.4 in (1.0 cm) per day. In general, a gradual decline in the water table following seed germination promotes the growth and survival of seedlings in both genera when compared to a rapidly declining or stagnant water table (Amlin and Rood 2002, pp. 338, 345).

As such, negative impacts to willows as a result of altered hydrologic flow regimes, flood control, development projects, and irrigation practices are similar to those impacts to black cottonwoods, and such factors have caused declines in willow populations in riparian habitat throughout the study area (Wissmar et al. 1994, pp. 17, 28). Field studies have demonstrated that, in general, altered streamflow has resulted in decreased willow abundance (Caskey et al. 2015, pp. 592-593). For example, one study in the Basin documented that (unregulated) river reaches upstream of dams on the Snake River, and river reaches with unrestricted flow on the undammed Salmon River, had higher willow abundance than (regulated) river reaches downstream of dams on the Snake River (Rood et al. 2011, pp. 31, 37-38).

Invasive species such as reed canary grass and Russian olive (*Elaeagnus angustifolia*) have spread throughout much of the riparian habitat throughout the Basin, greatly reducing the habitat complexity, species diversity, ecosystem function, and utility to wildlife, of the riparian corridor (Shafroth et al. 2010, p. vii). Under natural flow conditions, native riparian species such as cottonwood and willow will often survive and may even outcompete invasive species, due to their specialized adaptation to elements of life on the floodplain that prevent most other species from surviving there (Shafroth et al. 2010, p. 121-122). However, with the elimination or alteration of many important elements of the natural hydrologic flow regime on regulated systems, native species lose the competitive edge, and conditions may favor invasive species. For example, heavily moderated flows and persistent elevated summer stage associated with river regulation favor reed canary grass that now dominates much of the shoreline habitat where native cottonwood and willow once existed (Braatne et al. 2007a, p. 254).

Over the last century, riparian habitat, namely cottonwood and willow communities, has been in rapid decline due largely to anthropogenic factors such as water resource development (i.e., changes in hydrology), cattle grazing, and distribution and spread of invasive plant species (Braatne et al. 1996, pp. 74-76; Dykaar and Wigington 2000, p. 101; Obedzinski et al. 2001, p. 169). Cottonwoods and willows are major components of the canopy and understory, respectively, of structurally-complex riparian forests. As such, the loss of cottonwood and willow communities is one of the key factors contributing to the homogenization and loss of complex riparian habitat upon which riparian bird and insect diversity directly depend (Caskey et al. 2015, p. 586; Hinojosa-Huerta et al. 2008, p. 74; Nelson 2003, p. 210).

F.3.3.2 Riparian Songbirds

An estimated 95 percent of all riparian habitats in the western U.S. have been severely degraded in the last century. While riparian habitats represent only 1 percent of western landscapes, they support the richest diversity of birds compared to other habitats (Ohmart 1994, p. 273). The reduction in quantity and quality of riparian habitats, and the subsequent decline of many bird species, have been well-documented (DeSante and George 1994, p. 173; Hunter et al. 1987, p. 10; Ohmart 1994, p. 273). A recent large-scale comprehensive data analysis published in *Science* reports that North America has lost about 30 percent (or nearly three billion) birds from 1970 through 2019 (Rosenberg et al. 2019, p. 120). Notably, the destruction or degradation of riparian habitats is cited as the leading cause of bird population declines in western North America in the last century (DeSante and George 1994, p. 185). The degradation and loss of cottonwood-willow riparian habitat have led to the subsequent decline and local extirpation of many riparian songbirds including the yellow-billed cuckoo (*Coccyzus americanus*), willow flycatcher, vermilion flycatcher (*Pyrocephalus rubinus*), and Bell's vireo (*Vireo bellii*) (Hunter et al. 1987, p. 12). While these riparian songbirds are all protected under the MBTA, the yellow-billed cuckoo and willow flycatcher have an additional Federal listing status as a threatened species and BCC, respectively.

A heterogeneous (i.e., complex) riparian habitat supports greater species diversity and abundance, especially of birds (Skagen et al. 2005, p. 526). Riparian birds rely on the flow-related geomorphic processes responsible for establishing new willow and cottonwood stands, and avian species richness and diversity increase with increasing structural complexity of riparian vegetation (Scott et al. 2003, p. 284). Additionally, yellow warbler density as well as that of several other species (e.g., American goldfinch [*Spinus tristis*] and yellow-breasted chat [*Icteria virens*]) was found to be greater in cottonwood-shrub habitat than in stands of cottonwood alone, illustrating the importance of structurally diverse, mixed cottonwood-willow habitat with ample understory (Figure F3) (Scott et al. 2003, pp. 290-291). For example, a study of avian species richness along the South Fork of the Snake River in Idaho documented that the best predictors of avian species richness were natural and structurally complex landscapes, large cottonwood patches, and proximity to other cottonwood patches (Saab 1999, p. 135).

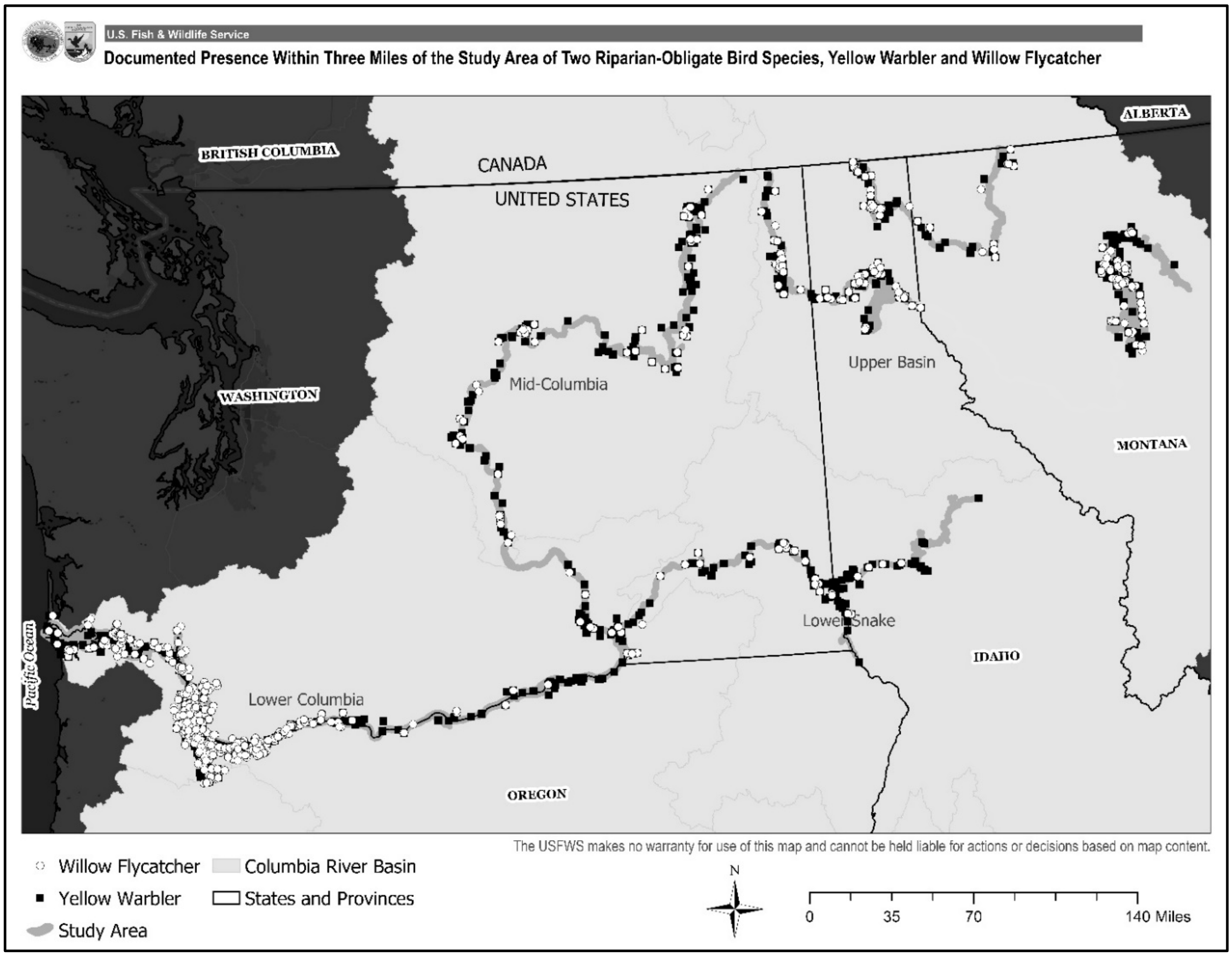

Figure F3. Documented presence of yellow warbler and willow flycatcher within 0.8 miles (5 km) of the study area

Avian diversity and abundance show a positive response to the restoration of willow and cottonwood habitat. For example, after the construction of large dams on the Colorado River, studies showed that the floodplain was deprived of the natural flood regime for nearly 50 years, which resulted in the loss of willow and cottonwood habitat and the local extirpation of at least nine bird species. However, in the last 25 years, larger-volume releases from some of the dams, operated to simulate natural base flows and pulse floods, have led to some regrowth of willow and cottonwood habitat, and, thus, several formerly-extirpated bird species reestablished in the regenerated forest (Hinojosa-Huerta et al. 2008, pp. 75, 80-81).

F.4 WETLANDS

F.4.1 Landscape, Habitats, and Subhabitats

Wetlands are typically "inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (40 CFR § 232.2). Water saturation (i.e., hydrology) influences soil development and determines the plant and animal communities living in and on the soil. Prolonged presence of water creates anaerobic conditions that favor the growth of specially-adapted plants and promote the development of wetland areas (e.g., river deltas and wetland subhabitats on islands).

The Service relied primarily on the NWI and the U.S. Department of Agriculture's and U.S. Department of Interior's LANDFIRE to identify and classify wetland habitats in the Basin for the analysis. The wetland habitats described in the analysis are either naturally occurring or managed as palustrine, lacustrine, and emergent or estuary (i.e., tidal) wetlands (Table F6) (Cowardin et al. 1979, pp. 3-5). The Service also evaluated wetlands based on connectivity to adjacent waterbodies such as rivers, lakes, and reservoirs, and other habitats including islands, as follows:

- directly connected wetlands are frequently, if not always, in association with water (e.g., riverine systems);
- indirectly connected wetlands may maintain connections with water at higher water levels but may lose those connections at low water levels; and,
- disconnected wetlands have no direct connection to water and are influenced primarily by snowmelt, runoff, and groundwater.

Table F6. The wetlands landscape, characterized by its habitats and subhabitats in the study area

Habitats	Subhabitats	Description
Palustrine	Forest	Wetlands that are dominated by woody plants at least 20 feet (6 meters) in height
	Scrub-shrub	Wetlands that are dominated by woody plants less than 20 feet (6 meters) in height; shrubs may include true shrubs or young trees that have not yet reached 20 feet (6 meters) in height, and woody plants that are stunted because of adverse environmental conditions
	Emergent	Wetlands shoreward of river channels, on river floodplains, estuaries, natural lakes, reservoirs, slopes, or in isolated catchments; usually characterized by erect, rooted, herbaceous plants and perennials
	Other	Wetlands associated with other palustrine characteristics including aquatic bed, rock bottom, unconsolidated bottom, and unconsolidated shore
Lacustrine		Wetlands along natural lakes and reservoirs in the littoral zone and characterized by depth of water
Emergent		Nutrient-rich wetlands that occur either in shallow water with groundwater input or in areas subjected to flooding

F.4.1.1 Palustrine Wetlands

Of the main wetland habitats found in the Basin, palustrine wetlands include all non-tidal wetlands dominated by trees, shrubs, persistent emergent, emergent mosses or lichens, as well as vegetated wetlands more traditionally known as marshes, swamps, bogs, fens, prairies, and ponds. Palustrine wetlands may be situated shoreward of lakes, river channels, or estuaries; on river floodplains; in isolated catchments; and on slopes. They may also occur as islands in lakes and rivers. In all seasons, forested and scrub-shrub wetland subhabitats, even more than other palustrine subhabitats, provide important feeding, sheltering, and breeding or nesting habitat for many fish and wildlife resources in the Basin.

F.4.1.2 Lacustrine Wetlands

Lacustrine wetland habitats include non-tidal and tidal freshwater wetlands that are associated with an intermittently to permanently flooded lake or reservoir while estuarine wetland habitats are present in low-wave-energy environments where there is a mix of seawater and freshwater (Brophy et al. 2019, p. 3; Lane and Taylor 1996, p. 393). Areas with deep, permanent water can also be classified as lacustrine wetlands, but, for the purposes of the analysis, the Service classified those areas as either lakes, reservoirs, or rivers landscapes.

F.4.1.3 Emergent Wetlands

Emergent wetlands are found throughout the study area except for in marine systems such as the Pacific Ocean. Like marshes and wet meadows, emergent wetlands include a number of areas subjected to extended periods of flooding. Due to significant groundwater contributions, emergent wetlands are nutrient-rich and are home to diverse communities of erect, rooted, herbaceous plants, usually perennials. In areas with relatively stable climate conditions, vegetation in emergent wetlands is present for most of the spring and summer (Cowardin et al. 1979, pp. 19-20).

Though wetlands occur naturally in the Basin, the NWR System and state-owned WMAs use several management strategies to maintain and enhance wetland function in certain locations to the extent possible for wetland obligate species. For example, some NWRs and WMAs manage wetlands by pumping water in and out to control water levels and vegetation abundance. On NWRs, the Service may also disk, burn, and actively manage wetlands in other ways. On McNary NWR on the east bank of the Columbia River, for instance, existing operations lead to seasonally flooding of wetland habitats, which are important for birds and, particularly, waterfowl by stimulating the growth of forage resources for these birds (USFWS 2014).

F.4.2 Evaluation Species

F.4.2.1 American Bittern (B. lentiginosus)

American bittern is protected under the MBTA. This species has a breeding range that includes the study area as well as much of the northern continental U.S. In the Basin, American bittern have been observed frequenting the Flathead River in Montana, Lake Pend Oreille, and the Pend Oreille River in Idaho and Washington, the Snake River near Lewiston, Washington, the Columbia River near Kennewick, Washington, and the Columbia River at Umatilla NWR in Paterson, Oregon. Throughout the study area, the greatest number of American bittern observations have occurred in wetland habitats below Bonneville Dam in the Lower Columbia River, at Steigerwald Lake NWR in Washougal, Washington, and at Ridgefield NWR in Ridgefield, Washington.

Typically, bittern habitat is dominated by tall emergent or aquatic bed vegetation with a high degree of cover-water interspersion, which includes wetland fringes, shorelines, bogs, swamps, wet meadows, but rarely tidal marshes. Within the Basin, American bittern primarily rely on scrub-shrub (i.e., palustrine wetland habitat) that provide an adequate forage base including insects, crayfish, amphibians, small fish, and small mammals.

American bittern also rely on the vegetation found in emergent wetland habitat for nesting. American bitterns build their nests on platforms of emergent vegetation surrounded by water (Gibbs and Melvin 1992, p. 52). They are solitary birds that prefer relatively large wetland habitats (i.e., that cover 7.0 acres [2.8 hectares or ha] or more) to strategically build nests that are obstructed from view by the tall vegetation (Brown and Dinsmore 1986, p. 394; Hanowski and Niemi 1986, pp. 19-20). American bittern use rush (*Juncus* spp.), sedge (*Carex* spp.), bulrush (*Schoenoplectus* spp.), prairie cordgrass (*Spartina pectinata*), tall mannagrass (*Glyceria grandis*), bur-reed (*Sparganium eurycarpum*), or cattail (*Typha* spp.) for nesting (Dechant et al. 1999, pp. 7-11). Generally, bittern build their nests from April through August on floating platforms in shallow water where they are vulnerable to major pool fluctuations. Individuals may continue to forage in emergent wetlands until September or October when they begin to migrate to coastal areas that stay above freezing for overwintering (Lor 2007, p. 19; Lowther et al. 2009). American bitterns overwinter in a variety of wetland habitats characterized by flooded willow and salt marshes along the west coast, extending south to Mexico and along the southern U.S. border.

From the late 1960s through 1990, American bittern populations were in decline due to overall wetland habitat loss and the establishment of non-native species in marshlands (Cooper and Beauchesne 2003, pp. ii, 1). However, according to data from the North American Breeding Bird Survey, their populations may now be stable, barring further wetland habitat loss (Sauer et al. 2013, p. 14). The study area encompasses the edge of both the breeding and overwintering ranges for American bittern and, thus, represents habitats and subhabitats that are of value to the overall life history and range of the species.

F.4.2.2 Mallard (A. platyrhynchos)

The mallard is protected under the MBTA, and the western mallard population is part of the Service's BMC list. Thus, mallards, like other bird species on the list, come with certain management challenges due to many factors depending on where they are located (e.g., too few, too many, conflict with human interests) (USFWS 2015b). Mallards also have public value as they are the most sought-after and harvested duck in North America (Petrie et al. n.d.).

The mallard is the largest of the dabbling ducks and the most abundant duck species in North America. This species is found in all four of the North American migratory flyways (USFWS 2018b). Mallards remain in the Columbia River and its tributaries year-round, and they make particular use of various habitats for overwintering and breeding. Mallards prefer slower-moving waters for foraging and they are generalist foragers, eating a variety of foods including aquatic insects, worms, crayfish, seeds, aquatic vegetation, and cereal crops.

Within the Basin, mallards primarily use the slower-moving waters found in wetlands for foraging. Around March or April, breeding pairs congregate in smaller wetlands and appear to prefer ephemeral, seasonal, and semi-permanent ponds and marshes. From April through June, mallards typically build their nests on dry land close to water and, occasionally, on floating platforms of vegetation (Barnes 2017). In the past, mallard populations have responded positively to changes in the amount of wetland habitat and associated vegetation, and to changes in water levels and sedimentation (Krapu et al. 1997, p. 743).

F.4.2.3 Western Painted Turtle (C. picta)

The Western painted turtle has a limited range in the Pacific Northwest, including British Columbia, Oregon, and Washington. A significant portion (i.e., the entire western-most) of the range of this species is located in the study area.

Western painted turtles prefer wetland habitats with stagnant or slower-moving waters, muddy substrate, and submerged woody material. In the study area, they inhabit marshes, ponds, sloughs, and streams (Gervais et al. 2009, p. 5). Western painted turtles feed on plants and small animals such as aquatic insects, fish, crustaceans, and some carrion. Mating occurs after hibernation, in the spring, when water temperatures are still cool. Females carry the fertilized eggs until June or July, after which they move to land, where they dig a hole in soft, sandy soil and lay their eggs. Hatchlings emerge by August, however, many hatchlings will overwinter in the nest and emerge the following spring. Wetland habitat diversity or heterogeneity is important for Western painted turtles and other wetland species as they forage among aquatic vegetation, bask on logs, and nest in soft soil on land.

There are few studies on the historical and current population status of Western painted turtles in the study area. However, based on their life history needs, this species will likely respond negatively to changes in the abundance of wetland habitat, associated vegetation and woody material, water level elevation, and changes in sedimentation, flow regimes, and habitat fragmentation.

F.4.2.4 Woodhouse's Toad (B. woodhousii)

Woodhouse's toad is a medium-sized toad of the family *Bufonidae*, and it is found in many west-central states in the U.S. While the Woodhouse's toad's range extends from Mexico to Montana, the only known populations of the toad in the Pacific Northwest occur in the study area (Jones et al. 2005, p. 169). In the study area, Woodhouse's toad has been observed in the Columbia Plateau Ecoregion along the Snake River, and between Priest Rapids Dam and John Day Dam along the Columbia River (Leonard et al. 1993, p. 114; WDFW 2019). The toad also inhabits areas in the stretch from Richland to Roosevelt along the Columbia River in Washington.

Woodhouse's toads are semi-aquatic, as they live most of their life on land but move to lowland areas with shallow, standing water where they lay and fertilize eggs (Jones et al. 2005, pp. 166-169). During breeding season, which typically occurs from March through June, Woodhouse's toads rely on shallow standing water in emergent wetlands (e.g., ponds, sloughs, ditches, marshes). Outside the breeding season, Woodhouse's toads are most often located in river valleys in grassland and shrub-steppe subhabitats. The toads are sensitive to hydrological fluctuations in spring and early summer, in addition to changes in wetland availability, seasonal inundation, water-level elevation, and habitat fragmentation (Sullivan 1989, p. 60; WDFW 2015, p. 21).

There is not enough available survey information to determine population trends in the study area.

F.4.3 Other Species

F.4.3.1 Columbia Yellowcress (R. columbiae)

Columbia yellowcress, a low growing perennial herb in the mustard family, is a state-listed threatened species in Washington and a Federal species of concern. Columbia yellowcress thrives in wetland habitats that are inundated for part of the year, experience seasonal fluctuations in water surface elevation, have wet soil well into the spring and summers, and support diverse vegetation. Columbia yellowcress abundance varies from year to year, with hydrologic conditions as a main driver of this variation. The plant grows and reproduces in late summer and early fall, when water levels are lowest (WNHP 2003, p. 1-1).

The population of Columbia yellowcress located in the Hanford Reach, administered by the Central Washington NWR Complex, represents one of 11 populations of the species (Stenvall, C., in litt. 2019a). Based on results from field studies in 1982 and 1994, the Hanford Reach population of Columbia yellowcress is considered the most vigorous population of the species (Evans et al. 2003, pp. 47-48). Populations occur throughout the Hanford Reach of the Columbia River and elsewhere, such as in the Lower Columbia River, south-central Oregon, and the Modoc Plateau in northeastern California.

Ongoing CRS operations have negatively impacted the wetlands landscape that supports Columbia yellowcress along the shoreline of the Columbia River. For instance, river flow management has led to regular (i.e., often daily) inundation of the landscape during the summer, which has shifted the growing season into late summer and fall. As a result, there is less time to support, and colder conditions that may thwart, Columbia yellowcress reproduction (by seed), growth, and development (Sackschewsky et al. 2014, pp. 2, 5). Due to regular inundation and other potential contributors (e.g., slumping, the entrapment of sediments above upriver dams), various monitoring data suggests that, in the Hanford Reach, Columbia yellowcress populations have been declining since 1994 (Sackschewsky et al. 2014, pp. 5, 9).

F.4.3.2 Sora (P. carolina)

The sora is protected under the MBTA and is a BMC. The sora is a marshbird that inhabits emergent wetlands (e.g., marshes) across North America. Despite its abundance, it is not easily found because it is often hidden in dense marshy growth or wet meadows. The sora forages by picking items from the ground, water surface, or plants, and will periodically probe with its bill among vegetation or in the mud. Although the sora appears to be a weak flier over wetland habitats, it regularly migrates long distances, as many travel to South America for the winter.

During some seasons, the sora feeds exclusively on seeds, including those of smartweeds, sedges, grasses, and other wetland plants. The marshbird also consumes a variety of insects, snails, and other aquatic invertebrates (Melvin and Gibbs 2012).

Sora courtship displays by both members of a breeding pair involve ceremonial preening and sometimes bowing, facing toward and then away from each other. Sora create nesting sites in dense marsh vegetation, especially cattails, sedges, and bulrushes. These nests are composed of well-built cups of dead cattails, grasses, other plants, lined with finer material, placed a few inches above water. The nests often have vegetation arched over top, and sometimes have a ramp or runway of plant material leading to the nest (Melvin and Gibbs 2012).

According to the North American Breeding Bird Survey, sora populations are declining in the Northern Pacific Rainforest Bird Conservation Region (BCR) and increasing in the Great Basin and Northern Rockies BCRs (Sauer et al. 2017). Sora breed, and stop over on migration and during winter, in portions of the study area.

Sora depend on diverse stands of both fine-leaved and robust emergent plants including sedges, bulrushes, and especially cattails, as well as moist-soil annuals around the periphery of wetland habitats. These marshbirds are particularly sensitive to manipulations in water surface elevation, which reduce habitat quality in wetlands.

F.5 UPLANDS

F.5.1 Landscape, Habitats, and Subhabitats

In general, upland habitats are located outside waterbodies (lakes, reservoirs, and rivers) and include areas that are not prone to inundation long enough for their soils to have anaerobic characteristics (i.e., wetlands). Flooding or high water tables do not greatly influence the function of upland habitats. Through the analysis, the Service identified two broad uplands habitats: forested uplands and arid uplands. Subhabitats within forested and arid uplands in the study area are described in Table F7.

Table F7. The uplands landscape, characterized by its habitats and subhabitats in the study area

Habitats	Subhabitats	Description
Forest uplands	Conifer	Lands with more than 70 percent coniferous trees
	Deciduous	Lands with more than 70 percent deciduous trees
	Mixed	Lands that include a mix of coniferous and deciduous trees
Arid uplands	Agriculture	Croplands, pastures, orchards, vineyards, poplar plantations, and associated buildings

Habitats	Subhabitats	Description
	Grasslands	Lands that are too dry to support shrubs and where the primary vegetation is grass
	Shrub-steppe	Lands with limited moisture and where the primary vegetation is shrubs

F.5.1.1 Forest Uplands

Forested uplands generally support more than ten percent tree canopy cover and are categorized by plant species and structural features. The Service based its analysis on broad groupings of forest habitat, characterized by dominant vegetation (conifers, deciduous, and mixed). Conifer forests including Western larch (*Larix occidentalis*) are found in the study area along the Hungry Horse Reservoir in the Flathead National Forest in western Montana. Deciduous forest (i.e., oak woodland), is found on both the east and west side of the Cascades and in dry portions of the Ridgefield NWR in Washington (USFWS 2018c). Mixed stands, such as those comprised of Douglas fir (*Pseudotsuga menziesii*), Western hemlock (*Tsuga heterophylla*), bigleaf maple (*Acer macrophyllum*), and red alder (*Alnus rubra*) are often located along the Lower Columbia River, west of the Cascade Crest and in portions of the Columbia Gorge.

F.5.1.2 Arid Uplands

The Service's analysis of arid uplands included human-influenced subhabitats such as agricultural lands, native grasslands, and shrub-steppe. Agriculture is a common land-use practice on private and publicly-owned lands throughout arid uplands in the Basin. Agricultural crops include irrigated orchards and vineyards as well as corn, wheat, and some other crops grown under cooperative agreements.

Arid uplands in the Basin include dry slopes and plateaus with well-drained soils that support native grasslands, dominated by drought-resistant perennial bunchgrasses (e.g., bluebunch wheatgrass [*Pseudoroegneria spicata*] and Idaho fescue [*Festuca idahoensis*]) and forbs. Grasslands have similar features to those of prairies and meadows (i.e., mesic areas that typically occupy depressions), and they share some prairie-associated animals (e.g., pygmy rabbit [*Brachylagus idahoensis*]) and plant species. These native grasslands are maintained by periodic disturbances including fire, wind, salt spray, and soil upheaval (i.e., burrowing) by rodents (Oregon Conservation Strategy 2016b).

In the Basin, shrub-steppe is a natural, treeless subhabitat of arid uplands that receives little rain and supports perennial shrubs (e.g., big sagebrush [*Artemesia tridentatae*]), steppe bunchgrasses, and forbs (e.g., common marrow [*Achillea millefolium*]) (Dobler et al. 1996, pp. 12, 29-30). Shrub-steppe thrives in various soil types often found on basalt bedrock sites. Within the shrub-steppe subhabitat, there may be other characteristic features such as meadows, bluffs, cliffs, talus caves, sand dunes, and saline soils (i.e., areas of low precipitation where mineral salts have accumulated on the soil surface). Ecological processes in the shrub-steppe subhabitat include frequent droughts and fire events and, thus, diverse species inhabitants have developed adaptations (i.e., extensive root systems and good seedling vigor) to summer drought conditions and low annual precipitation (WNPS 2019).

F.5.2 Evaluation Species

F.5.2.1 Long-Billed Curlew (N. americanus)

Long-billed curlew is protected under the MBTA, and the species is a BCC and BMC.

Considered the largest shorebird in North America, long-billed curlew once occurred in large numbers throughout most of the prairie areas of the U.S. and southern Canada. This species inhabits areas with sparse, short grasses including bunchgrass and mixed grass prairies, and will also use agricultural fields, if they are managed, and cheatgrass for breeding and nesting habitat (Stocking et al. 2010, p. 6). After long-billed curlews leave the nest, they may move to areas with taller and denser grasses. In Idaho, researchers have observed long-billed curlews inhabiting unusually tall, dense grassland areas resulting from high spring rainfall and foraging in freshly plowed fields or wet pastures rather than grass (Jenni et al. 1982, p. 64). During the nonbreeding season, from June through mid-March, long-billed curlew habitat preferences range from firm mud substrate of high-tidal areas to soft mud, sand, or low-tidal areas (Engilis et al. 1998, p. 334; Gerstenberg 1979, p. 33).

Long-billed curlew populations have experienced significant declines during the last 150 years. Overharvest in migration areas and overall loss of breeding habitat, in particular, are considered the main reasons for the species decline (Duggar and Duggar 2002). Further loss of grassland subhabitats is thought to be the greatest threat to long-billed curlew population stability and, thus, the shorbirds are now restricted to scattered populations. Though no comprehensive population abundance survey exists, the total population is estimated to be approximately 140,000 (approximately 90 percent certainty, potentially ranging from 98,000 to 198,000 individuals) (Andres et al. 2012, p. 183).

F.5.2.2 Sage Thrasher (O. montanus)

Sage thrashers are protected under the MBTA, and this species is a BCC and BMC.

Found primarily in shrub-dominated valleys and plains of the western U.S., the sage thrasher is a sagebrush obligate species and, thus, is dependent on large patches of sagebrush steppe habitat especially to ensure successful breeding. The sage thrasher primarily feeds on insects on the ground and nests in big sagebrush and three-tip sagebrush (*A. tripartita*), but will occasionally nest elsewhere such as in low sagebrush (*A. arbuscula*), black greasewood (*Sarcobatus vermiculatus*), rabbitbrush (*Chrysothamnus* spp.), bitterbrush (*Purshia tridentata*), horsebrush *(Tetradymia* spp.), and juniper (*Juniperus* spp.) (Alcorn 1988, p. 288; Bent 1948, pp.

427-434; Castrale 1982, p. 946; Gilman 1907, p. 43; Linsdale 1938, p. 106; Reynolds et al. 1999). Some nests are located on the ground at the base of the plant species while others may be placed up to 12 inches (30 cm) off the ground, but typically just below the densest vegetation in the vertical profile of the shrub (Castrale 1982 pp. 948-951; Rich 1980, pp. 363-365).

Sage thrasher populations have experienced an estimated declining trend of 1.2 percent per year for 40 years across the west with some local extirpations as a result of land conversion (Sauer et al. 2017). Where native sagebrush has been eliminated and replaced with non-native crested wheatgrass (*Agropyron cristatum*) and other species, the sage thrasher has also been eliminated (Reynolds and Trost 1980, p. 122). Conversion of native shrub-steppe habitat to agriculture lands has resulted in a 50 percent loss of shrub-steppe breeding habitat for the birds and other species, and has fragmented other formerly contiguous shrub-steppe dominated subhabitats (Reynolds et al. 1999).

G APPENDIX G: DETAILED DESCRIPTION OF LANDSCAPE FINDINGS

This appendix includes bulleted summaries followed by detailed descriptions of the effects of the proposed alternatives. These descriptions are organized first by landscape and then by MO.

G.1 RIVERS

G.1.1 NAA

G.1.1.1 NAA Summary of Rivers Landscape Findings

- Operations and maintenance of the Federal CRS projects will continue to negatively affect overall habitat complexity, water quantity, water quality, and connectivity.
- Current operations and maintenance will likely decrease and, at best, maintain the abundance of accessible bank and run-of-river reservoir shoreline, floodplain, side channel, transition area, tributary mouth, and unimpounded reach subhabitats throughout the study area.

G.1.1.2 NAA Impacts on Indicators of Ecological and Physical Processes

Water Quantity and Quality

In the Basin, water quantity is largely dependent on the size of the annual snowpack and runoff. Storage reservoirs can only hold approximately 40 percent of the average annual runoff. Current operations fill and drawdown various amounts of water out of storage reservoirs, and, in all but the highest water years, flows largely attenuate through run-of-river projects in the Lower Columbia River, Mid-Columbia River, and the Lower Snake River.

Under the NAA, the 14 Federal CRS projects greatly influence the rivers landscape downstream of each project (Nilson and Berggren 2000, p. 783; Ward and Stanford 1983, pp. 29-30). The current presence, operations, and maintenance of these projects pose major threats to indicators of ecological and physical processes like water quantity and water quality (e.g., temperature, TDG, turbidity) in mainstem and tributary subhabitats (Stanford and Ward 2001, p. 308).

For example, due to the presence of the hydropower system, temperature regimes are inconsistent in comparison to natural seasonal regimes throughout the Basin. In the Upper Basin, current operations of storage reservoirs, which contain varying amounts of water at different times during the year, result in fluctuations in water temperature. These fluctuations negatively impact aquatic species (e.g., freshwater mussels, white sturgeon) that rely on environmental cues like temperature to complete critical life-history stages (Ward 2002, p. 58). The amount of water within, and distributed through, storage reservoirs at various times of the year negatively impacts the rivers landscape related to historic flows and timing of peak flows (Figure G1) (Volkman 1997, p. 31).

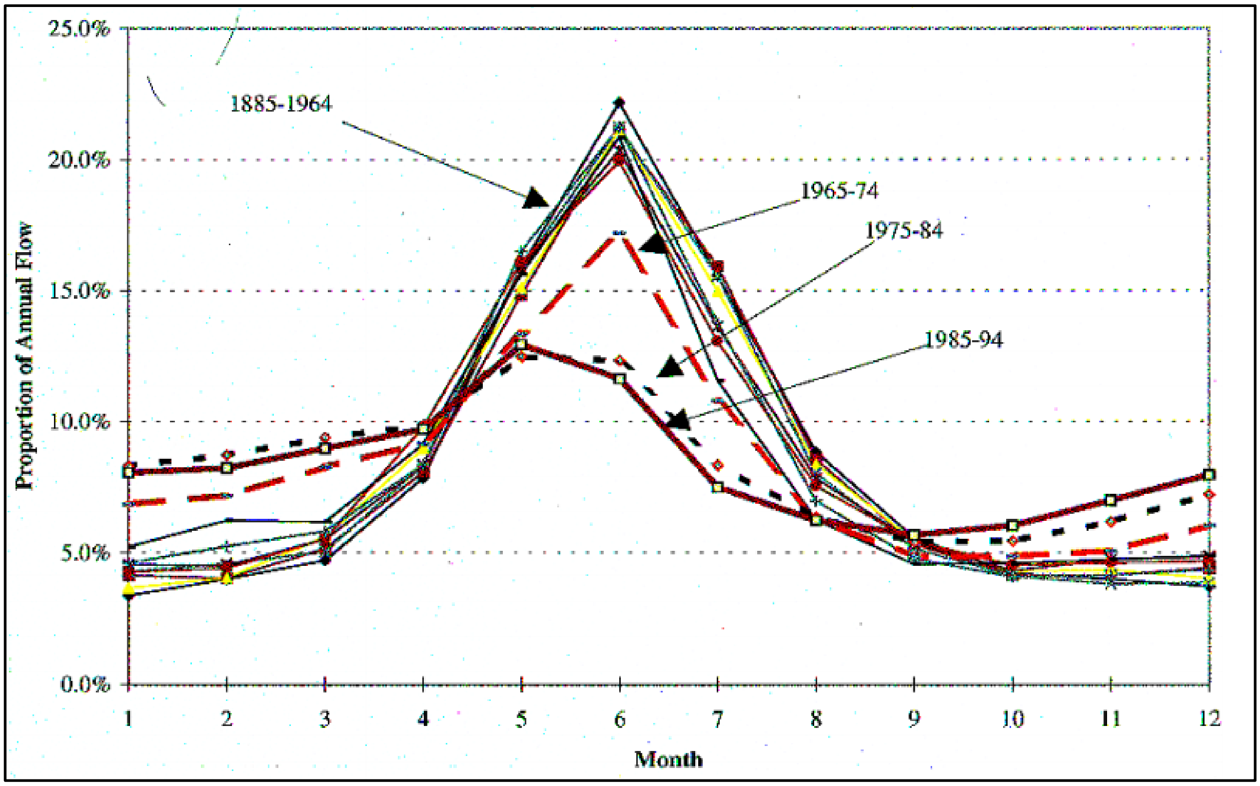

Figure G1. Historic magnitude of flows and peak flows at The Dalles Dam

Source: Volkman 1997, p. 31

These changes are shown by the co-lead agencies' H&H modeling efforts specific to four CRS projects: McNary Dam and Chief Joseph Dam, and the rivers landscape between the dams; Libby Dam and the Kootenai River in the Upper Basin, and Dworshak Dam, and the Lower Snake River habitat below the dam (Figure G2). Changes in water quantity and quality and physical processes (i.e., sediment deposition and channel avulsion) at these Federal projects in the Upper Basin are likely to have negative, cascading effects on storage reservoirs, areas downstream of the reservoirs, and throughout each successive run-of-river project in the Lower Columbia and Lower Snake Rivers.

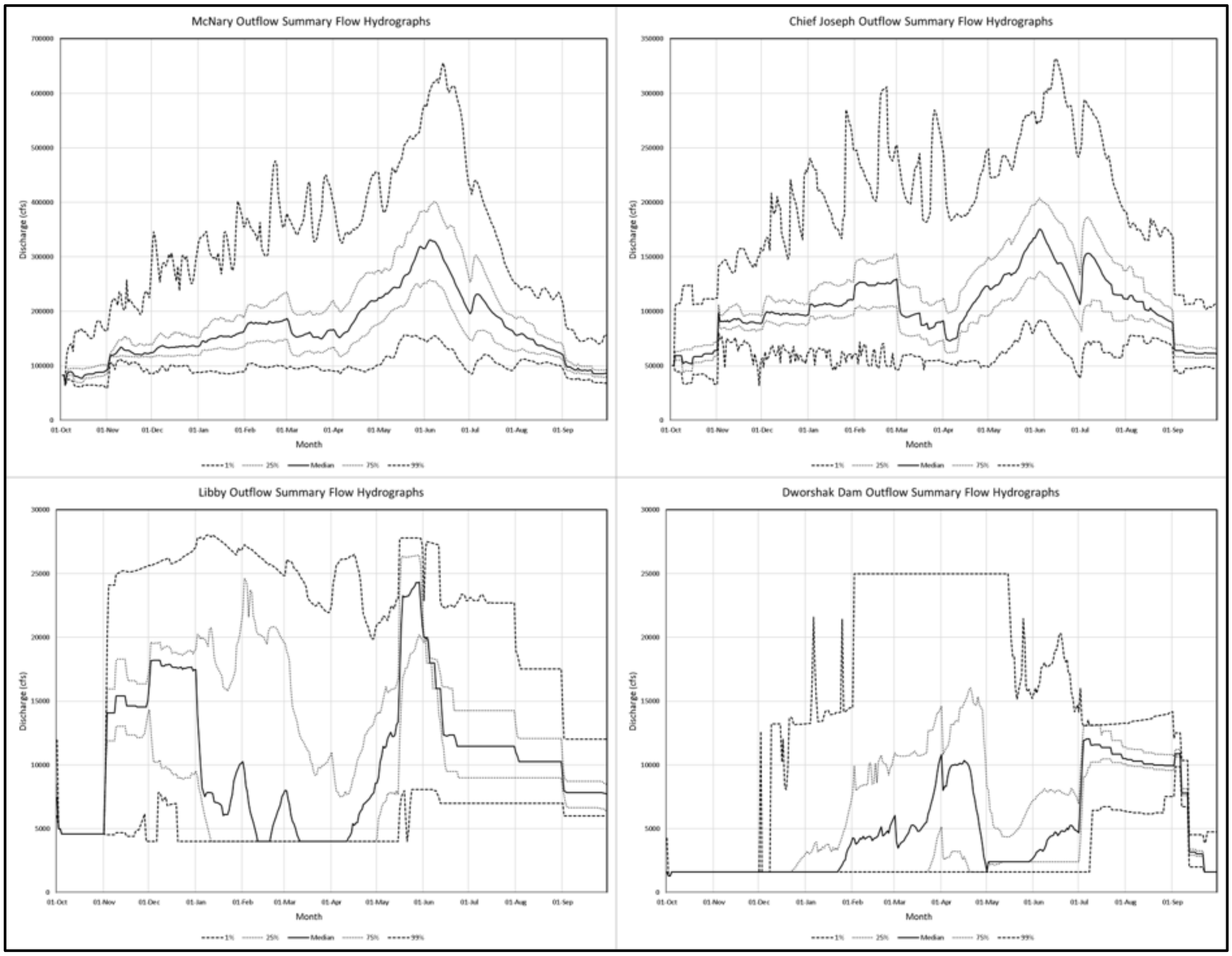

Figure G2. Summary hydrographs for McNary Dam, Chief Joseph Dam, Libby Dam, and Dworshak Dam

<u>Connectivity</u>

Alteration of the pre-dam hydrograph has limited opportunities to reconnect historical floodplain and side channel subhabitats, which have been further exacerbated by the presence of levees and tide gates, primarily in the Lower Columbia River. Loss of these historical connections has resulted, over time, in decreased access to productive, structurally complex habitats that offer essential resources to support aquatic and semi-aquatic species' life-history stages, and no surrogate resources exist in the remaining system (BPA and USACE 2013, p. 9).

As a result of the hydropower system, estimates show a loss of 25 percent of the historical floodplain and side channel subhabitats basinwide, negatively impacting ecological and physical processes (e.g., sediment transport) (Bond et al. 2018, pp. 1212, 1219). Under the NAA, operations and maintenance of the Federal projects would likely continue to negatively impact ecological and physical processes, preventing restoration of historical processes that serve an important role in maintaining habitat connectivity (Dauble et al. 2003, p. 641).

Habitat Complexity

In general, structurally complex river subhabitats include pools, riffles, and runs that support a variety of aquatic and semi-aquatic species. Throughout the study area, CRS operations have largely altered the structure and function, and reduced the complexity, of rivers, tributaries, and streams apart from the few existing unimpounded river reaches including: the Columbia River Estuary below Bonneville Dam; the Hanford Reach below Priest Rapids Dam; the Pend Oreille River below Albeni Falls Dam; the Kootenai River below Libby Dam; the Flathead River below Hungry Horse Dam; and the Clearwater River, a tributary of the Snake River. Under the NAA, river habitats throughout the Basin, including the remaining free-flowing reaches, are influenced by current operations at upstream dams. Approximately 13 percent of river habitats in the Columbia River and 58 percent of river habitats in the Snake River upstream of Hells Canyon Dam remain (Dauble et al. 2003, p. 641). Elsewhere, mainstem, tributaries, and streams are characterized by the pools created behind dams and throughout transition areas, such as the tailwater-to-reservoir transition area below Federal projects.

G.1.1.3 NAA Impacts on Habitats and Subhabitats

Banks and Shorelines

In the analysis, banks and shoreline subhabitats occur along run-of-river reservoirs and support the growth of aquatic vegetation and recruitment of LW, which provide food and shelter for aquatic and semi-aquatic species, respectively. Fluctuating reservoir levels and shoreline armoring do not provide the stability or appropriate substrate for these areas to establish. Operations under the NAA will likely continue to negatively impact these areas in the run-of-river reservoirs at key sites such as the John Day Reservoir in the Lower Columbia River and the Lower Monumental Reservoir or Pool (Lake Herbert G. West) in the Lower Snake River.

Floodplains

Floodplains are particularly important throughout the study area especially in the Columbia River Estuary, within and adjacent to reservoirs, and in unimpounded reaches. Floodplains provide critical food resources and protective cover for aquatic and semi-aquatic species during various life history stages (BPA and USACE 2013, p. 9). In the Basin, there has been an estimated loss of approximately 70 percent of historical floodplain subhabitat in the Columbia River estuary, in particular, due to conversion to agriculture and urban development protected by dikes (Marcoe and Pilson 2013, p. 1). Many of these dikes include tide gates that restrict exchange between the floodplain and river.

Floodplain subhabitat that historically existed in the study area has been inundated and lost under reservoir pools (e.g., John Day Reservoir and Lower Monumental Reservoir) situated behind dams and modified by unseasonal flows (i.e., more or less water than would normally flow in the natural river) from managed releases associated with current dam operations. To mitigate for the Federal projects, certain sites are protected throughout the Basin and are managed to maintain remaining floodplain habitat structure and function. Examples include several NWRs (e.g., Julia Butler Hansen NWR in the Lower Columbia River, Umatilla NWR in the Mid-Columbia River, Kootenai NWR in the Upper Columbia River, and Big Flat Habitat Management Unit [HMU] in the Lower Snake River).

Floodplain subhabitat still exists in unimpounded river reaches in the study area such as: the Hanford Reach, Reach 21, above Grand Coulee Pool or Lake Roosevelt (Table B2); the Kootenai River below Libby Dam; the Pend Oreille River below Albeni Falls Dam; and the Clearwater River below Dworshak Dam). However, due to regulation of the river, there have been declines in the availability of floodplain subhabitat in these unimpounded reaches, and these declines will likely worsen at the same or faster rate under the NAA (Stanford 2000, p. 172).

Side Channels

Side channel subhabitat is largely absent in impounded river reaches. While ecological and physical processes that create and maintain side channels may be present in unimpounded reaches, river regulation upstream can still negatively impact flow and sediment transport, which are critical in side channel establishment. Thus, current CRS operations limit the productivity of the rivers landscape in providing critical support for fish and wildlife resources. These conditions are expected to continue under the NAA.

Transition Areas

Transition areas like tailwater-to-reservoir transition areas are located at the head of the reservoirs such as the John Day Reservoir and the Lower Monumental Reservoir. These areas have qualities similar to those of natural river habitat and, in the CRS, occur just below the tailrace and extend to the head of the next downstream reservoirs. In transition areas, changes in water quantity influence flow and water depth through discharge at dams, and fluctuations in water quality depend on the timing and magnitude of dam releases at spillways. The regulated nature and limited longitudinal distance of these areas do not often provide ample opportunity for ecological and physical processes to function effectively. Operations under the NAA will likely continue to dynamically impact these areas, depending on the water year.

Tributary Mouths

Tributary mouths provide thermal refugia and serve as important subhabitats for sediment input and accumulation to occur. However, many tributary mouths in the Basin have been negatively impacted by ongoing CRS operations especially in the Deschutes, John Day, Umatilla, Walla Walla, and Snake Rivers. Fluctuating run-of-river reservoir levels do not provide the stability for delta formation and beneficial river subhabitats (e.g., floodplain, shorelines) to establish. Operations under the NAA will likely continue to negatively impact tributary mouths, resulting in decreased habitat complexity and loss of connectivity and access.

Unimpounded Reaches

The NAA along with existing management agreements (e.g., 1988 Vernita Bar Agreement, replaced by the 2004 Hanford Reach Fall Chinook Protection Program) have provided some stability in unimpounded river reaches, which has led to improved water quality and improved functioning of physical processes, resulting in ecologically complex habitat that supports many aquatic species (USFWS 2019e). Under the NAA, unimpounded river reaches will continue to provide the most benefits to aquatic and semi-aquatic species in the Basin.

G.1.1.4 NAA Impacts on Evaluation Species

White Sturgeon and Other Mainstem Migratory Fishes

White sturgeon, along with northern pikeminnow (*Ptychocheilus oregonensis*) and several species of suckers, are mainstem migratory fishes. White sturgeon spawn in the spring when water temperature is between 10 °C and 18 °C (50 °F and 64 °F) and water turbidity is high (Hanson et al. 1992, p. 14; Parsley et al. 1993, p. 220; Perrin et al. 2003, p. 154). In the Columbia River downstream of Bonneville Dam and in Hanford Reach, juvenile white sturgeon have been observed migrating upstream in the fall and downstream in the spring (Haynes et al. 1978, pp. 279-280; Parsley et al. 2008, p. 1007). While white sturgeon are migratory, they do not rely as critically upon the maintenance of specific migratory corridors in comparison to species like Pacific lamprey and coastal cutthroat trout (*O. clarkii clarkii*).

White sturgeon once thrived throughout the Basin. Currently, the most abundant white sturgeon population is found downstream of Bonneville Dam, where the nearshore marine environment, the Columbia River Estuary, and the Lower Columbia River provide habitat components unavailable elsewhere in the study area (Beamesderfer and Anders 2013, p. 59). The operation and maintenance of the CRSO under the NAA will continue to negatively impact juvenile and adult white sturgeon, in addition to other aquatic migratory fishes, reduce or eliminate connectivity among populations, and lead to reductions in quality of habitat necessary to support various life-history stages of fish (Beamesderfer and Anders, pp. 76-77).

Pacific Lamprey and Other Migratory Corridor Species

Pacific lamprey, like other aquatic species that use migratory corridors, rely on specific routes to travel to other river habitats to complete certain life history stages. For instance, Pacific lamprey may use differing habitats like the nearshore marine habitat for feeding; slow moving, depositional shoreline subhabitat along reservoir and streambanks for cover; swift river habitat for migration; and, eventually, upstream tributaries and streams for spawning and rearing.

Historically, Pacific lamprey were distributed in the Basin from the mouth of the Columbia River upstream to the headwaters, to Shoshone Falls in the Snake River, and in the tributaries of each of these rivers (Ward et al. 2012, p. 352). Currently, Pacific lamprey populations are found in most major tributaries and some smaller tributaries up to Chief Joseph Dam in the Columbia

River and up to Hells Canyon Dam in the Snake River (Luzier et al. 2011, pp. 118, 136, 154, 172). Under the NAA, continued operations and maintenance of the CRSO will continue to limit habitat connectivity and reduce habitat complexity that enable Pacific lamprey to fulfill all life history stages in the Basin.

Western Pearlshell Mussel and Other Non-Migratory Species

Freshwater mussels and other non-migratory species show preferences regarding substrate type (boulders and gravel substrate, with some sand, silt, and clay), turbidity, and water temperature (clear, cold water) and, thus, inhabit various river habitats at different times of the year (Howard and Cuffey 2003, p. 73; Stone et al. 2004, p. 341; Vannote and Minshall 1982, p. 4104).

Historically, freshwater mussels such as Western pearlshell were distributed in the Basin from the mouth of the Columbia River Estuary upstream to the headwaters in the Columbia and Snake Rivers, and in the tributaries of each of these rivers (Jepsen et al. 2012, p. 7). Currently, Western pearlshell have been observed in low numbers in the Hanford Reach of the Columbia River and Hells Canyon Reach of the Snake River (Helmstetler and Cowles 2008, p. 212). These and other aquatic non-migratory species will likely experience adverse impacts from continued CRS operations and maintenance due primarily to changes in water quality as a result of higher water temperatures, channel avulsion, and increased sedimentation.

G.1.2 MO1

G.1.2.1 MO1 Summary of Rivers Landscape Findings

- Structural and operational measures of MO1 may benefit mainstem migratory fishes such as white sturgeon and migratory corridor species such as Pacific lamprey, particularly in the Lower Snake River. However, the implementation of some operational measures associated with MO1 may negatively impact these species.
- Structural and operational measures of MO1 intended to benefit Pacific lamprey will likely have positive impacts on lamprey survival during spawning, rearing, and migratory life history stages.

G.1.2.2 MO1 Impacts on Indicators of Ecological and Physical Processes

Compared to the NAA, operational measures of MO1 (e.g., Lake Roosevelt Additional Water Supply, Hungry Horse Additional Water Supply) will likely negatively impact water quantity, especially in the Upper Basin, resulting in higher winter flows out of Libby Dam. The Chief Joseph Dam Project Additional Water Supply measure, which includes provisions to supply an additional 9,600 acre-feet (1,184 hectare meter) of irrigation water, will lead to higher flows in the Kootenai River. Other operational measures, including the Modified Dworshak Summer Draft measure, will likely result in further alterations of the hydrograph on the Clearwater River and water temperature regime downstream of the confluence of the North Fork River with the Clearwater River. The modified draft at Dworshak Dam is intended to benefit migratory fishes by providing additional cool water to the Lower Snake River in July and August, and in September.

Unique to MO1, the proposed Block Spill Test (Base +120/115 Percent) operational measure exceeds state water quality standards for TDG below the four Lower Columbia River dams and four Lower Snake River dams (ODEQ and WSDE 2002, pp. 11-12). However, this proposed spill is not different than what is proposed as part of the NAA. This measure will also likely negatively impact water quality in transition area subhabitat such as that found at the head of key sites like the John Day Reservoir and the Lower Monumental Reservoir, thereby affecting habitat complexity and connectivity for mainstem and migratory corridor species. Operational measures of MO1 represent changes from current operations, but they, if implemented, neither represent nor support historic conditions, prior to the dams, of the rivers landscape.

G.1.2.3 MO1 Impacts on Evaluation Species

White Sturgeon and Other Mainstem Migratory Fishes

Under MO1, structural and operational measures intended to benefit listed Pacific salmon may benefit other mainstem migratory fishes like white sturgeon. The Modify Bonneville Ladder Serpentine Weir structural measure, for instance, will benefit white sturgeon by improving the functioning of the weir for juveniles.

Operational measures including Predator Disruption Operations and Increased Forebay Range Flexibility (both at John Day Dam and the four Lower Snake River dams) will likely reduce the abundance of transition areas in river habitat at key sites like the John Day Reservoir and the Lower Monumental Reservoir.

Pacific Lamprey and Other Migratory Corridor Species

The following structural measures regarding fish passage outlined in MO1 will improve passage for adult Pacific lamprey at the four Lower Columbia River dams and four Lower Snake River dams: Lamprey Passage Structures, Turbine Strainer Lamprey Exclusion, Bypass Screen Modifications for Lamprey, and Lamprey Passage Ladder Modifications. These measures include the expansion and modifications of Lamprey Passage Structures and the modification of turbine intake screens.

However, under MO1, Pacific lamprey will still likely experience negative impacts including low conversion rates of adult Pacific lamprey passing Bonneville Dam and increased level of mortality of juvenile lamprey that encounter turbine intake screens, designed to protect juvenile Pacific salmon. The aforementioned structural measures attempt to address these issues and, thus, the Service encourages the co-lead agencies to implement these improvements under whatever alternative is ultimately selected.

Operational measures associated with MO1 (Increased Forebay Range Flexibility) will likely result in increased reservoir water surface elevation levels at John Day Dam, followed by increased forebay operating range flexibility, which may negatively impact juvenile Pacific lamprey situated along banks and reservoir shorelines. Out-migrating juvenile Pacific lamprey burrow in sediments along banks and shoreline river subhabitat, which may become inundated and subsequently exposed due to changes to operations proposed under MO1.

Western Pearlshell Mussel and Other Non-Migratory Species

Proposed structural and operational measures under MO1 were not developed to directly benefit localized, non-migratory species like the Western pearlshell mussel. However, those species that use transition areas at key sites like the John Day Reservoir and the Lower Monumental Reservoir could be negatively impacted by operational measures as those described to impact mainstem migratory fishes.

G.1.3 MO2

G.1.3.1 MO2 Summary of Rivers Landscape Findings

- Some structural measures under MO2 will benefit Pacific lamprey, however operational measures that enable operations at full pool and do not restrict ramping rates (i.e., rate of change of water flow, measured in meters per second per hour) could negatively affect this species.

G.1.3.2 MO2 Impacts on Indicators of Ecological and Physical Processes

Proposed operational measures under MO2 (Slightly Deeper Draft for Hydropower) will likely result in higher flows out of Dworshak Dam, thereby increasing spring flows in the Lower Snake and Clearwater Rivers and resulting in lower water temperatures. These conditions, compared to those under the NAA, may be more representative of those under a pre-dam hydrograph, and, thus, could benefit aquatic species analyzed in this CAR. However, proposed operational measures under MO2 (in comparison to those under the NAA, MO3, and MO4) that allow for full reservoir operating range at the four Lower Snake River dams (Winter System FRM Space) and reduce ramping rate limitations (Ramping Rates for Safety) may negatively impact both bank and reservoir shoreline and transition area subhabitats in John Day Reservoir and Lower Monumental Reservoir.

G.1.3.3 MO2 Impacts on Evaluation Species

White Sturgeon and Other Mainstem Migratory Fishes

The implementation of structural measures associated with MO2 includes the following activities: diverting fish away from turbines at John Day Dam, McNary Dam, and Ice Harbor

Dam (Additional Powerhouse Surface Passage); upgrading spillway weirs at John Day Dam, McNary Dam, Ice Harbor Dam, Lower Monumental Dam, and Little Goose Dam (Upgrade to Adjustable Spillway Weirs); installing pumping systems for fish ladders at Ice Harbor Dam and Lower Monumental Dam (Lower Snake Ladder Pumps); and installing fish friendly turbines at John Day Dam (Improved Fish Passage Turbines). As proposed, these measures may benefit juvenile Pacific salmon. However, it remains unclear whether or not the proposed structural measures will benefit other mainstem migratory fishes analyzed in this CAR (e.g., white sturgeon).

The MO2 operational measure intended to limit fish passage spill associated with TDG at 110 percent (Spill to 110 percent TDG) offers the most limited TDG under any of the MO scenarios, and does not exceed state water quality standards for TDG (ODEQ and WSDE 2002, pp. 11-12). This spill level will not likely provide any benefits to mainstem migratory fishes (e.g., white sturgeon) that inhabit riverine environments below the four Lower Columbia River dams (e.g., the John Day Reservoir or the four Lower Snake River dams.

Operating the Lower Snake River dams at full pool (Full Range Reservoir Operations) could limit the tailrace-to-pool transition area subhabitat such as the transition area at the head of the Lower Monumental Reservoir. Removing restrictions on ramping rates may lead to reductions in habitat quantity and quality throughout the rivers landscape in the study area.

<u>Pacific Lamprey and Other Migratory Corridor Species</u>

Under MO2, the implementation of fish passage improvements for juvenile Pacific salmon at the four Lower Columbia River dams and the four Lower Snake River dams will likely benefit Pacific lamprey. Likewise, the measures in MO2 associated with modifying the John Day Dam (Improved Fish Passage Turbines, Additional Powerhouse Surface Passage, and Upgrade to Adjustable Spillway Weirs) will likely yield additional benefits to migratory fishes like Pacific lamprey. However, it is unclear to what degree those benefits would be realized for Pacific lamprey and other migratory corridor fishes. Ceasing or delaying the installation of fish screens at John Day Dam and McNary Dam will likely benefit juvenile Pacific lamprey that are migrating downstream. Juvenile Pacific lamprey are often impinged on screens intended to protect juvenile Pacific salmon from Federal project turbines. Impingement mortality on these screens is often 100 percent. The Service recommends the co-lead agencies exercise some flexibility in the timing of screen installation to optimize the conservation benefits for species beyond just Pacific salmon (Moser and Russon 2009, p. 2; Moser et al. 2014, pp. 106, 113).

Operating the Lower Snake River dams at full pool (Full Range Reservoir Operations) could limit the tailrace-to-reservoir transition area, and no restrictions on ramping rates (Ramping Rates for Safety) at the four Lower Columbia River dams and the four Lower Snake River dams may reduce the stability of these subhabitats. More flexibility in elevation operating range could lead to reduced abundance of transition areas upstream, and no restrictions on ramping rates could lead to rapid fluctuations in the general size of these habitats, thus reducing stability. Further, juvenile Pacific lamprey burrow in sediments along banks and reservoir shorelines, which may be inundated and subsequently exposed due to proposed changes to ramping rates as part of MO2, threatening Pacific lamprey survival.

Western Pearlshell Mussel and Other Non-Migratory Species

Proposed structural and operational measures under MO2 are not intended to benefit localized, non-migratory species like the Western pearlshell mussel. Those species that utilize transition areas (e.g., suckers, sculpin) could also be negatively impacted by operational measures as those described to negatively impact mainstem migratory and migratory corridor species.

G.1.4 MO3

G.1.4.1 MO3 Summary of Rivers Landscape Findings

- The greatest ecological benefits for evaluation species and other mainstem migratory, migratory corridor, and localized, non-migratory species may be realized from breaching the earthen portions of the four Lower Snake River dams.
- While structural measures in MO3 will likely benefit Pacific lamprey, some of the operational measures in MO3 could negatively impact this species and other migratory corridor species due to the lack of ramping rate restrictions.

G.1.4.2 MO3 Impacts on Indicators of Ecological and Physical Processes

In comparison to the other CRSO alternatives, proposed structural measures (Breach Snake Embankments, Lower Snake Infrastructure Drawdown) and operational measures (Drawdown Operating Procedures, Drawdown Contingency Plans) associated with MO3 offer the greatest potential for ecological improvements in the study area. In particular, dam breaching would likely improve water quality, connectivity to existing unimpounded river reaches (e.g., Hanford Reach, Clearwater River), habitat complexity, floodplain and side channel creation and maintenance, and tributary mouths throughout the study area.

Similar to MO1, and in contrast to NAA and MO2, the implementation of operational measures in MO3 (Modified Draft at Libby, December Libby Target Elevation) will likely provide higher flows out of Libby Dam, leading to higher winter flows in the Kootenai River. Under MO3, in contrast to NAA and MO4, negative impacts on river ecological and physical processes could be realized at the four Lower Columbia River dams as a result of proposed operational measures that affect pool levels (John Day Full Pool), reduce restrictions on ramping rates (Ramping Rates for Safety), and increase TDG below projects (Spring Spill to 120 percent TDG). As a result, adverse effects may be observed at key sites like the mouth of the Deschutes River and John Day Reservoir. However, the overall ecological benefits from dam breaching measures are likely to surpass the potential negative impacts of other measures.

G.1.4.3 MO3 Impacts on Evaluation Species

White Sturgeon and Other Mainstem Migratory Fishes

The dam breaching structural and operational measures associated with MO3 have the greatest potential to positively impact mainstem migratory fishes, including Pacific lamprey and white sturgeon. Breaching the earthen portions of the four Lower Snake River dams will provide access to more habitat that can support several mainstem migratory fishes.

Proposed operational spring spill at the four Lower Columbia River dams (Spring Spill to 120 percent TDG) exceeds state water quality standards for TDG (ODEQ and WSDE 2002, pp. 11-12). This is not likely to negatively impact mainstem migratory fishes like white sturgeon that use these areas to complete multiple life history stages such as spawning and juvenile rearing.

Structural measures associated with MO3 include diverting fish away from turbines at John Day, McNary, and Ice Harbor Dams (Additional Powerhouse Surface Passage); upgrading spillway weirs at John Day, McNary, Ice Harbor, Lower Monumental, and Lower Granite Dams (Upgrade to Adjustable Spillway Weirs); and installing fish friendly turbines at John Day Dam (Improved Fish Passage Turbines). However, it remains unclear whether or not the proposed structural measures will benefit other mainstem migratory fishes analyzed in this CAR (e.g., white sturgeon).

Pacific Lamprey and Other Migratory Corridor Species

MO3 would lead to significant benefits for migratory corridor species. There are numerous resident and migratory species in the Lower Snake River that are negatively affected by current CRS operations. Breaching the earthen portions of the four Lower Snake River dams would benefit these species, and the rivers landscape overall, by increasing connectivity between river habitats that support various ecological and physical processes and life history stages.

Proposed operational spring spill at the four Lower Columbia River dams (Spring Spill to 120 percent TDG) exceeds state water quality standards for TDG. This would not likely negatively impact Pacific lamprey and other migratory corridor species in places such as the head of the John Day Reservoir (ODEQ and WSDE 2002, pp. 11-12).

Under MO3, the operational measure proposing no restrictions on ramping rates (Ramping Rates for Safety) at the four Lower Columbia River dams may negatively impact transition areas and bank and reservoir shoreline subhabitats (i.e., at sites like the John Day Reservoir). Proposed changes as a result of structural measures (e.g., expanding and thereby improving Lamprey Passage Structures at the four Lower Columbia River dams) would likely benefit Pacific lamprey. Similar to MO2, the implementation of measures associated with MO3 would provide greater benefits to Pacific lamprey than those measures associated with MO1.

Western Pearlshell Mussel and Other Non-Migratory Species

The structural and operational dam breaching measures of MO3 may benefit the Western pearlshell and other freshwater mussels, over time. However, in the short-term, the release of accumulated sediment behind the four dams will negatively impact any fishes and wildlife that cannot relocate to alternative sites (such as freshwater mussels). This effect will be particularly acute in the Lower Snake River and the McNary Reservoir (i.e., Lake Wallula). While there will likely be negative impacts on freshwater mussel habitat and other non-migratory species associated with the release of accumulated sediment, these impacts will also be short-term given the sediment transport capacity of the Lower Snake River (Grant and Lewis 2015, p. 34).

In the long-term, breaching the earthen portions of the four Lower Snake River dams will likely lead to the reestablishment of natural hydrologic processes (e.g., deposition and sediment transport). A return to natural hydrology would, in turn, promote island habitat and side channel subhabitat formation, which supports many aquatic species through multiple life history strategies.

G.1.5 MO4

G.1.5.1 MO4 Summary of Rivers Landscape Findings

- Structural and operational measures of MO4 are likely to benefit white sturgeon, Pacific lamprey, Western pearlshell mussel, and other mainstem migratory, migratory corridor, and localized or non-migratory species, but not to the extent of those benefits resulting from MO3.
- Operating at the Minimum Operating Pool (MOP) will likely maximize the abundance and size of transition areas throughout mainstem subhabitats within the study area, and enhance upstream and downstream migration for migratory evaluation species like white sturgeon and Pacific lamprey.
- MO4, which proposes the highest spill percentage among all CRSO alternatives, may lead to negative impacts on water quality standards critical for white sturgeon growth and survival.

G.1.5.2 MO4 Impacts on Indicators of Ecological and Physical Processes

In comparison to the NAA and MO2, the implementation of proposed operational measures under MO4 (Modified Draft at Libby, December Libby Target Elevation) will likely result in higher flows out of Libby Dam, which translate to higher winter flows in the Kootenai River. While these measures may provide more flexibility in downstream water delivery, they may not support historic environmental conditions in this reach.

Operational measures of MO4 proposed (Spill to 125 percent TDG) in the Lower Columbia and Lower Snake Rivers will result in the highest TDG levels among CRSO alternatives below Federal projects, potentially negatively impacting connectivity and critical transition area subhabitat (i.e., at key sites like the John Day Reservoir and the Lower Monumental Reservoir). However, in comparison to all other alternatives, operational measures under MO4 that provide minimum flows out of McNary Dam (McNary Flow Target) and establish reservoir levels at MOP (Drawdown to MOP) may reduce the overall temperature profile below McNary Dam. Such a reduction could result from peak flows lasting through the descending limb of the hydrograph, thus improving water quality and supporting the formation and maintenance of bank and reservoir shoreline, transition (e.g., John Day Reservoir), and tributary mouth (e.g., mouth of the Deschutes River) subhabitats in the Lower Columbia River.

G.1.5.3 MO4 Impacts on Evaluation Species

White Sturgeon and Other Mainstem Migratory Fishes

The implementation of structural measures associated with MO4 include diverting fish away from turbines at the John Day, McNary and four Lower Snake River dams (Additional Powerhouse Surface Passage) and improving the Lower Granite Dam adult trap bypass (Lower Granite Trap Modifications). MO4 also proposes to add spillway weir notch gates at John Day, McNary, and the four Lower Snake River dams (Spillway Weir Notch Inserts); pumping systems for fish ladders at Ice Harbor and Lower Monumental Dams (Lower Snake Ladder Pumps); and fish friendly turbines at the John Day Dam (Improved Fish Passage Turbines). These measures are intended to benefit primarily migratory corridor species like Pacific salmon, but, due to similar life history stage requirements, may also benefit mainstem migratory fishes like white sturgeon.

Proposed high spill during the spring emigration (Spill to 125 percent TDG) exceeds state water quality standards for TDG and may negatively impact mainstem migratory fishes (e.g., white sturgeon) at key sites like the head of the John Day and Lower Monumental Reservoirs more than MO3 (ODEQ and WSDE 2002, pp. 11-12).

Operating the four Lower Columbia River dams and the four Lower Snake River dams at MOP (Drawdown to MOP) would maximize the tailrace-to-reservoir transition area subhabitat at key sites like the John Day Reservoir and the Lower Monumental Reservoir, thereby increasing the complexity of the rivers landscape and support for mainstem migratory fishes, migratory corridor species, and non-migratory species.

The measure to maintain 220.0 kcfs (6,230 m^3/s) flows at McNary Dam (McNary Flow Target) may benefit mainstem migratory fishes in the Lower Columbia River, especially in low water years. For example, in 2015, from May 1 through July 31, 2015, the average outflow at McNary Dam was 164.0 kcfs (4,644 m^3/s) (ranging from 111.0 kcfs to 220 kcfs [3,143 m^3/s to 6,230 m^3/s]). Higher flows in low-water years may lead to improved ecological conditions below Federal projects in the Lower Columbia River that benefit multiple life history stages of mainstem migratory and migratory corridor species.

Pacific Lamprey and Other Migratory Corridor Species

Proposed modifications as part of MO4 (e.g., modification of cooling water strainer to exclude Pacific lamprey at the four Lower Columbia River and four Lower Snake River dams) will likely yield benefits for Pacific lamprey. Structural modifications (Improved Fish Passage Turbines, Bypass Screen Modifications for Lamprey, and Lamprey Passage Ladder Modifications) at the four Lower Columbia River dams will also likely benefit Pacific lamprey. These measures include expanding or improving lamprey passage structures at Bonneville Dam, The Dalles Dam, and John Day Dam; modifying cooling water strainer to exclude Pacific lamprey; modifying turbine intake screens at McNary Dam; and, modifying ladders for lamprey passage at the four Lower Columbia River dams and the four Lower Snake River dams. As in MO2 and MO3, the implementation of measures associated with MO4 would provide greater benefits to Pacific lamprey than MO1.

Operating the four Lower Columbia River dams and the four Lower Snake River dams at MOP would maximize the tailrace-to-reservoir transition area subhabitat (e.g., at key sites like the head of the John Day Reservoir and the Lower Monumental Reservoir), thereby increasing the complexity of the rivers landscape and support for migratory corridor species.

Western Pearlshell Mussel and Other Non-Migratory Species

Operating the four Lower Columbia River dams and the four Lower Snake River dams at MOP will maximize the tailrace-to-reservoir transition area (e.g., at key sites like the head of the John Day Reservoir and the Lower Monumental Reservoir), thereby increasing the structural complexity and resiliency of the rivers landscape.

G.2 LAKES AND RESERVOIRS

G.2.1 NAA

G.2.1.1 NAA Summary of Lakes and Reservoirs Landscape Findings

- Structural and operational measures will continue to negatively impact the current hydrograph by reducing water quantity in unimpounded river reaches during high flows, reducing peak discharges, and by storing water for use later in the year.

G.2.1.2 NAA Impacts on Indicators of Ecological and Physical Processes and Subhabitats

Water Quantity

In the Basin, water quantity is largely dependent on the size of the annual snowpack and runoff. Storage reservoirs hold water during the spring runoff for power generation, water supply, and to reduce flood risk downstream. Operations under the NAA fill and drawdown various amounts of water from the storage reservoirs in the Lower Columbia River, Mid-Columbia River, and the Lower Snake River.

Under the NAA, the 14 Federal CRS projects and associated reservoirs have greatly influenced the rivers landscape downstream of each project (Nilson and Berggren 2000, p. 783; Ward and Stanford 1983, pp. 29-30). Changes in operations and maintenance of these projects will also significantly affect water quantity in the lakes and reservoirs landscape throughout the study area (Stanford and Ward 2001, p. 308).

Habitat Complexity, Species Diversity, and Ecosystem Function

Due to the lack of diverse vegetation and natural substrate, storage reservoirs in the Columbia and Snake Rivers are not as morphologically or ecologically diverse as the natural lake or river habitats that were in place prior to dam construction (USFWS 1999, p. M4-1). There will likely be additional negative, cascading effects on the lakes and reservoirs landscape due to more frequent changes in water levels resulting from proposed CRS operations. Under the NAA, these effects include a loss in riparian vegetation and modification of shoreline structure and species composition, which could result in significant regional declines in, and even the extirpation of, wildlife species (McAllister et al. 2001, pp. 15-39).

Barren Lands and Islands

The abundance of barren land (i.e., drawdown zones) and shorelines surrounding reservoirs and islands within reservoirs depends on the water surface elevation of reservoirs in the Basin. Under the NAA, drawdowns and refills will continue to negatively impact fish and wildlife resources. For example, when reservoirs are full, the barren zone is unavailable to shorebirds, such as dunlin, that might benefit from exposed habitats for foraging purposes. Similarly, islands will be more exposed during times of low water surface elevation. Increased exposure can lead to the creation of land bridges, which may open new travel corridors for terrestrial predators or, potentially, non-native species. Increased predation and the spread of non-native species could result in more severe impacts to colonial nesting birds such as Caspian terns and double-crested cormorants. Conversely, if water levels are higher (i.e., decreased exposure), islands may become inundated and thus, unable to provide nesting habitat and other habitat for species analyzed in this CAR.

G.2.1.3 NAA Impacts on Key Sites

Lower Columbia River: John Day River Confluence, Blalock Island Complex, and Umatilla River Confluence

Under the NAA, from April 10 through September 30, John Day Dam is operated to minimize water travel time for out-migrating juvenile Pacific salmon. Operation of the forebay is held within the Minimum Irrigation Pool (MIP) range (from 262.5 ft to 264.0 ft [80.00 m to 81.00 m). The MIP is the lowest pool elevation that allows for irrigation withdrawals. Irrigation withdrawals from the John Day Pool typically begin in early March and extend through mid-November. During this time of year, additional barren lands and shoreline, as well as islands, will be exposed in comparison to winter months. Safety precautions prohibit sudden changes in the flow from the John Day Reservoir under current operating conditions. However, during unusual or emergency conditions, water surface elevation may be adjusted to meet other authorized project purposes such as navigation.

Operating projects within a large range (e.g., ±2.00 ft [0.61 m]) may cause lake and reservoir habitats to be unusable for fish and wildlife resources, even becoming a source of mortality for them. For example, when water levels are low, terrestrial wildlife may attempt to nest in the barren lands and along the shoreline. When low water levels are maintained, these habitats can be productive. However, if water levels are subsequently raised, any nests and eggs could be flooded, disturbed, or lost. These barren lands and nearshore areas can become mortality sinks because they appear to offer ideal conditions for nesting, but changing conditions (i.e., rising water levels) can result in lost productivity and mortality in the same areas. Conversely, when water levels are high, aquatic species may attempt to spawn in these areas during periods of flooding. If the water levels subsequently drop, then any eggs or larval fish will be lost, and those spawning attempts would ultimately fail.

Continuing to operate the John Day Reservoir to raise and lower water surface elevation on a regular basis will lead to similar impacts on fish and wildlife resources and critical lake and reservoir habitats. Conversely, maintaining a fairly stable pool elevation during important foraging, breeding, and spawning periods will minimize the negative impacts to both aquatic and terrestrial species analyzed in this CAR.

Mid-Columbia River: Lake Roosevelt

The current operational draft rate limit for Lake Roosevelt is 1.5 ft (46 cm) per 24 hours. Maintaining this rate minimizes potential bank sloughing and erosion caused by rapid reservoir drawdown. The co-lead agencies also manage Grand Coulee Dam, Libby Dam, Hungry Horse Dam, and Dworshak Dam to provide flow augmentation that benefits migratory fishes in the spring and summer. Spring flow augmentation generally begins in April, after the storage reservoirs have filled to the FRM targets for that year. These operations will continue under the NAA.

To provide summer flow augmentation under the NAA, water from Libby Dam and Hungry Horse Dam is allocated after refill to maximum water surface elevation, usually around June 30. The summer augmentation draft benefits native migratory and resident fishes downstream of the Federal CRS projects. Beginning in July, Grand Coulee Dam is also drafted to provide summer flow augmentation to benefit juvenile Pacific salmon the Columbia River. These drafts reduce negative impacts to lake and reservoir habitats for fish and wildlife resources along the Columbia and Snake Rivers by attempting to mimic a pre-dam hydrograph. The pulse improves conditions for native species that depend on high flows in late spring and early summer (i.e., for reproductive purposes), followed by a descending hydrograph from mid-summer to mid-fall.

Flow augmentation drafts will allow many of the key lakes and reservoir sites along the Columbia River to experience improved ecological conditions that benefit native species.

Upper Basin: Lake Pend Oreille and Lake Koocanusa

The co-lead agencies manage water surface elevation at Albeni Falls Dam to support kokanee, a critical food source for listed bull trout. During the spring, the co-lead agencies fill Lake Pend Oreille in accordance with existing FRM criteria. During the summer, the co-lead agencies maintain Lake Pend Oreille around an elevation of 2,062 ft (628.0 m) to support recreational activities through Labor Day. Starting October 1, the Federal project begins drafting to target a water surface elevation within 0.5 ft (15 cm) of 2,051 ft (625.0 m) by mid-November, prior to kokanee spawning.

Operations at Libby Dam include the release of flows to benefit listed Kootenai River white sturgeon. The co-lead agencies typically initiate sturgeon flow augmentation during mid- to late May, and it extends into mid-June. Augmentation may even continue into late June or early July, depending on sturgeon spawning behavior and location, water temperature, local inflow below the Libby Project, and FRM downstream of Libby Dam. The intent of sturgeon flow augmentation is to increase lower Basin runoff from tributaries of the Kootenai River downstream of the Libby Project. The benefits associated with this augmentation will continue under the NAA.

The co-lead agencies draft Libby Dam in the summer to benefit resident fishes in the Kootenai River and Pacific salmon in the Columbia River. To meet the needs of Kootenai River white sturgeon and resident trout species, current operations ensure minimum flows in the rivers downstream to support these species and are prioritized over summer refill for recreation. The co-lead agencies operate Libby Dam during the winter and early spring for FRM to achieve a 75 percent probability of reaching the April 10 elevation objective to provide water to increase spring flows. The co-lead agencies operate Grand Coulee Dam during the winter and early spring for FRM to achieve 85 percent probability of reaching the April 10 elevation objective to provide water to increase spring flows. These benefits for resident fishes will continue under the NAA.

Lower Snake River: Dworshak Reservoir

In the spring, the co-lead agencies operate Dworshak Dam to maximize the probability of refilling the reservoir to support summer flow augmentation and, additionally, to provide flows needed to meet spring objectives in the Lower Snake River during the out-migration of juvenile Pacific salmon and steelhead. In the spring, Dworshak Dam releases between approximately 4.00 kcfs and 6.00 kcfs (113 m^3/s to 170 m^3s) to help move fish from the Dworshak National Fish Hatchery and the Clearwater State Hatchery, located directly downstream, into the mainstem Clearwater River.

Flow augmentation from Dworshak Dam, which will continue under the NAA, significantly reduces water temperatures from mid-summer to early fall and increases water velocities through the Lower Snake and Clearwater Rivers. These lower temperatures and higher water velocities will likely benefit many lakes and reservoir habitats and species (e.g., Pacific lamprey and native freshwater mussels) by creating conditions close to those that historically supported these species best.

G.2.1.4 NAA Impacts on Evaluation Species and Other Guilds and Communities

Clark's Grebe and Western Grebe

Clark's grebe and Western grebes will be negatively impacted by rapid fluctuations in water surface elevation in CRS reservoirs. Maintenance of a stable water surface elevation in the persistent emergent vegetation areas around a water body during April through July is critical to grebe nesting success and to prevent isolation of individuals from their nests. Additionally, grebe nesting coincides with the boating and water-recreation season in the Basin, which can negatively impact grebes given their colonial nesting behavior, fragile-floating nest structures, and general refusal to fly during breeding (La Porte et al. 2013). Under the NAA, disturbance will continue to threaten grebe growth and survival on all but adequately protected waters.

Dunlin

Dunlin will likely experience benefits from additional barren lands and exposed shorelines. In the Lower Columbia River, dunlin use these areas, which include mudflats, for foraging during their spring and fall migration periods. Operations under the NAA will likely maintain the current abundance of migratory habitat that is seasonally available to species like dunlin.

Floaters

Rapid drawdowns of storage reservoirs can be problematic for a suite of wildlife species, but especially for freshwater mussels like floaters. Dry periods and reservoir drawdowns usually expose these mussels and, while a few individuals may travel to deeper water, most burrow into the sediment and die if water levels do not quickly return to normal before the mussels desiccate and overheat (Gates et al. 2015, pp. 620-621; Nedeau et al. 2009, pp. 1-4). Exposed mussels may also be more susceptible to predation by foraging birds and mammals. Under the NAA, operations will continue to result in negative impacts to freshwater mussels and floaters, in particular.

Colonial Nesting Waterbirds

The co-lead agencies operate the Federal CRS projects to reduce predation of juvenile Pacific salmon and steelhead in the Lower Columbia River by limiting habitat and colony establishment for colonial nesting waterbirds (Collis et al. 2006, pp. 5-8, 42-44). The continuation of these operations and activities under the NAA will effectively limit colonial nesting waterbird colonies in the Lower Columbia River and could negatively impact population abundance in the future.

G.2.2 MO1

G.2.2.1 MO1 Summary of Lakes and Reservoirs Landscape Findings

- Structural and operational measures proposed will continue to negatively impact the current hydrograph in some areas of the Basin. The most significant change observed will be an increase in water surface elevation, overall, and an increase in the frequency of fluctuations of the John Day Reservoir during the spring and summer.

G.2.2.2 MO1 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

MO1 will further alter the current hydrograph, leading to the accelerated loss of habitat complexity, species diversity, and ecosystem function. MO1 includes two operational measures (Increased Forebay Range Flexibility and Predator Disruption Operations) that will change water quantity and water surface elevation of the John Day Reservoir. For instance, the Increased Forebay Range Flexibility measure will increase the reservoir elevation range and operational flexibility at John Day Dam between April and August. Under this measure, the co-lead agencies will raise water surface elevation 2.0 ft (60 cm) above MIP between June 1 and August 31. Additionally, the implementation of the Predator Disruption Operations measure will raise the pool elevation in the John Day Reservoir in April and May by an additional 1.5 ft (46 cm) for a total of a 2.0 ft (61 cm) increase in reservoir elevation.

The implementation of several other structural measures under MO1 will improve passage rates for Pacific lamprey at John Day Dam.

G.2.2.3 MO1 Impacts on Key Sites

<u>Lower Columbia River: John Day River Confluence, Blalock Island Complex, and Umatilla River Confluence</u>

Under MO1, the Increased Forebay Range Flexibility operational measure will increase the frequency of fluctuations in water levels and water surface elevation by 0.5 ft (15 cm) in the summer. In addition, the Predator Disruption Operations operational measure at John Day Dam will raise the pool elevation by approximately 1.0 ft (30 cm) in the John Day Reservoir in April and May. This measure will also likely result in an increase in water surface elevation, thereby reducing the abundance of barren lands, shorelines, and low-lying areas for species to use in and around the John Day Reservoir during the spring and summer months.

Under MO1, Umatilla NWR will experience a severe loss in diversity of island habitat, primarily at the Blalock Island complex. The proposed structural and operational measures will negatively affect pool management capabilities at the refuge, thereby decreasing the resiliency of rare wet meadow plant communities that develop on the narrow edges of island habitat and support waterfowl and other species (Healy, F., in litt. 2019).

Mid-Columbia River: Lake Roosevelt

Collectively under MO1, the implementation of various operational measures, including the Update System FRM Calculation and Planned Draft Rate at Grand Coulee measures, will influence water quantity and water surface elevation, particularly in Lake Roosevelt. These measures will lower water levels in Lake Roosevelt longer into the spring months compared to current conditions. The Winter FRM Space operational measure will also likely result in a reduction in water quantity in Lake Roosevelt during the winter.

Under MO1, the implementation of some measures will increase the exposure time of the barren zone around the perimeter of Lake Roosevelt as well as around islands in the winter and spring, resulting in transitions from wetland or riparian habitats to those that are more tolerant of dry conditions.

Upper Basin: Lake Pend Oreille and Lake Koocanusa

Under MO1, no structural changes will be implemented at Albeni Falls Dam. Similarly, no changes will be made to Albeni Falls operations in most water years. The co-lead agencies' H&H modeling output shows that water surface elevation in most water years will be consistent with that under the NAA, except for a few river reaches that would not affect Lake Pend Oreille. The difference in monthly water surface elevation (less than 6.0 inches [15 cm]) during most water years and months is within the expected range of natural variability.

Only one operational measure in MO1 (Winter System FRM Space) will likely impact Albeni Falls Dam. This measure will increase flexibility to account for winter precipitation runoff events by increasing space for water in Lake Pend Oreille. Under MO1, water quantity and natural lake water surface elevation will remain the same in Lake Pend Oreille, with the exception of lower water levels in the winter months.

The co-lead agencies propose to implement three measures (Modified Draft at Libby, December Libby Target Elevation, and Sliding Scale at Libby) at Libby Dam. The Modified Draft at Libby operational measure will base Lake Koocanusa's refill initiation on the local forecast versus forecasts at The Dalles Dam, as specified in the NAA. This change will allow for additional flexibility in the co-lead agencies' responses to local conditions in the Upper Basin. This measure also will provide more flood space for local high-spring flow and lower the risk of filling the reservoir early, which could result in the need to draw down the reservoir to create more flood space before the end of the FRM operations season.

The implementation of the December Libby Target Elevation measure will change current operations at Libby Dam from a variable draft at the end of December to a fixed draft target of elevation 2,420 ft (738.0 cm) to prevent over-drafting of the Lake Koocanusa in years that have less precipitation than forecasted. The implementation of the Sliding Scale at Libby measure will increase operational flexibility at Libby Dam through use of local water supply forecasts to manage operations to support local fish and wildlife resources, rather than using forecasts at The Dalles Dam as specified in the NAA. This measure establishes a new September target elevation 5.0 ft (1.5 m) higher, resulting in higher water levels (i.e., from 1.0 ft to 2.0 ft [30 cm to 61 cm], on average) in Lake Koocanusa between June and September. During the spring, water levels in Lake Koocanusa will drop and, during the summer, fall, and winter, water levels will increase in comparison to current conditions.

Lower Snake River: Dworshak Reservoir

Under MO1, two operational measures (Winter System FRM Space and Modified Dworshak Summer Draft) will impact water quantity at and around Dworshak Reservoir. The Winter System FRM Space measure will increase the space, and therefore lower the water surface elevation, in Dworshak Reservoir from December through March. The Modified Dworshak Summer Draft measure will result in lower water surface elevation in the early summer months. However, in August and early September, the draft rate will also decrease, resulting in increases in water surface elevation by as much as 10 ft (3.0 m) relative to current conditions. By the end of September, water surface elevation in the reservoir would be consistent with pool elevations in current conditions. The implementation of the Modified Dworshak Summer Draft measure will reduce water quantity in Dworshak Reservoir during the early summer and increase water quantity later in the summer.

G.2.2.4 MO1 Impacts on Evaluation Species and Other Guilds and Communities

Floaters

Operational measures will likely subject floaters and Western pearlshell to more frequent fluctuations in water surface elevation, which could leave these species intermittently exposed to desiccation and predation, especially by waterbirds (LaPorte et al. 2013; Nedeau et al. 2009, p. 21). Conversely, the implementation of several structural measures in MO1 will improve passage rates for Pacific lamprey at John Day Dam upstream to the John Day Reservoir and then on to upstream rivers (e.g. John Day River and Umatilla River).

In the Mid-Columbia River, the implementation of some measures associated with MO1 could increase the exposure time of the barren zone around the perimeter of Lake Roosevelt and island habitats during the winter and spring, which could lead to a transition from wetland and riparian subhabitats to those more tolerant of dry conditions. Thus, species like floaters could be negatively impacted (Nedeau et al. 2009, p. 21).

Colonial Nesting Waterbirds

Structural and operational measures will result in higher and more variable reservoir elevations in the Lower Columbia River. The Predator Disruption Operations measure will raise and maintain John Day Reservoir water surface elevations between 263.5 ft (80.00 m) and 265.0 ft (81.00 m) during April and May to disrupt Caspian terns from successfully nesting at the Blalock Islands complex. Higher water surface elevation will also reduce the abundance of barren lands, shorelines, and low-lying areas in and around the John Day Reservoir during the spring and summer months.

The Increased Forebay Range Flexibility operational measure in MO1 will increase the operating elevation range by 2.0 ft (61 cm), from 262.5 ft to 264.5 ft (80.00 m to 81.00 m), from June 1 to August 31 to MIP. Caspian terns have historically experienced low productivity at the Blalock Island complex either due to nest predation by mammalian or avian predators or to high water levels and high winds in John Day Reservoir (BRNW 2013, p. 23; BRNW 2014, p. 27). Under MO1, the threat of inundation during incubation season will be greater than in recent years as a result of the Increased Forebay Range measure. Water surface elevation at and below the 263.5 ft (80.00 m) reservoir level will likely provide nesting habitat for approximately 6,000 waterbirds. However, an increase in water surface elevation will inundate nests. The greatest negative effects would occur if birds initiate nesting and, subsequently, reservoir water surface elevation increases.

The potential impacts of raising or maintaining John Day Reservoir water surface elevation between 263.5 ft and 265.0 ft (80.00 m and 81.00 m) during typical nest initiation time through the Predator Disruption Operations measure, and implementing the Increased Forebay Range Flexibility measure during typical incubation time include:

- reduction in the regional breeding population by 3 percent if the Caspian terns do not relocate and do not nest again;
- nest initiation followed by subsequent flooding of nests with eggs or chicks, which would decrease productivity;
- relocation by Caspian terns to other areas in the Columbia River Plateau Region, like colony sites at Sprague Lake and Lenore Lake; and,
- relocation by Caspian terns to other areas in, or outside of, the Basin at active or historic sites and Corps-created or -enhanced sites. Although habitat was created and enhanced at sites outside the Basin to mitigate impacts resulting from past management plans, Caspian tern population abundance has not increased in recent years (Hartman et al. 2019, p. 13; Peck-Richardson et al. 2019, p. 22; Peterson et al. 2017a, p. 22; Peterson et al. 2017b, p. 1). The sites are likely limited by other factors such as food availability, disturbance, and predation.

At John Day Reservoir, impacts to Caspian terns should be viewed from a Pacific Flyway population perspective, considering the cumulative effects of past management plans and actions taken across the flyway that affect the population. These impacts, along with all previous and likely future impacts, will further reduce the Caspian tern regional breeding population.

Increases in water surface elevation caused by the Predator Disruption Operations measure will also reduce the abundance of barren lands, shorelines, and low-lying areas in and around the John Day Reservoir during the spring and summer, thereby limiting the quantity and quality of foraging areas available to migratory birds (e.g., dunlin) (Warnock and Gill 1996). Conversely, under MO1, some operational measures in the Mid-Columbia River will increase the exposure time of barren lands and shoreline surrounding Lake Roosevelt, as well as surrounding island habitat in the winter and spring.

G.2.3 MO2

G.2.3.1 MO2 Summary of Lakes and Reservoirs Landscape Findings

- MO2 will result in deeper drafts for hydropower, which will lead to an overall temporary reduction in water surface elevation and the potential for the most frequent fluctuations in water surface elevation in both mainstem and storage reservoirs.

G.2.3.2 MO2 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

The implementation of MO2 includes two operational measures (Spill to 110 percent TDG and Contingency Reserves in Fish Spill) that will increase the amount of water moving through turbines, but will not affect water quantity or water surface elevation in the John Day Reservoir. Other operational measures associated with MO2 that may impact reservoirs in the study area include Ramping Rates for Safety and the John Day Full Pool measures. The Ramping Rates for Safety measure will allow water levels in natural lake and reservoir habitats to fluctuate more often, which could negatively impact ecological and physical processes that support habitat complexity, species diversity, and ecosystem function. The John Day Full Pool operational measure will increase the water quantity in, and elevation of, the John Day Reservoir. This measure will also lead to the most frequent (hourly and daily) fluctuations in water levels compared to other measures associated with other alternatives.

MO2 includes several structural measures including: Lamprey Passage Structures, Turbine Strainer Lamprey Exclusion, Bypass Screen Modifications for Lamprey, and Lamprey Passage Ladder Modifications. Collectively, these measures will improve survival of juvenile Pacific lamprey and improve upstream passage conditions for adult Pacific lamprey, especially at John Day Dam.

G.2.3.3 MO2 Impacts on Key Sites

<u>Lower Columbia River: John Day River Confluence, Blalock Island Complex, and Umatilla River Confluence</u>

Under MO2, overall water surface elevation will increase, reducing the quantity of available barren lands, shorelines, and low-lying areas throughout the year in comparison to current conditions. However, under MO2, the Ramping Rates for Safety and the John Day Full Pool operational measures will increase the likelihood of frequent fluctuations in water levels, thereby negatively impacting subhabitats and species in the John Day Reservoir.

Similar to MO1, under MO2, Umatilla NWR will experience a major loss in island habitat diversity, primarily at the Blalock Island complex, thereby negatively impacting rare wet meadow plant communities, waterfowl, and colonial nesting waterbirds.

Mid-Columbia River: Lake Roosevelt

Under MO2, no structural measures will be implemented in the Mid-Columbia River. However, several operational measures proposed at Grand Coulee Dam, including Ramping Rates for Safety, Slightly Deeper Draft for Hydropower, Update System FRM Calculation, Planned Draft Rate, Grand Coulee Maintenance Operations, and Winter System FRM Space will influence water surface elevation in Lake Roosevelt, resulting in changes to the quantity and distribution of lake-like habitats in this area.

The implementation of the Update System FRM Calculation operational measure will use forecasts at The Dalles Dam to determine end-of-April draft requirements without modification at Grand Coulee Dam (every year, from January through April). Under the Planned Draft Rate and Winter System FRM Space operational measures, lower water surface levels in Lake Roosevelt are expected to persist longer into the spring months in comparison to current conditions.

The implementation of Ramping Rates for Safety and Slightly Deeper Draft for Hydropower operational measures will result in changes in draft rates to provide more operational flexibility for hydropower production. The Ramping Rates for Safety measure, in particular, will better enable dam operators to change flow operations within a 24-hour period to meet various energy demands; functionally, this measure will enable the co-lead agencies to modify water surface elevation at a faster rate.

The implementation of several operational measures associated with MO2 will influence water quantity and water surface elevation in Lake Roosevelt. The Planned Draft Rate and Winter System FRM Space measures will create lower water levels in Lake Roosevelt that are expected to persist longer into the spring months in comparison to current conditions. Under MO2, the implementation of these measures will increase the exposure time of barren lands and shorelines around the perimeter of Lake Roosevelt, as well as around islands in the winter and spring, benefitting terrestrial species that rely on these habitats.

Upper Basin: Lake Pend Oreille and Lake Koocanusa

No structural changes will be implemented at Albeni Falls Dam. However, three operational measures (Winter System FRM Space, Slightly Deeper Draft for Hydropower, and Ramping Rates for Safety) will be implemented at Albeni Falls Dam, thereby affecting Lake Pend Oreille.

These measures will alter draft and refill processes to maximize hydropower production while balancing FRM to adjust winter pool elevation targets. In average water years, winter outflows from Albeni Falls Dam in the winter months will increase substantially in comparison to current conditions.

Under MO2, water quantity and disturbance as a result of recreational activities will largely remain the same in Lake Pend Oreille, with the exception of water surface elevation, which will decrease during the winter months. Changing ramping rates and draft conditions at Albeni Falls Dam will also change water surface elevation on Lake Pend Oreille, leading to increased desiccation of submerged aquatic vegetation and emergent wetland plants.

Under MO2, several operational measures will be implemented at Libby Dam including: Ramping Rates for Safety, Slightly Deeper Draft for Hydropower, Sliding Scale at Libby, Modified Draft at Libby, and December Libby Target Elevation. The implementation of the Ramping Rates for Safety and Slightly Deeper Draft for Hydropower measures will result in changes in draft rates from current conditions. The Ramping Rates for Safety measure will enable the co-lead agencies to change flow operations and allow for water surface elevation to fluctuate at a faster rate. The Slightly Deeper Draft for Hydropower measure will relax restrictions on seasonal pool water surface elevation at the Federal storage projects to allow for deeper drafts. These operational measures, compared to those associated with the NAA and MO1, will lead to a significant increase in the rate of change in water levels in Lake Koocanusa.

The implementation of the Sliding Scale at Libby operational measure will increase operational flexibility at Libby Dam by using local water supply forecasts to manage operations to balance local fish and wildlife priorities and downstream flows, rather than using those associated with The Dalles Dam. This measure will also establish a new September target elevation 5.0 ft (1.5 m) higher than in current conditions, resulting in higher water surface levels (i.e., from 1.0 ft to 2.0 ft [30 cm to 61 cm], on average) in Lake Koocanusa between June and September. Under MO2, the Modified Draft at Libby and December Libby Target Elevation operational measures will result in similar impacts as those of MO1.

Under MO2, water quantity and natural lake elevation in Lake Koocanusa will be lower for the majority of the year in the winter and spring months, in comparison to current conditions. During the summer, water quantity will be slightly higher and likely more variable based on energy demands.

Lower Snake River: Dworshak Reservoir

As a result of the implementation of the Ramping Rates for Safety, Slightly Deeper Draft for Hydropower, and Winter System FRM Space operational measures associated with MO2, the co-lead agencies would draft Dworshak Reservoir deeper than in current conditions. Under MO2, pool elevations will decrease by approximately 2.5 ft to 3.0 ft (76 cm to 91 cm) during the winter, spring, and summer.

G.2.3.4 MO2 Impacts on Evaluation Species and Other Guilds and Communities

Clark's and Western Grebes

MO2 will result in more barren lands around Lake Roosevelt, which would lead to subsequent transformations in associated plant and animal communities. Changes in water surface elevation in Lake Pend Oreille will alter the availability of vegetation and suitable nesting habitat for grebes and other nesting waterbirds. If water levels drop rapidly or become lower than those in current conditions, nests could dislodge and break apart, which would likely result in egg and juvenile mortality (USFWS 2019f). Rapid fluctuations in ramping rates will expose nests to increased risk of predation and additional disturbance (i.e., boat traffic and recreation) (LaPorte et al. 2013). Measures in MO2 that increase the frequency of water surface level fluctuations in Lake Koocanusa will also negatively impact grebes and floaters that reside there (LaPorte 2013; Nedeau et al. 2009, pp. 1-4).

Dunlin

The implementation of the John Day Full Pool operational measure has the potential to reduce the quantity, quality, and distribution of barren land habitat in the John Day Reservoir, likely negatively impacting the amount of foraging areas available to migrating birds such as dunlin (Warnock and Gill 1996).

Floaters

Under MO2, higher reservoir levels are expected in the Upper Basin during the summer, which would benefit resident fishes like kokanee and trout, and floaters (Nedeau et al. 2009, p. 21). Lower reservoir levels are expected in the Dworshak Reservoir, which would negatively impact resident, cold-water fishes. Variable water elevations would be also detrimental to many species such as nesting birds, migratory fishes, and freshwater mussels.

Colonial Nesting Waterbirds

In the John Day Reservoir, measures under MO2 will likely reduce the availability of prey resources that support a variety of wildlife populations at higher trophic levels (e.g., Caspian terns, double-crested cormorants, gulls). The Service expects certain avian species that depend on juvenile Pacific salmon as prey to transition to other food resources or relocate to other sites or locations where there is more access to more diverse prey resources. MO2 includes measures that will increase the range of reservoir elevations in the John Day Reservoir. The impacts of these measures will be similar to the impacts of the Predator Disruption Operations and Increased Forebay Range Flexibility measures, especially in regard to Caspian tern, of MO1.

G.2.4 MO3

G.2.4.1 MO3 Summary of Lakes and Reservoirs Landscape Findings

- The four structural and operational dam breaching measures will restore portions of the Lower Snake River to near-natural ecological conditions, thereby providing benefits to various natural lakes habitats and species; however, these benefits will not be observed in storage reservoirs throughout the study area.
- Apart from the projected impacts associated with the four dam breaching measures, MO3 will more negatively impact natural lake and reservoir habitats in the Basin than in current conditions.

G.2.4.2 MO3 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

MO3 proposes breaching the earthen portions of the four dams on the Lower Snake River. This measure, though beneficial to almost all ecological and physical processes and habitats identified in this report, would neither impact the Federal storage reservoirs in the Basin nor increase the flood risk anywhere in the Basin.

The implementation of other measures associated with MO3 are specific to power generation and, collectively, will change draft rates and increase water surface elevation of the storage reservoirs in the Lower Columbia and Mid-Columbia Rivers. Proposed operational measures that modify draft rates from those in current conditions will also lead to changes in the quantity of barren land and island habitat, leading to potentially positive (e.g., for dunlin) and negative (e.g., for freshwater mussels) impacts to fish and wildlife resources in the study area.

MO3 also includes several structural measures that will improve passage rates for juvenile and adult Pacific lamprey.

G.2.4.3 MO3 Impacts on Key Sites

<u>Lower Columbia River: John Day River Confluence, Blalock Island Complex, and Umatilla River Confluence</u>

Under MO3, the implementation of the John Day Full Pool operational measure will reduce the MIP +1.5 ft (46 cm) restriction, thereby raising the pool elevation in the John Day Reservoir during the entire year. This measure will increase the amount of water in the John Day Reservoir and, thus, reduce the abundance of barren land and island habitat at key lakes and reservoir sites. The implementation of this measure, in comparison to other alternatives, will allow for the greatest change (hourly and daily) in water levels in the John Day Reservoir. Higher water levels in reservoirs, especially during the spring and summer months, could benefit freshwater mussels (Nedeau et al. 2019, p. 21). These benefits may be negated, however, by operational measures that could result in more frequent fluctuations in water levels, thereby stranding freshwater mussels and other invertebrates (USFWS 2019f).

Similar to MO1 and MO2, Umatilla NWR will experience a major loss in diversity of island habitat, primarily at the Blalock Island complex under MO3.

Mid-Columbia River: Lake Roosevelt

The implementation of some operational measures will influence water quantity and water surface elevation in Lake Roosevelt. The Planned Draft Rate operational measure will create lower water levels in Lake Roosevelt that persist longer into the spring in comparison to current conditions.

The Ramping Rates for Safety operational measure could result in more rapid water surface elevation changes in reservoirs throughout the study area, which could affect the abundance of barren land and shoreline habitat.

Upper Basin: Lake Pend Oreille and Lake Koocanusa

Under MO3, like MO1 and MO2, no structural changes will be implemented at Albeni Falls Dam. Output from the co-lead agencies' H&H modeling show that water surface elevation in most water years will remain consistent with the NAA, except for a few river reaches that will not impact Lake Pend Oreille.

Only one operational measure (Ramping Rates for Safety) in MO3 applies to Albeni Falls Dam and, thus, will impact Lake Pend Oreille. This measure will enable the co-lead agencies to modify flow operations within a 24-hour period to meet changing energy demands. All impacts to water quantity, disturbance as a result of recreational activities, and water surface elevation will be similar to those of MO1.

Under MO3, the December Libby Target Elevation, Modified Draft at Libby, and Sliding Scale at Libby operational measures will all be implemented at Libby Dam. The implementation of these measures will result in similar impacts as those of MO1 and MO2.

Lower Snake River: Dworshak Reservoir

Under MO3, pool elevations at Dworshak Reservoir will decrease by approximately 2.5 ft to 3.0 ft (76 cm to 91 cm) during the winter, spring, and summer in comparison to current conditions.

G.2.4.4 MO3 Impacts on Evaluation Species and Other Guilds and Communities

Floaters

Higher storage reservoir water surface elevation during the spring and summer will likely benefit freshwater mussels such as the Western pearlshell mussel and floaters (Nedeau et al. 2009, p. 21). Maintaining a higher water surface elevation, however, will likely result in less migratory foraging habitat for dunlin. Regardless, Western pearlshell and floaters will likely be subject to rapid fluctuations in water surface levels, which could leave them intermittently exposed to desiccation and predation (LaPorte et al. 2013; Nedeau et al. 2009, p. 21).

Colonial Nesting Waterbirds

MO3 includes structural and operational measures that increase the range of reservoir elevation in the John Day Reservoir. The impacts of these measures would be similar to the impacts of the Predatory Disruption Operations and Increased Forebay Range Flexibility measures, especially in regard to Caspian tern, of MO1.

G.2.5 MO4

G.2.5.1 MO4 Summary of Lakes and Reservoirs Landscape Findings

- Structural and operational measures will lead to lower water surface elevation in storage reservoirs in the Lower Columbia River during the spring and summer.

G.2.5.2 MO4 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

Under MO4, reservoir water surface elevation throughout the Lower Columbia River will likely be at least 1.5 ft (46 cm) lower (operating to MOP) than in current conditions. Proposed operational measures such as Spill for Adult Steelhead, Spill to 125 percent TDG, Drawdown to MOP, and Above 1 Percent Turbine Operations are intended to improve the survival of migratory fishes. The implementation of the Drawdown to MOP operational measure, for instance, will likely result in short-term negative impacts to natural lake and reservoir habitats and long-term positive impacts due to lower water surface elevation in the John Day Reservoir between April and July (in all years) and between March and August in dry years.

G.2.5.3 MO4 Impacts on Key Sites

Lower Columbia River: John Day River Confluence, Blalock Island Complex, and Umatilla River Confluence

Under MO4, water surface elevation in the John Day Reservoir will be approximately 1.5 ft (46 cm) lower than current conditions during April and July (in all years) and March and August in dry years. Portions of the shoreline regularly inundated in current conditions will be exposed during spring and summer. As a result, open water could transition to mudflats or barren lands (Warnock 1996).

Under MO4, lower water levels in the John Day Reservoir will reduce irrigation capacity for NWR operations. Irrigation inputs for refuge operations at this location come through wells or pump stations, both of which are dependent on specific pool levels (Healy, F., in litt. 2019).

Mid-Columbia River: Lake Roosevelt

Impacts of those measures proposed at Grand Coulee Dam will be similar to those of MO1. Additionally, impacts to water quantity and reservoir elevations associated with MO4 will not be noticeably different from those associated with the NAA and MO1.

Upper Basin: Lake Pend Oreille and Lake Koocanusa

Under MO4, like the other MOs, no structural changes will be implemented at Albeni Falls Dam, and no changes will be made to project operations in most water years. Output from the co-lead agencies' H&H modeling show that water surface elevation in most water years will remain consistent with current conditions, except for a few river reaches that will not impact Lake Pend Oreille.

Like MO3, only one operational measure in MO4 (Winter System FRM Space) applies to Albeni Falls Dam and, thus, will have an impact on Lake Pend Oreille. This measure will increase flexibility for the co-lead agencies to account for winter precipitation run-off events in Lake Pend Oreille. All impacts to water quantity, disturbance as a result of recreational activities, and water surface elevation will be similar to those of MO1 and MO3.

MO4 includes three operational modifications (Modified Draft at Libby, December Libby Target Elevation, and Sliding Scale at Libby) at Libby. In the spring and early summer, water levels will drop 2.5 ft (76 cm) below average to account for deeper draft. The December Libby Target Elevation measure proposes a new draft target that will increase winter water levels in Lake Koocanusa. Water levels will peak in January when the pool elevation will be 7 ft (2 m) higher than in current conditions. Similar to other MOs, MO4 will also result in increased operational flexibility at Libby Dam.

Lower Snake River: Dworshak Reservoir

Only one operational measure (Winter System FRM Space) will influence water quantity in the Dworshak Reservoir. This measure will reduce the water surface elevation in the Dworshak Reservoir from December through March to provide space for winter precipitation run-off events.

G.2.5.4 MO4 Impacts on Evaluation Species and Other Species

Through MO4, the co-lead agencies propose to operate the John Day Dam at MOP rather than MIP. Operating the John Day Dam at MOP will support the most natural ecological conditions at key sites, which would benefit species analyzed in this CAR (USFWS 2019f).

Potential impacts to grebes will be the same as those under MO1. Structural and operational measures that increase the abundance of barren land in and around Lake Roosevelt will affect plant and wildlife communities both positively and negatively. MO4 includes modifications that will reduce water surface elevation and expose certain key sites during spring and summer. In the short-term, key sites with open water could transition to mudflats or barren land habitats. These areas could attract and support more wading waterbirds like dunlin, especially during migratory periods (Warnock 1996). However such a transition could also lead to the loss of important ecological and physical processes that support freshwater mussels and other aquatic invertebrates (Nedeau et al. 2009, p. 21).

G.3 RIPARIAN

G.3.1 NAA

G.3.1.1 NAA Summary of Riparian Landscape Findings

- Due to lack of functional flows throughout most of the study area, native riparian obligate species will continue to decline. These species will be replaced by later-successional communities and, eventually, uplands landscapes, thereby decreasing habitat complexity and species diversity throughout the region.
- As old relict cottonwood stands reach the end of their lifespan without new generations to take their place, river corridors may lose this species, which supports a disproportionate (i.e., large) quantity and diversity of wildlife.

G.3.1.2 NAA Impacts on Indicators of Ecological and Physical Processes and Subhabitats

Pre-Dam Hydrograph and Natural Flood Regime

In the Basin, the pre-dam hydrograph included rising stage in the spring associated with snow melt, followed by peak flows in early June and a gradual recession to base flow by September, and lowest flows during the winter months (Figure G3). The general shape of a pre-dam hydrograph does not vary significantly in an unregulated system, but it may show higher or lower extremes during wet or dry years. The timing associated with peak floods and return to base flow for the pre-dam hydrograph may vary slightly given geographic location, but hydrographs for rivers across western North America, from Alberta to New Mexico, exhibit similar patterns and timing (Mahoney and Rood 1998, p. 636).

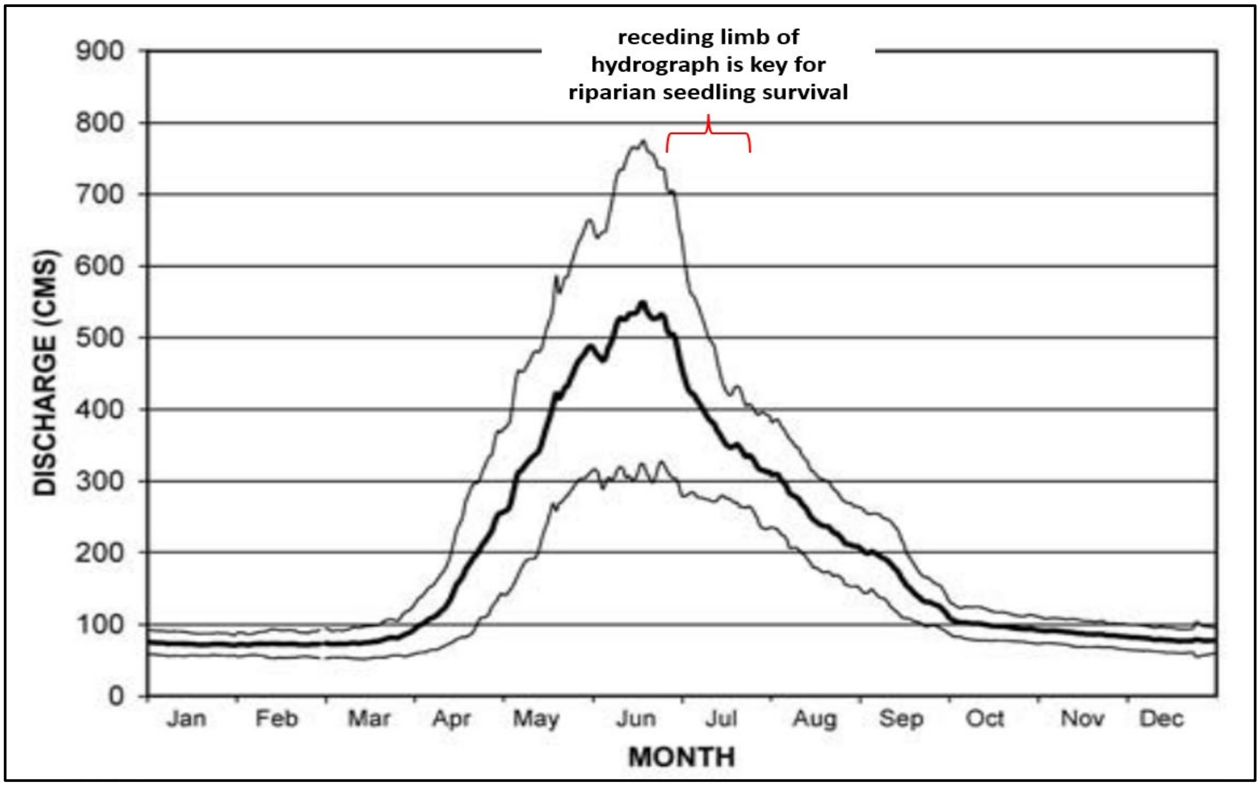

Figure G3. A typical hydrograph of the Upper Snake River (±1 standard deviation) during the pre-dam period of record, from 1911 to 1956.

Source: Adapted by the Service from Hauer and Lorang 2004, p. 31

<u>Native Riparian Vegetation</u>

The pre-dam hydrograph governs nearly every aspect of the riparian landscape, including streambed morphology, nutrient cycling, and deposition, and it helps riparian vegetation and wildlife fulfill essential life history stages (Poff et al. 1997, p. 769). Cottonwood and willow, keystone species in riparian habitats throughout the Basin, are specially adapted to the pre-dam hydrograph and natural flood regimes, as they must survive and outcompete flood-intolerant species along the shoreline and on the floodplain. Annual seed dispersal of cottonwoods and willow is timed to coincide with peak flood events, allowing wind and water to transport seeds to the flood-created, newly exposed, moist and barren shoreline habitat, as flood waters recede. Cottonwood and willow seeds are released in large numbers, but are only viable for up to a few weeks. Seeds germinate on the newly exposed habitat, and the roots of the newly established seedlings must elongate at a rate that keeps them in contact with the receding water table, which is typically less than 1.0 inch (2.5 cm) per day (Mahoney and Rood 1998, pp. 634-638).

Due to the close correlation of the life history of riparian plant species with the pre-dam hydrograph, disruption as a result of river regulation can impede survival and regeneration of these species, and, thus, other wildlife species that depend on them. Regulated rivers like the

Columbia and Snake Rivers and their tributaries have moderated hydrographs, with greatly attenuated peak flow events, which can inhibit cottonwood and willow regeneration by disrupting ecological and physical processes that create habitat for species germination (Mahoney and Rood 1998, pp. 634-635). In regulated rivers, peak flow events may also occur at different times, perhaps several weeks earlier or later than normal, which also inhibit cottonwood and willow regeneration and benefit non-native species. For example, when peak flows occur one month later than average peak flows, in early July instead of early June, they coincide with seed maturation and dispersal of non-native reed canary grass (Waggy 2010; Rood, S., pers. comm. 2019). Additionally, ramping rates on regulated rivers affect how quickly water levels increase and drop downstream of dams. Even if a regulated river does experience a peak flood at the appropriate timing, ramping rates draw water down at a rate that is faster than the rate at which new cottonwood and willow seedling roots can elongate to survive, also preventing regeneration of cottonwood and willow forests (Mahoney and Rood 1993, p. 231). These conditions and their impacts will continue under the NAA.

Regeneration of riparian forests depends not only on establishment of new seedlings dictated by elements of the normal river hydrograph, but also on seedling and adult survival. Established cottonwood and willow plants can suffer from drought stress or prolonged inundation when management causes the river stage to rise above or fall below levels that are typical for that particular season for extended periods of time (Braatne et al. 2007a, p. 262). Additionally, unnaturally high or frequently fluctuating winter stages can displace newly established seedlings, when ice rising with the river stage brings associated seedlings with it, plucking them from the ground (USFWS 2019b).

The suppression of cottonwood and willow regeneration has led to a widespread loss in structural complexity of riparian forests, as well as to a loss of native species diversity due to the invasion and establishment of non-native plant species (Braatne et al. 2007a, p. 263; Kleindl et al. 2015, p. 1366; Macfarlane et al. 2016, p. 454). Such loss of structural complexity may have contributed to the extirpation of species such as the yellow-billed cuckoo, once common in the study area, and the decline of other riparian bird species (Hughes 2015; Ohmart 1994, pp. 276-277; Scott et al. 2003, p. 284; Skagen et al. 2005, p. 526). Most of the remaining patches of riparian obligate vegetation in the study area are comprised of old cottonwood trees forming the canopy, with sparse native understory, which would typically support a large proportion of the nesting bird species (Braatne et al 2007b, pp. 254-256; Ohmart 1994, pp. 274-275). Much of the riparian corridor in the study area is now devoid of cottonwood, while other areas still support relict populations of aging trees with limited long-term viability (Figure G4) (Braatne et al. 2007a, p. 247; Dykaar and Wigington 200, p. 92). Loss of riparian landscape will continue and perhaps be exacerbated (as extant trees age and slow reproduction) under the NAA.

Figure G4. Example of relict cottonwoods along the Mid-Columbia River subbasin near Chelan, Washington

Source: Stewart Rood, University of Lethbridge

Habitat Complexity, Ecosystem Function, and Connectivity

Riparian communities are very diverse and also naturally scarce in the study area and, as a result, the loss of riparian habitat has disproportionate impacts on the diversity and abundance of semi-aquatic and terrestrial species that depend on it for part, or all aspects, of their life history stage requirements (Brinson et al. 1981, pp. iv, 87). Thus, habitat complexity and ecosystem function decrease when riparian habitat and subhabitats are lost or converted to more common upland forest, grassland, sagebrush subhabitats (Fierke and Kauffman 2005, p. 160). An overall decrease in habitat complexity and function reduces the diversity and abundance of wildlife the region can support (Naiman et al. 1998, p. 289). Habitat connectivity may also be greatly reduced with the loss of small tracts of riparian habitat, as these remnant riparian corridors function as important migratory and dispersal routes for many wildlife species (Hauer et al. 2016, p. 9). An altered hydrograph and lack of normal flood regime can lead to negative, cascading impacts, starting with the loss of native riparian vegetation and the alteration of structure and species composition of shorelines. These effects may eventually result in significant regional declines and even extirpation of wildlife species under the NAA conditions (Hauer et al. 2016, p. 9; Hunter et al. 1987, p. 12).

G.3.1.3 NAA Impacts on Key Sites

<u>Lower Columbia River: Julia Butler Hansen NWR, Sandy River Delta, Umatilla NWR</u>

Julia Butler Hansen NWR has a relatively large area of undeveloped shorelines. Precipitation helps replenish the water table in this region and, as a result, riparian habitat has maintained resiliency during changes in river water surface elevation caused by dam operations (Rood, S., pers. comm. 2019). However, the altered hydrograph at this key site limits the regeneration of new cottonwood-willow habitat. Thus, while more riparian habitat survives here than at other key sites in the Basin, what remains is degraded and in decline (Christy and Putera 1993, pp. 21, 27). This trend will continue under the NAA.

The majority of the Sandy River Delta is protected from development under either Federal or state jurisdiction, and therefore has a relatively large area of undeveloped shoreline with healthy wetland and riparian habitat. Additionally, this site has been the focus of ongoing habitat restoration efforts since the late 1990s, including planting of cottonwood seedlings and removal of non-native reed canary grass and Himalayan blackberry (*Rubus armeniacus*) (Kelly and Dobson 2001, p. 1). Although the riparian habitat on the Columbia River portion of this key site is affected, and will continue to be affected under the NAA, precipitation helps recharge the water table so that drought-induced mortality due to abnormal river flows is less of a threat to existing cottonwoods and willows (Christy and Putera 1993, p. 13; Rood, S., pers. comm. 2019).

The Sandy River Delta is also one of the few places in the Pacific Northwest where sightings of vagrant yellow-billed cuckoos have been observed in recent years, though there are no known breeding populations throughout this part of the species' former range (eBird Basic Dataset, Version: EBD_relMar-2019). While this key site is relatively protected from development and supports some of the largest stands of cottonwood and willow in the Lower Columbia River, abnormal Columbia River flows inhibit natural riparian regeneration and, thus, the understory is highly degraded (Christy and Putera 1993, pp. 13, 21; Kelly and Dobson 2001, p. 1). Unlike other places in the Basin where cottonwoods remain, the large relict patches of cottonwood at this key site now exist alongside younger cohorts that have been planted since 1997. Though structural diversity is degraded at this site, and what little understory remains is comprised mostly of invasive blackberry, invasive plant removal has been one of the restoration strategies implemented here (Dobson 2009, p. 16; Kelly and Dobson 2001, p. 1). Overall, riparian habitat at this key site has declined from historical conditions, but it could increase slightly in quality under the NAA due to existing restoration efforts (Christy and Putera 1993, p. 27; Kelly and Dobson 2001, p. 1).

Umatilla NWR is located approximately 8.0 RM to 15 RM (13 RKM to 24 RKM) downstream from the McNary Federal project, and it was established to protect migratory birds. While this refuge is managed mostly for waterfowl, it is also critical in supporting other bird species including neotropical migrants and other riparian-dependent plants and wildlife. Because this key site is protected as a NWR, its undeveloped shorelines have potential to support riparian vegetation, and therefore increase habitat diversity and ecosystem connectivity. The hydrograph here is highly regulated, inhibiting natural flood regimes that promote riparian recruitment. Despite being an important stronghold of riparian habitat in the region, the quantity and quality of riparian habitat here will continue to decline under NAA operations as existing stands of cottonwood mature with little regeneration.

Mid-Columbia River: Okanogan River Confluence, Threemile Creek to Six Mile Creek Confluences, and the Little Sheep Creek Confluence

The Okanogan River Tributary Confluence and River Delta is located in a part of the Basin where much of the shoreline is either steeply banked, armored, or otherwise developed. These conditions, along with the heavily moderated hydrograph, leave little opportunity for regeneration of riparian species (Figure G5). Thus, this tributary confluence supports dynamic processes (e.g., sediment deposition, erosion) that do not occur in much of the rest of this region (USFWS 2019b). Riparian habitat exists along some of the river shoreline as well as on the Cassimer Bar, Washburn Island, and Wells Wildlife Area, but non-native Russian olive and cheatgrass have been encroaching on the riparian zone (USFWS 2019b). Although degradation of riparian habitat at this key site will likely continue without change to current management practices, the site still functions as an important oasis of habitat diversity and related ecological and physical processes that are lacking throughout most of this subbasin.

Figure G5. The Okanogan River Delta

Source: Stewart Rood, University of Lethbridge

The Threemile Creek to Sixmile Creek Confluences are located approximately 50 RM (80 RKM) upstream from the Grand Coulee Dam, and the Little Sheep Creek Confluence is located approximately 140 RM (225 RKM) upstream from the Grand Coulee Dam near the Canadian border. Threemile Creek to Sixmile Creek Confluences, the Little Sheep Creek Confluence, and surrounding area represent reaches of the Mid-Columbia River characterized by several small tributary confluences, which contribute flow and sediment to the mainstem, and relatively undeveloped shoreline (Yarnell et al. 2015, p. 965). Aerial imagery shows that much of the exposed shoreline not inundated by Lake Roosevelt currently supports upland vegetation. There are some shallower-sloped shorelines and sandy bars in both of these confluences, which appear to support some riparian vegetation and could support more given a more natural flow regime, but they will likely continue to be converted to upland vegetation under NAA conditions.

The summary hydrograph for the Threemile Creek Confluence shows the lowest water surface elevation occurring from February through May, and a higher water surface elevation in July throughout the rest of the year. The summary hydrograph for the Little Sheep Creek area shows low flows from February through April and attenuated peak flows occurring in July. Neither of these hydrographs promote regeneration of native riparian species, and this status quo will continue under NAA conditions. In the absence of substantial flooding, stable conifer climax communities develop in place of riparian species (Gucker 2012).

Upper Basin: Stillwater River Confluence, Clark Fork Delta at Lake Pend Oreille (Derr Island, Panhandle Wildlife Management Area [WMA]), Yaak River and Star Creek Confluences

The Stillwater River Confluence is located approximately 20 RM (32 RKM) downstream of the confluence of the South Fork Flathead and Flathead Rivers and 25 RM (40 RKM) downstream of the Hungry Horse Dam. Because Hungry Horse Dam affects only one tributary (South Fork Flathead) of the three that flow into the main stem Flathead River (North, Middle, and South Forks of the Flathead River), impacts of Hungry Horse Dam to the mainstem Flathead River are somewhat diluted now and will likely be diluted under NAA conditions. The largest impacts are typically confined to the reach above the confluence of the South Fork Flathead, while impacts below the confluence are diluted and typically most pronounced during low flows from mid- to late summer (Rood, S. pers. comm. 2019; USFWS 2019g). However, the reach of the Flathead River above Flathead Lake has experienced a reduction in potential inundation (flooding) of 27 percent and 32 percent for the 100-year 50-year floodplain, respectively, which results in a 35 percent loss of ecological function in the 50-year floodplain (Bergeron and Wood 2018, pp. 2, 78). This loss in ecological function will continue under the NAA.

Riparian habitat at the Stillwater River Confluence, though degraded, is more plentiful than many other parts of the Basin, and the inflow of the Stillwater River brings unique sediment and flow dynamics to this reach. Even though it is clear from aerial imagery that many portions of the riparian corridor in this subbasin have transitioned to upland conifer forest, the Stillwater River Confluence maintains wide meanders, sandy exposed shoreline, and fairly undeveloped bars and islands making it an ideal location for restoration of riparian vegetation.

The confluences of several small tributaries, as well as the inflow delta created where the main channel enters the reservoir, makes the Clark Fork Delta a complex system of side channels, islands, and a matrix of riparian forest and wetland habitats and subhabitats (USFWS 2019b). As with most tributary confluences, added flow, sediment dynamics, and nutrient input provided from the Johnson and Lightning Creek tributaries benefit the mainstem Clark Fork River. In addition, there is an artificial inflow pattern here, where the river enters the reservoir, which mimics a natural delta (USFWS 2019b). These factors enhance the ecological value of the site. However, as in most other areas of the Basin, declines in riparian habitat complexity, quantity, and quality due to the loss of a functional flow regime and the subsequent spread of invasive species are evident, and this trend will continue under NAA conditions (Jankovsky-Jones 1999, p. 69; Kauffmann 1988, p. 49).

The Yaak River Confluence is located approximately 45 RM (72 RKM) downstream from Libby Dam on the Kootenai River. Here and elsewhere, riparian habitat has declined in quantity and quality due in part to dam operations, and this decline will continue under the NAA (Burke et al. 2009, p. S224). Functional flows may be implemented at dams to mimic the most important aspects of the pre-dam hydrograph and benefit riparian habitat and wildlife that evolved with important elements of the pre-dam hydrograph (Rood et al. 2005, p. 193). Since functional flows were implemented at Libby Dam, cottonwood and willow recruitment has been increasing. While the quantification of this trend has not yet been published, it has been observed by multiple experts in the field (Burke et al. 2009, p. S235; USFWS 2019b). This trend will continue under NAA conditions.

Despite new recruitment of cottonwood and willow with the newly adopted functional flow regime, abnormally high winter water surface elevation causes mortality of newly established cottonwood and willow seedlings. Under a natural flow regime, water levels peak in the late spring due to snowmelt, followed by a gradual recession back to base flow by September, with the lowest flows in winter. Even when peak flows are mimicked by releases at Libby Dam, promoting downstream cottonwood and willow recruitment, various manipulations of the flows for power generation can cause water levels to rise in the winter, thereby displacing young trees that have not yet grown large enough to withstand the force of the rising water and ice. This phenomenon has been observed on the Kootenai River, where successful cottonwood and willow recruitment has been partially offset by the inability of newly-established seedlings to survive the following winter (Merz et al. 2013, p. 126; USFWS 2019g). There has been an overall loss of riparian habitat on the Kootenai River since the Federal CRS projects were installed, and this trend will continue under the NAA.

<u>Lower Snake River: Catholic Creek Confluence downriver to Hog Island, Tucannon River Confluence, Big Flat Recreation Area</u>

Undeveloped shoreline with some riparian vegetation characterize the confluence of Catholic Creek, in addition to several other islands in the main channel. Similarly, downstream at the Lapwai Creek Confluence near Spalding, Idaho, there is a riparian stringer (i.e., narrow strip) that meets the mainstem at the Nez Perce National Historical Park, where additional undeveloped shoreline habitat exists. Downstream, several islands including Hog Island support some riparian vegetation, and could present opportunities for recruitment of riparian vegetation if flow conditions are appropriate. Steep canyon walls, manmade infrastructure, and shoreline armoring limit already-scarce riparian vegetation in this subbasin. Key sites have maintained undeveloped, shallow-sloped shoreline that presents opportunities for riparian recruitment unavailable elsewhere in the subbasin. Narrow bands of riparian habitat, even if degraded, provide critical wildlife habitat in the form of migratory corridors and stopover sites, offering unique foraging and rearing opportunities in areas with limited resources. However, as with other regulated reaches throughout the Basin, dam operations on the Snake River inhibit recruitment of riparian obligate vegetation (Rood et al. 2010, p. 102). This trend will continue under NAA conditions.

The narrow riparian strip along the Tucannon River provides some of the only riparian or LW in the area, which is evident from aerial imagery. Although the extent of riparian vegetation is confined here, due to current conditions (e.g., steep canyon walls) and anthropogenic development (e.g., Highway 261 infrastructure), existing habitat is important for maintaining habitat diversity and connectivity. As in other parts of the Basin where flows are highly regulated, riparian quality here is degraded and its regeneration will be limited under the NAA.

Big Flat Recreation Area is part of an HMU constructed and maintained by the Corps as mitigation for dam construction on the Lower Snake River. As a result, this site is heavily managed using irrigation to promote growth of native riparian plants (cottonwood and willow). Approximately 90 percent of this site is dominated by invasive Russian olive, although removal efforts are underway (Valente et al. 2019, pp. 1, 3-4). These irrigated plots of woody vegetation exist among a larger proportion of uplands landscape that dominates the subbasin and, thus, they represent some of the only forested and scrub-shrub habitat in the Lower Snake River. Assuming that invasive removal and irrigation continues at this key site as proposed in the NAA, the quality of riparian habitat here could slowly increase in the future.

When the Lower Snake River dams were constructed, historical shorelines that once supported riparian vegetation were inundated, leaving uplands landscape along the river's edge in most areas (USACE 2014b, p. 19). In addition, most shorelines of the Lower Snake River are now either armored or otherwise developed, and flow moderation and flood attenuation further reduce the opportunity for riparian vegetation survival and regeneration. This constraint will continue under NAA conditions.

Remaining fragments of riparian habitat in and along the Lower Snake River are important to plant and wildlife diversity and habitat connectivity. The Big Flat Recreation Area represents one of these remaining fragments. This key site is currently managed with irrigation for riparian plants, and experimental removal of invasive Russian olive (Valente et al. 2019, pp. 1-18). For the analysis, the Service assumed all current management practices at this key site will continue under all the alternatives.

G.3.1.4 NAA Impacts on Evaluation Species and Other Guilds and Communities

Under natural conditions on unregulated rivers, uplands species are prevented from encroaching on the riparian corridor due to periodic flooding and the high water table, while riparian species are prevented from moving into the uplands due to the lack of available soil moisture. In most arid environments, the transition between uplands and riparian landscapes is less than 3 ft (91 cm) (Ohmart 1994, p. 273). Riparian forests succeed to upland subhabitats due to the altered hydrograph. Where undeveloped shoreline remains in the study area, much of the riparian corridor has been converted to uplands vegetation due to the lack of ecological and physical processes that form and maintain riparian communities (Macfarlane et al. 2016, p. 9). This conversion will continue under NAA conditions.

Cottonwood and Willow

Cottonwood and willow historically occurred along most of the Basin in the study area (Bergeron et al. 2018, p. 13; Braatne et al. 2007b, p. 271; Christy and Putera 1993, p. 21; Naiman et al. 1998, pp. 305-306; Polzin and Rood, 2000, p. 221; Wissmar 2004, p. 378). While gallery forests are far less extensive in river canyons where the river banks rise steeply in elevation, transitioning abruptly to uplands vegetation like conifer forest or shrub-steppe, narrow riparian stringers that occur in these confined reaches are important for maintaining habitat diversity and connectivity (USFWS 2019b).

The lack of gallery forests in portions of the Basin today does not necessarily indicate that none were present historically. There is evidence that riparian forest once occurred even in more upland subhabitats of the Basin. For example, historical records in the semi-arid regions of eastern Oregon show that cottonwood and willow occurred along most streamlines including Columbia River tributaries such as the Deschutes, John Day, and Crooked Rivers, throughout the 1800s (McAllister 2008, p. 420). Historical accounts document cottonwood galleries 0.25 miles (402 m) wide on the John Day River, where only a few relict cottonwoods now stand (Wissmar et al. 1994, p. 17).

Today, gallery forests with cottonwoods exist in other arid regions such as in the southwest, and they are remnant in upland subhabitats in the study area (e.g., Lower Snake River) (Asplund and Gooch 1998, p. 21; USACE 2014b, p. 19). While it is possible that some locations in the Basin, including some reaches of the Lower Snake River, may not have ever supported gallery forests, it is reasonable to assume willow and other riparian species would have occurred at least in narrow stringers. For example, historical accounts from the 1800s show willow was the most dominant streamside species in the large John Day/Clarno Uplands Ecoregion (McAllister 2008, p. 418).

Though river regulation negatively impacts riparian habitat, it is not the only cause of decline in riparian forests. Riparian habitat would have already been somewhat altered and degraded, or lost completely in certain locations, by the time the dams were built in the mid-1900s. Deforestation, grazing, mining, overharvesting, draining of wetlands, channel manipulation for navigation, water diversion, irrigation and flood control, among other factors, have been at play during the 200 years since European settlement (Christy and Putera 1993, p. 5; Wissmar et al. 1994, p. 1). In particular, livestock grazing tends to be concentrated in riparian areas, with 80 percent of vegetation removed by livestock occurring in riparian corridors (Roath and Krueger 1982, p. 101). In addition to river regulation, livestock grazing has been documented in some areas as the most imminent threat to remaining riparian habitat (Ohmart 1994, p. 278). This source of decline in riparian vegetation will continue under the NAA.

Viceroy Butterfly

In the Service's analysis, there was very limited data available to determine the presence of viceroy butterfly and other pollinators in the study area. Using a national database and expertvalidated citizen science submissions to Moths and Butterflies of North America, the Service found few records, only seven of which fell in the study area: four in the Lower Columbia River between the John Day and Ice Harbor projects including one at Umatilla NWR; one on reach 16 at RM 419 (RKM 674) on the Mid-Columbia River near Vantage, Washington; one at the Okanogan River Confluence in the Mid-Columbia River; and one on the Lower Snake River just south of the Clearwater River Confluence (Lotts and Naberhaus 2017). There were no records of viceroy available from the Upper Basin. However, this CAR assumes that viceroys could be present anywhere in the study area east of the Cascades where cottonwood and willow (i.e., the larval host plants) occur, and where adequately moist soils required for puddling are present during the summer (i.e., viceroy flight period). Loss of host plant and moist soils historically produced through annual flooding is likely threatening viceroy butterfly populations, and this trend will likely continue under NAA conditions (Nelson 2003, p. 210).

Yellow Warbler and Riparian Songbirds

Riparian birds represent what is the largest and most diverse guild of wildlife species that depend on riparian habitat (Croonquist and Brooks 1991, p. 708). Destruction of riparian habitat is a major cause of decline for landbirds in western North America, like those species analyzed in this CAR (DeSante and George 1994, p. 177). This decline will continue under the NAA. To identify whether the yellow warbler and other focal riparian birds were likely breeding at certain locations or key sites in the recent past, the Service filtered eBird observations by location (within 3.0 miles [4.8 km] of the study area) and by date (between June 1 and July 31 or the height of the breeding season from 2010 to 2018) (Table G1).

Table G1. Documented presence of riparian birds at various locations in the study area

Key Sites	Yellow Warbler	Willow Flycatcher	Bullock's Oriole
Julia Butler Hansen NWR	X	X	X
Sandy River Delta	X	X	X
Umatilla NWR	X	X	X
Okanogan River Confluence	X	X	X
Threemile to Sixmile Creek Confluences			
Little Sheep Creek Confluence	X		
Stillwater River Confluence	X	X	X
Clark Fork Delta/Derr Island	X	X	X
Yaak River Confluence	X		

G.3.2 MO1

G.3.2.1 MO1 Summary of Riparian Landscape Findings

- Structural and operational measures will lead to minor to moderate loss of riparian habitat on the Lower Columbia River and in the Upper Basin on the Kootenai River.
- Because the Lower Columbia River and Kootenai River support some of the least degraded riparian habitat in the study area, structural and operational measures will have disproportional (i.e., large), negative effects on riparian habitat, and should be avoided to the extent possible.

G.3.2.2 MO1 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

MO1 will further modify the hydrograph and flood regimes in some areas of the Basin, which will lead to accelerated degradation and loss of native riparian vegetation. Degradation and loss of native riparian vegetation will alter the structure and vegetative species composition of riparian habitats, and ultimately reduce habitat complexity, connectivity, and ecosystem function. The most ecologically significant changes to the hydrograph will be slightly decreased peak and summer flows in lower regions of the Lower Columbia River such as the Sandy River Delta site; extreme prolonged shoreline inundation throughout the spring and summer in the upper portions of the Lower Columbia River; and decreased peak flows paired with increased winter stages in the Kootenai River of the Upper Basin.

G.3.2.3 MO1 Impacts on Key Sites

<u>Lower Columbia River: Julia Butler Hansen NWR, Sandy River Delta, Umatilla NWR</u>

Julia Butler Hansen NWR is located approximately at RM 35 (RKM 56). Water surface elevation downstream of RM 105 (RKM 169) is expected to decrease by less than 3.0 inches (7.6 cm) during the spring and summer months, which is considered within the current range of variability. Thus, there should be no significant impacts to riparian habitat at this key site under MO1.

The Predator Disruption Operations and Increased Forebay Range Flexibility operational measures will lead to an increase (by approximately 3.0 inches [7.6 cm]) in water surface elevation at the Sandy River Delta key site during the winter and a decrease (by approximately 5.0 inches [13 cm] or less) in water surface elevation during the spring and summer. Under MO1, winter water surface elevation should result in minor impacts to riparian vegetation, but lower spring and summer water levels may result in a reduction in riparian habitat through lost contact with the lowered water table. The drop in water surface elevation would also likely expose a small amount of riparian shoreline immediately adjacent to the water. This newly exposed shoreline could foster new riparian growth if the exposure occurred during the spring and was followed by a gradual recession rate (1.0 inch [2.5 cm] per day or less) to allow root elongation to maintain contact with the water table. However, newly exposed shoreline could also be colonized by non-native plants. Most likely, given the altered hydrograph at this site, and, without proper implementation of the change, there will be a small net loss of riparian habitat under MO1 in comparison to NAA.

The Predator Disruption Operations and the Increased Forebay Range Flexibility operational measures will cause prolonged inundation (approximately 1.5 vertical ft [46 cm) of riparian shoreline at Umatilla NWR during April through August, leading to a loss of riparian vegetation. Additionally, MO1 will likely lead to an overall reduction in habitat complexity and ecosystem function at the refuge, further limiting habitat connectivity and access to wildlife resources in the region.

Mid-Columbia River: Okanogan River Confluence, Threemile Creek to Six Mile Creek Confluences, and the Little Sheep Creek Confluence

As a result of the Chief Joseph Dam Project Additional Water Supply operational measure, water surface elevation immediately below the Chief Joseph project is expected to decrease by 1 percent or less. This change is expected to remain within the current range of variability. The Okanogan River Confluence is located approximately 6.0 RM (10 RKM) downstream of Chief Joseph Dam, and, thus, impacts to riparian habitat are not expected to differ significantly from those of the NAA.

Water surface elevation in the river reaches upstream of the Grand Coulee Dam will range from 3.0 ft to 6.0 ft (91 cm to 1.8 m) lower throughout the winter and into early spring (December through March) due to the following operational measures: Lake Roosevelt Additional Water Supply, Planned Draft Rate at Grand Coulee, and Winter System FRM Space. However, water surface elevation will likely return to current levels, beginning in March and throughout the rest of the spring and summer. Because the drop in water surface elevation occurs outside the spring and summer, it is not expected to negatively impact riparian vegetation. Thus, impacts on riparian habitat under MO1 are not expected to differ significantly from those of the NAA at Threemile Creek to Sixmile Creek Confluences.

The impacts described above will likely be even more muted at the Little Sheep Confluence due to it being situated at a greater distance upstream from Grand Coulee Dam. Thus, under MO1, impacts on riparian habitat at this key site are not expected to differ significantly from the NAA.

Upper Basin: Stillwater River Confluence, Clark Fork Delta at Lake Pend Oreille (Derr Island, Panhandle Wildlife Management Area [WMA]), Yaak River and Star Creek Confluences

The Sliding Scale at Libby and Hungry Horse operational measure will increase water surface elevation on the South Fork Flathead River by a few inches or less in August and September, but this change is within the current range of variability. While a slight increase in water surface elevation during August and September could benefit riparian vegetation, thus change is minor and is not expected to alter the quantity and quality of riparian habitat on the South Fork

Flathead. Reaches downstream of the confluence with the Flathead River will experience even more negligible effects. Thus, impacts to riparian habitat are consistent with those of the NAA at the Stillwater River Confluence.

Water surface elevation in reaches below Albeni Falls Dam may decrease by a few inches in high water years in November, which should have no impacts to riparian habitat at the Clark Fork Delta at Lake Pend Oreille. Reaches above Albeni Falls, including the Clark Fork Delta, are not expected to change under the MO1 relative to the NAA.

The Modified Draft at Libby and December Libby Target Elevation operational measures under MO1 will reduce water surface elevation at the Yaak River Confluence in April and May, and during peak flows in June, but will raise water surface elevation in February and March. Water surface elevation may drop by 1.0 ft (30 cm) or more in December and increase by the same amount in February and March. Large winter fluctuations in water surface elevation could lead to increased mortality of newly established cottonwood and willow seedlings, as rising ice uproots them. Reductions in flows in April and May could cause drought stress or mortality in existing cottonwood and willow no longer able to access the lowered water level, and reductions in peak flows in June would hinder recruitment of new cottonwood and willow. Decreased water levels in the spring could also disrupt life cycles of aquatic emergent insects, an important base component of the riparian food web, which may affect fitness and fecundity of riparian birds. Changes under MO1 will have negative impacts to riparian habitat at the Yaak River Confluence in comparison to the NAA.

Lower Snake River: Catholic Creek Confluence downriver to Hog Island, Tucannon River Confluence, Big Flat Recreation Area

The Modified Dworshak Summer Draft operational measure will lead to a slight increase in habitat inundation downstream of Dworshak Dam on the Clearwater River during June and July. This change considered within the current range of variability. The impacts downstream of the Clearwater River Confluence with the Snake River are expected to be even more negligible, and, thus, overall impacts to riparian habitat at the Catholic Creek and Tucannon River Confluences, and at the Big Flat Recreation Area, are not expected to differ significantly from those under the NAA.

G.3.2.4 MO1 Impacts on Evaluation Species and Other Guilds and Communities

While most of the key sites analyzed in this CAR will not experience significant changes under MO1 relative to the NAA, the additional loss of riparian habitat at three key sites (Sandy River Delta, Umatilla NWR, and the Yaak River Confluence) will lead to further declines in species diversity and the riparian plant abundance.

The Sandy River Delta will likely experience a small net loss of riparian habitat due to the lower (5.0-inch [13-cm] decrease) summer stage. This loss could potentially be mitigated and possibly result in greater riparian habitat abundance if the mitigation is executed in ways that promote colonization of newly exposed riparian shoreline with native riparian species (Rood, S., pers. comm. 2019). Such mitigation would require timing the initial drawdown with germination of native cottonwood and willow (June). Additionally, the drawdown would need to occur at a rate not to exceed 1.0 inch (2.5 cm) per day, allowing for seedling root elongation. The viceroy butterfly and other pollinators may also experience short-term conservation gains from additional moist soil along shoreline subhabitats to initiate puddling. However, depending on the condition of the shoreline, it could be colonized by non-native species. There could also be a loss of some existing riparian habitat due to the decreased summer stage. All riparian species at the Sandy River Delta could be negatively impacted as a result of MO1, with cottonwood and willow potentially being most directly impacted if lower summer stage causes drought-stress or mortality alongside reduced connectivity among tree root systems and the water table. Any impacts, positive or negative, will likely be relatively minor given that only a small amount of shoreline would be impacted under MO1. Negative impacts to riparian species at the Sandy River Delta will be slightly more severe than those under the NAA, and comparable to those under MO2, MO3, and MO4.

Umatilla NWR will experience a significant loss of riparian habitat, with the prolonged inundation of approximately 1.5 vertical ft (46 cm) of currently exposed habitat throughout most of the spring and summer (April through August). Prolonged inundation of riparian habitat could cause mortality in riparian vegetation such as cottonwood and willow, and eventual conversion of riparian vegetation to emergent aquatic vegetation, such as reed canary grass. Viceroy butterfly will also be negatively impacted from the loss of some exposed riparian shoreline. Riparian habitat is already in decline at this key site, and MO1 will quicken the rate of decline than what is expected under current conditions. Viceroy butterfly, yellow warbler, Bullock's oriole, and willow flycatcher have all been recently observed during the peak breeding season at Umatilla NWR, and all of these species and others will be negatively impacted by the additional loss of riparian habitat. Umatilla NWR and surrounding riparian habitat will likely experience more loss or degradation under MO1 than under the NAA, MO2, and MO3, but not as much loss as under MO4.

Changes at the Yaak River Confluence under MO1 will generally lead to degradation of riparian habitat (e.g., cottonwood and willow) through increased (about 1 ft [30 cm]) winter stage, reduced spring stage, and reduced peak flows in June. There will likely be more degradation of riparian habitat at this site under MO1 than under the NAA or MO4, but less degradation of riparian habitat in comparison to MO2 or MO3.

G.3.3 MO2

G.3.3.1 MO2 Summary of Riparian Landscape Findings

- Structural and operational measures proposed under MO2 will result in the most severe and widespread impacts to riparian habitat and species in comparison to any of the other proposed alternatives, including the NAA.

G.3.3.2 MO2 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

The implementation of structural and operational measures under MO2 will further modify the hydrograph and flood regime in many areas of the Basin, thereby accelerating degradation and loss of native riparian vegetation. The most ecologically significant changes to the hydrograph include slightly decreased peak and summer flows in lower regions of the Lower Columbia River such as the Sandy River Delta site; decreased river stages during the early part of the spring and summer paired with increased winter stages in the Upper Basin and Lower Snake River; and increased frequency and rate of daily stage changes throughout the Basin due to ramping rates.

G.3.3.3 MO2 Impacts on Key Sites

<u>Lower Columbia River: Julia Butler Hansen NWR, Sandy River Delta, Umatilla NWR</u>

Julia Butler Hansen NWR is located approximately at RM 35 (RKM 56), and changes to water surface elevation downstream of RM 105 (RKM 169) are expected to be minor and considered within the current range of current variability. There will be no significant changes in riparian habitat at this key site in comparison to the NAA.

The co-lead agencies attribute water surface elevation changes at the Sandy River Delta in the Lower Columbia River to an unspecified combination of proposed operational modifications at Grand Coulee Dam and other upstream projects under MO2. As such, impacts to riparian habitat in reach appear to result from interactions among the suite of structural and operational measures, and specific measures individually cannot account for the resulting change presented by the co-lead agencies' H&H modeling output. Downstream of Bonneville Dam, the overall impact to water surface elevation will be an increase of less than 12 inches (30 cm) in November through January, and a decrease of less than 6.0 inches (15 cm) in the spring and summer months. Winter water surface elevation is not expected to impact riparian habitat because of its occurrence outside the spring and summer and its occurrence in a river reach not normally prone to deep freezing during the winter. A reduction in water levels of approximately 6.0 inches (15 cm) during the spring and summer would result in similar impacts to those of MO1. Some loss of riparian vegetation may occur due to the lowered summer water table, and newly exposed riparian shoreline would likely be colonized by non-native species unless efforts were made to time the exposure and flows properly to promote colonization of native riparian species. There is likely to be some loss of riparian habitat under MO2 in comparison to the NAA.

Under MO2, despite changes to reservoir levels at John Day Dam, water surface elevation in the John Day Reservoir, which includes Umatilla NWR, will not experience measurable differences from the NAA.

<u>Mid-Columbia River: Okanogan River Confluence, Threemile Creek to Six Mile Creek Confluences, and the Little Sheep Creek Confluence</u>

Due to the Ramping Rates for Safety and Winter System FRM Space operational measures under MO2, water surface elevation at the Okanogan River Confluence will increase slightly in December and decrease from February through September. This change is expected to be 6.0 inches (15 cm) or less and within the current range of variability. Thus, impacts on riparian habitat should not differ significantly in comparison to the NAA.

Water surface elevation in the river reaches upstream of the Grand Coulee Dam will shift between 3.0 ft and 6.0 ft (91 cm and 1.8 m) lower throughout the winter months due to the Planned Draft Rate at Grand Coulee and Slightly Deeper Draft for Hydropower operational measures. However, water surface elevation will be consistent with that of the NAA throughout the rest of the year. Because the drop in water surface elevation occurs outside of the spring and summer, it is not expected to result in negative impacts to riparian vegetation. Thus, impacts to riparian habitat in the area of the Sixmile Creek Confluence and the Little Sheep Creek Confluence are not expected to differ significantly from those of the NAA

Upper Basin: Stillwater River Confluence, Clark Fork Delta at Lake Pend Oreille (Derr Island, Panhandle Wildlife Management Area [WMA]), Yaak River and Star Creek Confluences

The Ramping Rates for Safety and Slightly Deeper Draft for Hydropower operational measures appear to be associated with an increase (18 inches [46 cm]) in water surface elevation on the Flathead River in January and a decrease (6.0 inches [15 cm] or less) in water surface elevation between March and July. A substantial increase in water levels during January would severely impact riparian vegetation, causing mortality of newly established seedlings. The modest decrease in water levels during the spring and summer could lead to vegetation mortality or could degrade the health of riparian vegetation by causing drought stress. Proposed modifications associated with MO2 are expected to lead to declines in riparian vegetation quantity and quality, preventing cottonwood and willow recruitment in the riparian zone. Thus, riparian habitat is expected to decline significantly, and at a faster rate, in comparison to the NAA.

The Ramping Rates for Safety and Slightly Deeper Draft for Hydropower operational measures appear to be associated with an increase in water surface elevation by 6.0 inches (15 cm) at the Clark Fork Delta during the winter and a decrease by 6.0 inches (15 cm) between March and May. Both of these changes could lead to cottonwood and willow mortality. An increase in winter water levels will reduce survival rates of newly recruited cottonwood and willow, and the decrease in water surface elevation during the spring may result in drought stress for riparian vegetation. Additionally, a reduced spring stage could disrupt insects, a food source for riparian birds, from completing all of their life history stages. Thus, MO2 will result in a more significant decline in riparian habitat at the Clark Fork Delta in comparison to the NAA.

A combination of the Ramping Rates for Safety, Slightly Deeper Draft for Hydropower, Modified Draft at Libby, and December Libby Target Elevation operational measures appear to lead to a significant departure from the pre-dam hydrograph on the Kootenai River (Yaak River Confluence), resulting in significantly higher flows in winter and lower flows in the spring and summer. Water surface elevation will increase from 18 inches to 36 inches (46 cm to 91 cm) in the winter, and decrease by 18 inches (46 cm) during the rest of the year. Both of these changes will have detrimental impacts to riparian habitat on the Kootenai River. Higher winter water levels will lead to increased riparian seedling mortality, and lower water levels throughout the rest of the year (spring freshet and spring and summer) will hinder cottonwood and willow recruitment and threaten the survival of existing plants.

Impacts resulting from MO2 are expected to be the most detrimental to riparian habitat, relative to current ecological conditions and the other MOs, in this portion of the Basin. This finding is important because this subbasin represents the highest quantity and quality of riparian habitat remaining in the study area.

Lower Snake River: Catholic Creek Confluence downriver to Hog Island, Tucannon River Confluence, Big Flat Recreation Area

The Ramping Rates for Safety and Winter System FRM Space operational measures appear to be associated with an increase in water surface elevation by 12 inches (30 cm) at the Catholic Creek Confluence in January and February and a slight decrease in March, April, June, and July. The increase in water surface elevation in the winter could displace newly established cottonwood and willow seedlings. The decrease in water levels during the spring and summer, especially in hot months, could lead to drought stress or mortality and reduced recruitment of riparian vegetation. Thus, riparian vegetation at this key site will decrease in quantity and quality in comparison to the NAA.

MO2 will negatively affect flows on the Clearwater River, but not on the Lower Snake River, so impacts to riparian habitat at the Tucannon River Confluence and Big Flat Recreation Area are not expected to differ significantly from those of the NAA.

Under MO2 all key riparian sites will be negatively impacted by the operational measure (Ramping Rates for Safety) that aims to lift ramping rate restrictions. In addition to the potential for increased ramping rates to strand fish and other aquatic species, increased rate and frequency of river stage fluctuations are potentially damaging to riparian habitat. Without knowing the scale of stage fluctuations, it remains a challenge to predict impacts, as smaller-scale fluctuations would be less damaging than relatively larger-scale fluctuations. Frequent stage fluctuations will be harmful to riparian vegetation during the short seed dispersal window, especially if these fluctuations continuously resuspend seeds and prevent them from depositing and establishing on suitable shoreline habitat while viable. Frequent stage fluctuations could also change soil texture over time through the removal of sand, fines, and organics, therefore impacting soil quality and functionality, and would also likely promote colonization of invasive species such as reed canary grass (Burke, M., in litt. 2019). Erratic stage fluctuations that change soil composition and subsequently alter vegetation types promoted by those soils could cause cottonwood and willow mortality and lead to long-term loss of riparian vegetation.

G.3.3.4 MO2 Impacts on Evaluation Species and Other Guilds and Communities

Impacts to riparian species at the Sandy River Delta will be comparable to those described under MO1, as the resulting change in water surface elevation under MO1 and MO2 have approximately the same magnitude and timing. Negative impacts to riparian species at the Sandy River Delta under MO2 will be slightly more severe than under the NAA, and comparable to those under MO1, MO3, and MO4.

Changes in water surface elevation at the Stillwater River Confluence will cause the hydrograph to deviate further from its pre-dam state and will lead to limited recruitment of riparian vegetation, survival of newly established seedlings during the winter, and resiliency of existing riparian vegetation. Impacts to cottonwood and willow will be direct and immediate, and impacts to viceroy butterfly, riparian birds, and other wildlife resources that rely on riparian plants will be indirect, resulting from long-term loss or degradation of habitat. There are multiple recent records of yellow warbler, Bullock’s oriole, and willow flycatcher occurring in the Basin during the breeding season, and these species could experience long-term local declines in population abundance due to loss of habitat used for breeding, feeding, and migrating. Riparian species near the Stillwater River Confluence will experience negative impacts under MO2 to a greater degree compared to the NAA, MO1, MO3, or MO4.

Under MO2, impacts to riparian habitat and species at the Clark Fork Delta will be similar to, but less severe than, those at the Stillwater Confluence. Changes in flow regime will stray further from the pre-dam hydrograph, causing mortality of newly established cottonwood and willow seedlings. Existing riparian vegetation may also undergo drought stress due to lower water levels in the early part of the spring and summer, but a return to normal water levels by the time of the spring freshet will likely lessen the severity of impacts to riparian species at this key site. Viceroy butterfly, yellow warblers, other riparian songbirds, and other wildlife that depend on riparian habitat may also be negatively affected, thereby resulting in a reduction in fitness, survival, and productivity.

Key sites on the Kootenai River downstream of Libby Dam (e.g., Yaak River Confluence) will experience changes that will severely impact riparian species analyzed in this CAR. Significant declines in river stage throughout the spring and summer will modify conditions associated with peak flows that lead to cottonwood and willow establishment and cause drought stress. Significant increases in winter stage will further reduce recruitment by causing displacement of any newly established seedlings. Thus, key riparian sites will experience habitat loss, and there would likely be regional species population declines. Under MO2, riparian species at the Yaak River Confluence will experience more severe impacts than under any other alternatives, including the NAA.

A reduction in water surface elevation at key riparian sites (e.g., Catholic Creek Confluence) during the spring and throughout most of the spring and summer will lead to prolonged drought-stress for cottonwood and willow. Loss of cottonwood and willow habitat could have minor short- and long-term negative impacts on viceroy butterflies and riparian birds that depend on riparian habitat, which is already limited and degraded in this subbasin. Habitat diversity and connectivity is especially important for viceroy butterfly (i.e., dispersal) and for neotropical migrants such as yellow warblers, Bullock's orioles, and willow flycatchers that depend on migratory corridors for food and shelter. Negative impacts to riparian species at the Catholic Creek Confluence area will be more severe than those associated with the NAA or the other MOs.

The Ramping Rates for Safety operational measure will likely have negative impacts on riparian species analyzed in this CAR. The long-term loss of riparian vegetation such as cottonwood and willow as a result of lifting ramping rate restrictions will lead to indirect negative impacts to species productivity and survival. In addition, increased rate and frequency of stage fluctuations will likely disrupt life history stages of aquatic emergent insects and other invertebrates, leading to population declines or even extirpation (Kennedy et al. 2016, p. 561). Disruptions in the timing or success of insect hatches could also have significant negative implications for the productivity and survival of riparian birds, many of which depend more heavily upon the high-protein insect component of their diets during the breeding season when energy expenditure is high. Therefore, lifting ramping rate restrictions is likely to have negative consequences for riparian species occupying all key riparian sites under MO2 and MO3.

G.3.4 MO3

G.3.4.1 MO3 Summary of Riparian Landscape Findings

- If steps are taken to prevent the spread of non-native (invasive) species into newly exposed riparian shoreline beyond what is specified in MO3, the potential long-term ecological benefits to riparian habitat afforded by breaching the earthen portions of the four Lower Snake River dams will be greater than any short-term costs, such as loss of riparian vegetation existing on the current shorelines when water levels drop.
- If implemented properly, structural and operational measures will bring the most ecological benefits to riparian habitat of all the other proposed MOs.

G.3.4.2 MO3 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

Structural and operational measures will further modify the hydrograph and flood regime throughout the study area, leading to accelerated degradation and loss of native riparian vegetation. However, in the Lower Snake River, the hydrograph will become more like the pre-dam hydrograph, and riparian shorelines will improve. Potentially, these shorelines could return to their historical status and support more riparian growth, which could lead to long-term gains in structure and species composition of these riparian shorelines. Under MO3, the most ecologically significant changes to the hydrograph will be: moderate prolonged shoreline inundation during the spring in the upper portions of the Lower Columbia River; slightly decreased peak flows and summer stage in lower regions of the Lower Columbia River such as the Sandy River Delta; decreased peak flows and decreased river stage during the spring and summer paired with increased winter stage in the Kootenai River of the Upper Basin; and increased frequency and rate of daily stage changes throughout the Basin (due to ramping rates).

G.3.4.3 MO3 Impacts on Key Sites

Lower Columbia River: Julia Butler Hansen NWR, Sandy River Delta, Umatilla NWR

Water surface elevation is expected to change less than 3.0 inches (7.6 cm) downstream of RM 105 (RKM 169), and this change is within the current range of variability. Impacts to riparian habitat at Julia Butler Hansen NWR, under MO3, will not differ significantly from those under the NAA.

The Ramping Rates for Safety and John Day Full Pool operational measures appear to be associated with an increase (less than 6.0 inches [15 cm]) in water surface elevation downstream of Bonneville Dam in November and December and a decrease (6.0 inches [15 cm]) in water surface elevation in January and April through September. The Sandy River Delta will likely experience a reduction in riparian habitat quantity and quality as a result of lower spring and summer stage, similar to what would occur under MO1 and MO2.

The John Day Full Pool operational measure will raise water surface elevation from 6.0 inches to 12 inches (15 cm to 30 cm) in April and May, resulting in prolonged inundation of riparian shoreline, which could cause mortality of existing riparian vegetation in the inundation zone. Under MO3, impacts to riparian habitat at Umatilla NWR are expected to be similar to, but less severe than, those associated with MO1 (18 inches [46 cm] inundation in MO1). One impact of MO3, in comparison to the NAA, may be a faster rate of decline in riparian habitat quantity and quality at Umatilla NWR.

Mid-Columbia River: Okanogan River Confluence, Threemile Creek to Six Mile Creek Confluences, and the Little Sheep Creek Confluence

The Chief Joseph Dam Project Additional Water Supply operational measure under, which diverts additional water from the river to support agricultural irrigation needs during the spring and summer, will reduce water surface elevation immediately below the dam by 1 percent or less. This minor change is expected to remain within the current range of variability. The Okanogan River Confluence is located approximately 6.0 RM (10 RKM) downstream of Chief Joseph Dam, and, thus, impacts to riparian habitat under MO3 are not expected to differ significantly from those under the NAA.

MO3 diverts additional water from the mainstem for agriculture, and capturing this extra water will result in higher water levels (approximately 6.0 inches [15 cm]) immediately upstream of Grand Coulee Dam during the winter. Withdrawing this water would lead to a reduction in water levels (less than 12 inches [30 cm]) in the early spring. Water surface elevation would return to those levels consistent with the NAA by May. Impacts to riparian vegetation situated immediately upstream of the dam may be minor. Nearly 50 RM (80 RKM) upstream of Grand Coulee Dam, where Threemile and Sixmile Creek Confluences are located, the impacts may be negligible or consistent with those under the NAA.

Structural and operational measures likely to impact Lake Roosevelt are expected to have impacts only immediately upstream of Grand Coulee Dam. Little Sheep Creek Confluence is located approximately 140 RM (225 RKM) upstream of Grand Coulee Dam, and, thus, impacts to riparian habitat are not expected to differ significantly from those of the NAA.

Upper Basin: Stillwater River Confluence, Clark Fork Delta at Lake Pend Oreille (Derr Island, Panhandle Wildlife Management Area [WMA]), Yaak River and Star Creek Confluences

The Ramping Rates for Safety operational measure under MO3 is the only measure that will impact the Stillwater River Confluence. The co-lead agencies claim that variability in water surface elevation on the South Fork Flathead is within the current range of variability, and that variability will be more muted downstream of the South Fork and the mainstem Flathead River Confluence. Because the Stillwater River Confluence is located approximately 20 RM (32 RKM) downstream of the South Fork and mainstem Flathead River Confluence, impacts to this area are not expected to differ significantly from those of the NAA.

The Hungry Horse Additional Water Supply operational measure is expected to have negligible impacts to Lake Pend Oreille, resulting only in a reduced water surface elevation (by a few inches) in the winter and spring. This change is minor, and it would occur largely outside the spring and summer. Thus, under MO3, impacts to riparian vegetation at the Clark Fork Delta should not differ significantly from those of the NAA.

The Ramping Rates for Safety, Modified Draft at Libby and December Libby Target Elevation operational measures will raise water surface elevation on the Kootenai River from 6.0 inches to 24 inches (15 cm to 61 cm) in November and December and reduce water surface elevation from 6.0 inches to 36 inches (15 cm to 91 cm) during the rest of the year. MO3 will lead to increased cottonwood and willow mortality during the winter. Under MO3, the loss of riparian vegetation at the Yaak River Confluence will be more severe than the loss experienced under MO1, but slightly less than the loss experienced under MO2.

Lower Snake River: Catholic Creek Confluence downriver to Hog Island, Tucannon River Confluence, Big Flat Recreation Area

The Ramping Rates for Safety operational measure under MO3 will lift non-safety-related ramping rate restrictions at Dworshak Dam, but no other operational measures would occur at Dworshak Dam to impact the Catholic Creek Confluence. Besides negative impacts resulting from proposed changes in ramping rates, impacts to riparian habitat under MO3 are not expected to differ significantly from those under the NAA.

The four structural and operational dam breaching measures (Breach Snake Embankments, Lower Snake Infrastructure Drawdown, Drawdown Operating Procedures, and Drawdown Contingency Plans) may impact riparian vegetation at the mouth of the Tucannon River tributary by disconnecting the tributary from the water table when the water level drops. However, riparian vegetation in the tributary itself may persist after mainstem water levels drop due to its connection with the tributary water table. Dam breaching will expose new shoreline of the former floodplain for riparian vegetation to colonize. Initially, however, there may be some net loss of riparian vegetation at the mouth of the tributary. As with other key sites along the Snake River, there is potential for non-native plants to invade, especially without proper management during and immediately following dam breaching. Adoption of functional flows at Dworshak Dam will promote native riparian establishment over the invasion of non-native species and, coupled with targeted invasive species removal during the first few years following dam breaching, it could result in a significant net gain of riparian habitat at the Tucannon River Confluence and other similar habitats in the Lower Snake River subbasin under MO3.

Breaching the four Lower Snake River dams under MO3 could result in significant impacts to the Big Flat Recreation Area and nearby sites. The recreation area may not change if current management practices continue, but if management ceases, it is likely that Russian olive will continue to dominate this site and, eventually, outcompete native riparian vegetation. Alternatively, if management continued at this site, in concert with invasive plant control efforts, native riparian vegetation could establish on the newly exposed shoreline, resulting in a long-term increase in riparian habitat quantity and quality at this key site. Additional monitoring and management actions will be necessary to ensure the suitable conditions for establishment of native riparian species during and immediately following dam breaching. The co-lead agencies should consider timing dam breaching so shorelines are exposed, coinciding with native riparian seed release, and allow for a gradual recession of water levels. The adoption of a functional flow regime at Dworshak Dam, at least in high-water years, would also help ensure the survival and longevity of native riparian habitat along the newly exposed shoreline. Assuming the use of available and cost-effective means to prevent the spread of invasive species, there could be a long-term increase and overall improvement in riparian habitat at this key site in comparison to the NAA.

All sites under MO3 will be affected by the operational measure (Ramping Rates for Safety) that aims to lift ramping rate restrictions. Thus, for all key sites in this subbasin (apart from those sites that would be directly impacted by the implementation of the dam breaching measures), the Service expects this measure will lead to negative impacts to riparian habitat as previously described.

G.3.4.4 MO3 Impacts on Evaluation Species and Other Guilds and Communities

Under MO3, impacts to species at the Sandy River Delta will be comparable to those under MO1, as the resulting change in water surface elevation under MO3 and MO1 are of approximately the same magnitude and timing. Thus, under MO3, negative impacts to riparian species at the Sandy River Delta will be slightly more severe than those under the NAA, and comparable to those under MO1, MO2, and MO4.

Under MO3, impacts to riparian species at Umatilla NWR are expected to be similar to, but less severe than, those of MO1. Prolonged inundation could cause some mortality of riparian vegetation along the riparian shoreline, which could result in a net loss of habitat for riparian species such as the viceroy butterfly, yellow warbler, Bullock's oriole, and willow flycatcher. Inundated riparian habitat could eventually be converted to submerged or emergent aquatic vegetation such as reed canary grass. Conversion of riparian habitat to any other habitats will reduce habitat complexity, ecosystem function, and connectivity. Under MO3, negative impacts to riparian species at Umatilla NWR would be greater than those under the NAA or MO2, but not as severe as those under MO1 and MO4.

A decrease in water surface elevation at key sites downstream of Libby Dam on the Kootenai River (e.g., Yaak River Confluence) during the early summer will lead to fewer new cottonwood and willow seedlings, and increased winter stage will cause mortality in newly established seedlings. In addition, a reduction in water surface elevation through the rest of the year could cause drought stress or mortality of existing cottonwood and willow. Loss of cottonwood and willow habitat will negatively impact species that depend on this vegetation for one, or all, life history stages. These species include the viceroy butterfly, which uses only plants in the willow family as larval host plants, and riparian birds (e.g., yellow warbler, Bullock's oriole, willow flycatcher). If initial drops in water surface elevation occur in early June, and are allowed to recede at a rate of no more than 1.0 inch (2.5 cm) per day for the following several weeks, then additional shoreline would be exposed at a time when new riparian vegetation would naturally establish. However, high winter water levels in the Basin could lead to displacement of newly established seedlings, negating the benefits of riparian establishment earlier in the season. Because MO3 will result in significant increases in water levels in winter stage, the implementation of spring stage recession will be unlikely to benefit riparian species, as increased winter stage would lead to a net decrease in riparian vegetation quantity and quality. Direct impacts on cottonwood and willow will have indirect effects on riparian species such as riparian songbirds. Under MO3, negative impacts to riparian species in the Yaak River Confluence will be slightly more severe than those of MO2 and slightly more beneficial than those under MO1.

Under MO3, at key sites in the Lower Snake River (e.g., Tucannon River Confluence and the Big Flat Recreation Area), dam breaching could lead to some immediate losses in existing riparian vegetation. However, most of the riparian vegetation in the Tucannon River will likely survive due to its connection with the water table. At the Big Flat Recreation Area, riparian vegetation irrigated by the Corps will also likely survive. Over time, dam breaching will enable the shoreline to return to a condition closer to its historical state, which once supported more riparian vegetation than the current shoreline. In addition to MO3, newly exposed riparian shoreline at either of these key sites could be colonized with native riparian vegetation and, if managed properly, could result in improved riparian habitat quantity and quality compared to the NAA.

The initial loss of existing riparian vegetation at the Tucannon River Confluence and Big Flat Recreational Area sites will negatively impact the availability of suitable nesting sites, reduce the quantity of host plant substrate, and limit food resources for riparian species in the short-term. There may also be short-term declines in the productivity and survival of riparian species at these sites, which could negatively impact local populations. However, if some actions are taken to prevent the future spread and establishment of non-native plants into newly exposed riparian shoreline, native riparian vegetation will likely increase in abundance at both of these sites in the long-term, benefitting native riparian species.

Under MO3, the Service projects a long-term increase in riparian vegetation, such as cottonwood and willow, in the Lower Snake River reaches, which would lead to long-term benefits to riparian species. Healthier, more complex riparian vegetation would support a more resilient ecosystem in this subbasin.

The Ramping Rates for Safety operational measure will likely lead to negative effects, as previously described, on all riparian species that inhabit various key sites throughout the study area apart from those sites affected by the four structural and operational dam breaching measures.

G.3.5 MO4

G.3.5.1 MO4 Summary of Riparian Landscape Findings

- Structural and operational measures will lead to declines in riparian habitat quantity and quality, comparable to those under MO2, in all areas of the Basin except for on the Kootenai River, where the Lower Stage for Riparian operational measure will enhance the riparian landscape and better support species inhabitants.
- MO4, with the inclusion of some riparian landscape-specific management provisions primarily associated with the rate and timing of drawdown, represents the largest opportunity for improvement of riparian habitat quantity and quality throughout the study area.

G.3.5.2 MO4 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

The structural and operational measures proposed under MO4 will accelerate the degradation and loss of native riparian vegetation in most areas of the Basin. The greatest changes to the hydrograph will include slightly decreased peak flows and summer stage in lower regions of the Lower Columbia River, such as the Sandy River Delta site; extreme prolonged shoreline inundation throughout the spring and summer in the upper portions of the Lower Columbia River; extreme reductions in stage throughout the spring and summer in the Mid-Columbia; and prolonged inundation throughout the spring and summer on the Lower Snake River. However, lower and less erratic fluctuations in winter stage on the Kootenai River would shift the current hydrograph closer to the pre-dam hydrograph and, thus, could result in some positive impacts to riparian habitat.

G.3.5.3 MO4 Impacts on Key Sites

Lower Columbia River: Julia Butler Hansen NWR, Sandy River Delta, Umatilla NWR

Under MO4, changes in water surface elevation downstream of RM 105 (RKM 169) are expected to remain within the current range of variability. Thus, impacts to riparian habitat at Julia Butler Hansen NWR are not expected to differ significantly from those of the NAA.

Under MO4, the Drawdown to MOP operational measure appears to be associated with a reduction in water surface elevation at the Sandy River Delta from 2.0 inches to 7.0 inches (5.0 cm to 18 cm) during the spring and summer, resulting in similar impacts to riparian habitat of MO1, MO2, and MO3. Water surface elevation will also increase from 2.0 inches to 4.0 inches (5.0 cm to 10 cm) during the winter, but this change should not impact riparian habitat significantly. As with MO1, MO2, and MO3, a reduction in water surface elevation during the spring and summer could result in drought stress or riparian vegetation mortality. However, exposed shoreline could be colonized by native riparian species, provided the initial transition to the lower water level is managed properly. If the rate and timing of drawdown is disregarded, then there would likely be a net loss of riparian habitat in comparison to current conditions, which is consistent with the projected loss resulting from MO1, MO2, and MO3.

The Drawdown to MOP operational measure also appears to be associated with a reduction in water surface elevation on river reaches between McNary Dam and Bonneville Dam. This reduction would occur between April and July in most years and between March and August in dry years. A drop in water surface elevation would begin at 6.0 inches to 18 inches (15 cm to 46 cm) above McNary Dam, and it would increase in magnitude (2.3 ft to 4.0 ft [70 cm to 1.2 m]) with distance downstream to Bonneville Dam. Under MO4, the water surface elevation at Umatilla NWR will decrease by approximately 1.0 ft to 2.0 ft (30 cm to 61 cm), which could lead to a significant loss of riparian habitat. As with the Sandy River Delta key site, exposed shoreline could be colonized by native riparian species if the initial transition to the lower water level is managed appropriately. However, without proper management of the stage decrease, there will likely be a net loss in riparian habitat under MO4 in comparison to NAA.

Mid-Columbia River: Okanogan River Confluence, Threemile Creek to Six Mile Creek Confluences, and the Little Sheep Creek Confluence

Due to the Lake Roosevelt Additional Water Supply and Chief Joseph Dam Project Additional Supply operational measures, the change in water elevation downstream of Chief Joseph Dam is expected to remain within the current range of variability. Therefore, impacts to riparian habitat at the Okanogan River Confluence, are not expected to differ significantly from those of the NAA.

The Winter FRM Space and McNary Flow Target operational measures will reduce water surface elevation from 6.0 ft to 8.0 ft (1.8 m to 2.4 m) in the winter in Lake Roosevelt immediately upstream of the Grand Coulee Dam and from 2.0 ft to 8.0 ft (61 cm to 2.4 m) in the spring and summer. The amount of stage decrease will attenuate with upstream distance from Grand Coulee Dam, resulting in reduction in water surface elevation from only 3.0 ft to 4.0 ft (91 cm to 1.2 m) in the winter and from 1.0 ft to 2.0 ft (30 cm to 61 cm) in the spring and summer in the upstream reaches near the Canadian border. A general reduction in water surface elevation in the winter should be inconsequential for riparian habitat quantity and quality, but the same reduction during the spring and summer would result in the loss of riparian vegetation. If the timing of the initial drop in the water level is scheduled appropriately, and maintained at a gradual rate during the first year of implementation, then native riparian species could colonize the newly exposed shoreline, leading to an increase in riparian vegetation quantity. However, the hydrograph for MO4 is stagnant most of the year except for a reduction in water surface elevation occurring between February and July. Thus, the colonization of riparian species would not be supported. Under MO4, the Service expects that there will be a greater loss of riparian habitat from the Threemile Creek to Six Mile Creek Confluence site in comparison to the NAA.

Under MO4, the Winter FRM Space and McNary Flow Target operational measures appear to be associated with a reduction in water surface elevation at the Little Sheep Creek Confluence from 3.0 ft to 4.0 ft (91 cm to 1.2 m) in the winter and from 1.0 ft to 2.0 ft (30 cm to 61 cm) in the spring and summer. The nature and mechanism of the impacts to riparian habitat will be similar to those described for Threemile Creek to Sixmile Creek Confluences, but less severe. The Service expects there will be a greater loss of riparian habitat at this site in comparison to the NAA.

<u>Upper Basin: Stillwater River Confluence, Clark Fork Delta at Lake Pend Oreille (Derr Island, Panhandle Wildlife Management Area [WMA]), Yaak River and Star Creek Confluences</u>

Water surface elevation on the South Fork of the Flathead River is expected to be slightly lower in the winter and spring, and slightly higher in the summer. However, these changes in water surface elevation on the South Fork are expected to remain within the current range of variability, and changes downstream of the confluence of the South Fork and mainstem Flathead River are expected to be muted. The Stillwater River Confluence is located approximately 20 RM (32 RKM) downstream from the South Fork and mainstem Flathead River Confluence, and therefore is not expected to experience impacts as a result of MO4 that differ from those of the NAA.

Operational measures implemented at Hungry Horse Dam (e.g., Hungry Horse Additional Water Supply) are expected to have negligible impacts downstream of the South Fork and mainstem Flathead River Confluence, where the Clark Fork Delta is located. The McNary Flow Target operational measure at Albeni Falls Dam appears to be associated with no change in water surface elevation in Lake Pend Oreille in most years, but with a reduction in water surface elevation at Lake Pend Oreille during dry years by up to 31 inches (79 cm) during the summer.

This decrease in water surface elevation could lead to drought-induced mortality of existing riparian vegetation in dry years. Even if native riparian species were able to colonize the newly exposed soil during dry years, they would become inundated when water levels return to the normal summer surface elevation in other years. Although, in most years, the impacts of MO4 on native riparian habitat will not differ significantly from those of the NAA, there will be a greater decline in riparian habitat quantity and quality caused by drought-induced mortality during dry years under MO4 in comparison to the NAA and MO2 (6.0 inch [15 cm] drop in spring water levels).

The Modified Draft at Libby and December Libby Target Elevation operational measures appear to be associated with a reduction in water surface elevation downstream of Libby Dam (i.e., Yaak River Confluence) in November and December, increasing from January through March, decreasing in April and May, and increasing again through the spring peak flows in June and through July. Under MO4, the Lower Stage for Riparian operational measure will prevent winter water levels from exceeding the previous peak flood water level in a given year. The summary hydrograph from the co-lead agencies H&H modeling output at this key site shows slightly higher water levels in January and February, but much lower water levels in November and December, and overall more consistent water levels throughout the winter.

More consistent water levels throughout the winter would help prevent winter mortality of newly established cottonwood and willow by reducing the potential for fluctuating winter water levels to displace ice-encased seedlings. The increased number of peak flows occurring in June, followed by a recession rate similar to that of the NAA, which allows for cottonwood and willow establishment, would benefit riparian habitat by increasing the potential for new recruitment with larger peak floods. Higher water levels through the end of July would also limit drought stress experienced by riparian vegetation during hot, dry summers. This regime would further enhance functional flows already occurring at Libby Dam that favor cottonwood and willow recruitment, and it would also increase overwintering survival of newly established seedlings that would be under threat of rising winter water levels in current conditions. MO4 is expected to lead to enhanced riparian habitat compared to the NAA.

Lower Snake River: Catholic Creek Confluence downriver to Hog Island, Tucannon River Confluence, Big Flat Recreation Area

No changes in operations at Dworshak Dam will occur under MO4. Impacts of the Drawdown to MOP operational measure at Lower Granite Dam will reduce water surface elevation by approximately 12 inches (30 cm) in March and increase water surface elevation by approximately 4.0 inches (10 cm) in spring and summer. However, impacts to the Lower Granite Dam pool will be reduced upstream of the Catholic Creek Confluence, and the summary hydrograph for the Catholic Creek Confluence is very similar to that of the NAA. Thus, under MO4, impacts to riparian habitat at this key site would not differ significantly from those of the NAA.

Under MO4, the Drawdown to MOP operational measure at Ice Harbor Dam appears to be associated with a reduction in water surface elevation by approximately 12 inches (30 cm) in March, as well as an increase of approximately 4.0 inches (10 cm) through June, in reaches above Ice Harbor Dam including the Tucannon River Confluence. A reduction in water levels in March may lead to drought stress experienced by riparian vegetation. The maintenance of higher water levels through June would overlap with normal peak flow and seed release in early June, which would inhibit the regeneration of riparian vegetation. The summary hydrograph for the NAA at the Tucannon River Confluence is abnormally shaped, as it is for MO4, but with lower lows in the early spring and higher peaks in June. Thus, impacts to the riparian landscape at the Tucannon River Confluence under the NAA and MO4 will be similar, but, under MO4, there may be some further degradation of the riparian landscape.

At the Big Flat Recreation Area, the Drawdown to MOP operational measure will lead to changes in water surface elevation similar to those described for the Tucannon River Confluence. However, the majority of riparian vegetation at Big Flat Recreation Area is heavily managed and exists at an elevation that would not be inundated by a modest increase in water surface elevation. Riparian vegetation that is not irrigated but exists naturally adjacent to the shoreline could be negatively impacted by early summer inundation under MO4, but the majority of riparian vegetation at this key site would likely remain unaffected. Overall, under MO4, the quantity and quality of riparian vegetation at this key site is not expected to differ significantly from that of the NAA.

G.3.5.4 MO4 Impacts on Evaluation Species and Other Guilds and Communities

Under MO4, impacts to riparian species at the Sandy River Delta will be comparable to those described under MO1, as the resulting change in water surface elevation under MO1 and MO4 are of approximately the same magnitude and timing. Thus, under MO4, impacts to riparian species at the Sandy River Delta will be slightly more severe than those under the NAA, and comparable to those of MO1, MO2, and MO3.

Under MO4, water surface elevation at Umatilla NWR will decrease throughout most of the spring and summer, dropping in April through July in most years and March through August in dry years. The drop in water surface elevation during June will further reduce spring peak flows, inhibiting cottonwood and willow recruitment, and lower water levels throughout the spring and summer could result in drought stress and riparian plant mortality. The net loss of riparian vegetation at this key site would lead to indirect impacts on riparian species such as the viceroy butterfly, yellow warbler, Bullock's oriole, and willow flycatcher. A reduction riparian habitat quantity and quality could lead to reduced productivity and survival of these species at this key site and in other areas. Riparian habitat is limited in quantity and quality in this subbasin, and, thus, even minor losses can have disproportionate (i.e., large) effects on fish and wildlife resources.

Under MO4, water surface elevation at both Threemile to Sixmile Creek Confluences and Little Sheep Creek Confluence will decrease in the winter and throughout the spring and summer.

Cottonwood and willow vegetation unable to maintain contact with the lower water table during this time will experience drought stress and mortality, and there will be a net loss of riparian vegetation quantity and quality, which would negatively impact local riparian species. Due to the altered hydrographs at these key sites and exposed shoreline, there will likely be a higher risk of potential non-native species establishment. However, strategic flow management could negate these impacts and even result in benefits to riparian habitat. Without proper management, however, negative impacts to riparian species upstream of Grand Coulee Dam will be more severe than those of the NAA or the other MOs.

Potential drought stress experienced by riparian vegetation combined with increased inundation through the end of June will likely further degrade riparian vegetation at the Tucannon River Confluence in comparison to current conditions. Riparian stringers such as the one at the Tucannon River Confluence are important to maintain, as they serve as dispersal and migratory corridors for riparian species. In comparison to the NAA, MO4 is the only proposed MO that will result in more severe impacts to riparian species at the Tucannon River Confluence.

The reduction in water surface elevation at the Clark Fork Delta during dry years of up to 2.6 ft (79 cm) during the spring and summer will result in drought stress and subsequent mortality of cottonwood and willow. Under MO4, adverse impacts on riparian habitat at the Clark Fork Delta are comparable to those of MO and exceed those of the NAA, MO1, and MO3 in severity.

Riparian songbirds such as yellow warbler, Bullock's oriole, and willow flycatcher and other riparian species will suffer indirectly from long-term loss of cottonwood and willow at all of the aforementioned key sites. During dry years, wildlife resources may also suffer directly due to desiccation. For example, the desiccation of typically moist or inundated shoreline in the middle of the summer can disrupt the life history stages of invertebrates, such as aquatic emergent insects, which serve as sustenance for breeding riparian birds, among other species, and help form the base of the riparian food web.

Riparian vegetation at the Yaak River Confluence will likely benefit from the impacts of MO4 for several reasons. First, winter water levels will be more consistent in general, and they will be managed to not exceed levels of the previous peak flow. Second, peak flows would be slightly higher in June and followed by a carefully managed stage recession rate that would promote the native riparian vegetation recruitment. Third, slightly higher water levels in July will reduce drought stress for riparian vegetation during hot and dry summer periods. These factors will likely lead to a modest increase in riparian vegetation quantity and quality immediately adjacent to the shoreline, even though riparian vegetation situated deeper into the riparian corridor will be unlikely to benefit. In comparison to current conditions, MO4 is the only proposed MO under which riparian species in the area of the Yaak River Confluence will likely gain some ecological benefits.

G.4 WETLANDS

G.4.1 NAA

G.4.1.1 NAA Summary of Wetlands Landscape Findings

- Structural and operational measures associated with the NAA will continue to maintain the current quantity and quality of wetland vegetation, subhabitats, and species inhabitants at key sites in the study area.

G.4.1.2 NAA Impacts on Indicators of Ecological and Physical Processes and Subhabitats

Habitat Complexity and Ecosystem Function

Continued dam operations and water surface elevation changes will result in reduced habitat complexity and ecosystem function across the wetlands landscape in the study area, impacting the ecological and physical processes that support wetland vegetation for species analyzed in this CAR. These conditions and their impacts would continue under the NAA. In some parts of the Basin, the current composition of native wetland vegetation, in particular, is reduced, and the implementation of structural and operational measures under the NAA will likely lead to further reductions in plant and wildlife species diversity.

Pre-Dam Hydrograph and Natural Flood Regime

The wetlands landscape and subhabitats may be negatively affected by mainstem river discharge or fluctuating water surface elevation either directly (i.e., direct connection or interactions) or indirectly via long-term impacts of water discharge patterns. The NAA will continue to sustain wetland habitats and subhabitats in their current ecological condition, and continued regulation of the hydropower system will limit pioneering of wetland habitat reestablishment in the study area (USFWS 2019c).

G.4.1.3 NAA Impacts on Key Sites

Key Island Sites

For the purposes of this CAR, the Service analyzed impacts of the NAA and the MOs on key island sites in the four subbasins. These island sites, and other sites in the study area, are characterized by wetlands landscape that is likely to be particularly sensitive to fluctuations in water surface elevation as a result of both continued and modified dam operations and maintenance.

The NAA includes an array of structural and operational measures, along with a major off-site habitat-restoration program (i.e., at Steigerwald Lake NWR), which could affect the wetlands landscape at certain island sites. Under the NAA, the co-lead agencies will maintain wetland habitats and subhabitats in their current, but overall degraded, state at key sites as a result of alternating periods of desiccation and inundation of wetlands, disconnected from the mainstem and river subhabitats. Future wetlands landscape-driven restoration projects may improve the complexity and ecological function of the wetlands landscape at local levels, however.

Key River Delta Sites

For the purposes of this CAR, the Service analyzed impacts of the NAA and MOs on key river delta sites in the four subbasins. These river delta sites, and other sites in the study area, are characterized by wetlands landscape that is likely to be particularly sensitive to fluctuations in water surface elevation as a result of both continued and modified dam operations and maintenance (Vörösmarty et al. 2009, p. 35). These conditions and their impacts will likely continue under the NAA. For example, continued fluctuations in water surface elevation may lead to more frequent periodic erosion, supporting a pattern of alternating periods of desiccation and inundation of wetland habitats and subhabitats. These fluctuations will ultimately affect the expansion of the wetlands landscape and limit the foraging and nesting opportunities for wetland obligate species at various key sites (USFWS 2019c).

At the 15,000 acre (61.000 km^2) McNary NWR, water entrained from the CRSO has created a network of high-carbohydrate food-providing farm fields and wetland subhabitats. The Burbank Slough system occupies the original Snake River channel and has evolved to a stabilized water system that produces high quality aquatic vegetation beds for staging and wintering waterfowl. The Wallula Unit encompasses the original Walla Walla River Delta and floodplain, and it is actively managed to replicate natural hydrologic regimes through moist-soil wetland impoundments (Healy, F., in litt. 2019). Over 75,000 acres (304.000 km^2) of river habitat within the jurisdiction of the McNary NWR contain native submerged aquatic vegetation beds that support a significant proportion of the wintering waterfowl in the Basin (USFWS 2007, p. 4-26).

G.4.1.4 NAA Impacts on Evaluation Species and Other Species

Species that rely on wetland habitats and subhabitats in the study area include the American bittern, Columbia yellowcress, mallard, sora, tiger salamander (*Ambystoma tigrinum*), Western painted turtle, Woodhouse's toad, and Western toad (*Anaxyrus boreas*). In current ecological conditions, some of these species benefit more from dam operations than others. For example, mallard will continue to occupy slow moving waters within the wetlands landscape basinwide on an annual basis, and they will continue to use nesting areas in the uplands landscape from April to June. Reptiles and amphibians, including turtles, toads, and salamanders, will also continue to use the existing wetland landscape to complete various life history stages (FERC 2006, p. 241).

The implementation of structural and operational measures associated with the NAA will enable the American bittern and sora to use wetland subhabitats comprised of tall, emergent vegetation. However, regulated water surface elevation throughout the study area will likely negatively impact population expansion and species productivity by limiting access between foraging and breeding areas (Stevens et al. 1997, p. 164). These conditions and their impacts would continue under the NAA.

Prior studies show that artificial flooding of wetland habitat and subhabitats for prolonged periods of time as a result of dam operations can alter grass and sedge composition (Ward and Stanford 1979, p. 127). This artificial flooding, to varying degrees, is expected to continue with the implementation of the NAA. Columbia yellowcress, for instance, located in the Mid-Columbia River, will be impacted by hydrological changes associated with the NAA (FERC 2006, p. 273; Sackschewsky et al. 2014, pp. 5, 9). Species populations may vary in abundance and changes in water surface elevation patterns impact seasonal reproduction (during late summer and early fall), growth, and development.

G.4.2 MO1

G.4.2.1 MO1 Summary of Wetlands Landscape Findings

- Structural and operational measures associated with MO1 will result in some negative impacts to the wetlands landscape (e.g., reduced vegetation quantity and quality), especially throughout the Lower Columbia River subbasin and the Kootenai River.
- The implementation of some measures under MO1 will lead to the temporary inundation of wetland subhabitats at some key sites and, conversely, the desiccation of wetland habitats and subhabitats at other sites, resulting in the potential for non-native species invasion.

G.4.2.2 MO1 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

The implementation of several operational measures under MO1, including those proposed for Libby Dam in northwestern Montana (e.g., Modified Draft at Libby), have the potential to negatively affect wetland habitats and subhabitats by increasing or decreasing water surface elevation at a faster rate than in current conditions. This effect would be especially evident in backwaters, which may become disconnected from the mainstem (e.g., Kootenai River). Disconnected wetlands expose species inhabitants to higher levels of desiccation, which result in less complex habitat and reduced species abundance (USFWS 2019c).

Changes in water surface elevation resulting from MO1 will also negatively impact wetland vegetation quantity and quality in comparison to NAA conditions. Higher water levels in the summer (June through September) will increase inundation at adjacent wetland habitats upstream of dams, resulting in potential loss of existing emergent vegetation and fewer transitions in plant community structure and status (to one that is more tolerant of regular inundation patterns). However, under MO1, the implementation of operational changes in outflows downstream of Federal projects would reduce water levels during the spring by several inches, resulting in the desiccation of wetland habitats and preventing regrowth of existing native vegetation.

G.4.2.3 MO1 Impacts on Key Sites

<u>Key Island Sites</u>

Lower Columbia River: Reed Island, Steigerwald Lake NWR, and Sauvie Island Wildlife Area

As a result of the Block Spill Test (Base +120/115 Percent) and Increased Forebay Range Flexibility operational measures, impacts to key island sites in the Lower Columbia River would be most evident at Reed Island, Steigerwald Lake NWR, and the Sauvie Island Wildlife Area. These measures would likely result in the periodic short-term reduction of water during spring and summer, leading to desiccation of wetland habitats.

Mid-Columbia River: Hanford Reach and Wells Wildlife Area

The implementation of the Block Spill Test (Base +120/115 Percent) operational measure would likely have some effects in the Mid-Columbia River at key island sites. The Hanford Reach, in particular, would be exposed to the effects of this test due to operational changes at Grand Coulee Dam. In comparison to the NAA, water surface elevation near the Hanford Reach is expected to decrease by approximately 6.0 inches (15 cm) from February through September. Thus, under MO1, the Hanford Reach will likely experience short-term periods of desiccation in May and June, resulting in the potential loss of critical wetland vegetation that supports breeding and rearing habitat for wetland species. Such impacts may also be evident, but diminished, upstream at the Wells Wildlife Area.

Upper Basin: Everett Island and Kootenai NWR

Under MO1, the effects of some operational measures would also likely be diminished during some water years at key island sites (e.g., Everett Island) that are adjacent to river tributary subhabitat, which can buffer the impacts of fluctuating water levels. According to the co-lead agencies H&H modeling output, water surface elevation at most key island sites during most water years would likely be similar to that in current conditions. However, during the highest water years, in river reaches below Albeni Falls Dam, sites like Everett Island might experience decreases in water surface elevation up to 5.0 inches (13 cm) in November. Overall, in comparison to the NAA, changes in water surface elevation related to MO1 could result in a faster rate of decline in wetland habitat quality at Everett Island and other key sites.

In comparison to the NAA and other MOs, the implementation of the Modified Draft at Libby and December Libby Target Elevation operational measures in MO1 will likely have the greatest impacts to the wetlands landscape at the Kootenai NWR in the Upper Basin. Under MO1, water surface elevation will be lower in December and higher in February and March. The refuge currently manages wetland subhabitat by pumping water from the Kootenai River and Deep

Creek from September through November, and dikes keep the river flows from impacting the majority of the refuge's wetlands. Higher water surface elevation during this time could lead to increased inundation at the Kootenai NWR, but likely only in some wetlands outside of existing dikes. After March, as air and water increase in temperature, proposed operational measures will result in lower flows near the Kootenai NWR. Lower flows could be detrimental to the wetlands landscape only if they are low enough to disconnect wetlands from the mainstem Kootenai River (Stenvall, C., in litt. 2019b).

Lower Snake River: Silcott Island

As a result of MO1, wetland habitats and subhabitats at Silcott Island in the Lower Snake River will also likely experience slightly more inundation, however, the impacts of erosion during this time would likely be buffered and would not differ from those of the NAA.

Key River Delta Sites

In most years, the implementation of MO1 is expected to result in few, if any, negative impacts to key river delta sites in the study area. For example, in the Pack River Delta near Lake Pend Oreille in the Upper Basin, there may be a slight increase in late summer flow, but within the current range of variability. Under MO1, changes in water surface elevation changes in mainstem river subhabitat in the study area will also likely fall within current range of variability and, thus, would have little to no impact to the wetlands landscape throughout all subbasins. Under MO1, McNary NWR will likely experience similar impacts to those of the NAA. However, in the case that McNary NWR and the associated Walla Walla River Delta experience significantly lower water levels under MO1, then the refuge's water management capabilities will be impaired (Healy, F., in litt. 2019; Stenvall, C., in litt. 2019a).

G.4.2.4 MO1 Impacts on Evaluation Species and Other Species

Lower water levels during the spring and summer in the Lower Columbia River may lead to reductions in the quantity and quality of wetland habitats, especially at NWR sites including Reed Island, Steigerwald NWR, and the Sauvie Island Wildlife Area, where Service managers maintain wetlands landscape for species such as Western painted turtles.

As a result of potential changes in water levels proposed under MO1, semi-aquatic species that live in and use wetland habitat and subhabitat in the study area may experience negative effects. For example, mallard will likely have less open water to forage, and amphibians (e.g., Woodhouse's toad) that inhabit the Hanford Reach and Wells Wildlife Area may lose breeding and rearing habitat due to potential desiccation. Mallard, tiger salamander, and Western painted turtle may be less influenced by MO1 at the Lower Crab Creek site, since changes in water surface elevation resulting from operations of Grand Coulee Dam are likely to be minor.

In the Upper Basin, mallard would likely benefit initially from high water surface elevation for feeding purposes. As higher water levels persist, the composition of emergent vegetation in inundated areas will transition and, instead, support a different suite of species that are perhaps more adaptable in their food resource needs (e.g., mallard). For example, MO1, which includes operational measures that will increase the frequency and duration of fluctuations in water surface elevation, will impact species (e.g., mallard, sora, and Western toad) at Kootenai NWR. Increased water levels over longer periods of time will limit seasonal access to forage resources and reduce available nesting habitat during the breeding season. Given the current dike infrastructure at Kootenai NWR, shallow backwaters at this site (i.e., at the confluence of the Kootenai River and Myrtle Creek) may become intermittently dry as water surface elevation decreases, leading to desiccation of some wetland habitat needed by amphibians (e.g., Western toad) to lay their eggs (McMenamin et al. 2008, p. 16989; Stenvall, C., in litt. 2019b).

The implementation of the operational measure (Modified Dworshak Summer Draft) at Dworshak Dam has the potential to negatively affect wetland habitats and evaluation species at Silcott Island and the Snake River and Palouse River deltas, yet the impacts may become diminished below the confluence of the Clearwater River. Mallards will likely benefit from the creation of more wetlands landscape with slower moving water. Under MO1, proposed changes in summer draft operations may also benefit amphibians. The Western toad, for example, breeds in pools and slower-moving waters in Idaho from early May to late June, and tadpoles are generally present from late May to early September (WDFW 2015, p. 19). Increasing the quantity and quality of wetted areas during the breeding season would support increased reproductive success and overall fecundity of this species, which is susceptible to minor changes in water quality (USFWS 2019c).

Increased reservoir water surface elevation as a result of proposed changes in MO1 may reduce water velocity at some sites and, thus, will likely lead to increased predation by non-native species (e.g., amphibians, birds, and fish) of amphibians in the study area (Rosen and Schwalbe 1995, p. 453). Alternatively, decreased reservoir water surface elevation could lead to the invasion and establishment of non-native plant species in drawdown zones.

G.4.3 MO2

G.4.3.1 MO2 Summary of Wetlands Landscape Findings

- A pattern of higher winter flows followed by lower spring and summer flows at various key island and river delta key sites in the study area may lead to conversion of wetland habitats and displacement of wetlands species analyzed in this CAR.
- Proposed operations of some Federal CRS project reservoirs regarding MOP will likely result in widespread negative impacts on the wetlands landscape and species that depend on this landscape.

G.4.3.2 MO2 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

MO2 includes structural and operational measures that will result in more frequent fluctuations in water levels, thereby negatively impacting the growth potential of critical wetland vegetation at various key sites (USFWS 2019c). Under MO2, on average, water levels immediately downstream of Bonneville Dam would be slightly higher in the winter (November through January) and lower in the spring and summer. Although these changes appear to be minor, they will likely lead to low to moderate changes in wetland habitat complexity and ecosystem function throughout the Lower Columbia River.

The implementation of operational measures associated with MO2 (e.g., Planned Draft Rate at Grand Coulee) will likely result in deeper drafts for power generation, lowering water surface elevation from 3.0 ft to 6.0 ft (91 cm to 1.8 m) during the winter at Grand Coulee Dam and in Lake Roosevelt. Since these proposed changes in drafting operations would be implemented during the winter months, there would likely be negligible impacts on wetland habitats and subhabitats during the spring and summer. Deeper drafts could affect the pre-dam hydrograph and natural flood regime in the Mid-Columbia River unless such drafts remain in the current range of variability.

At the Kootenai NWR on the Kootenai River, water levels under MO2 will vary between 1.5 ft and 3.0 ft (46 cm and 91 cm) higher in early winter and approximately 1.5 ft (46 cm) lower throughout the rest of the year. As a result of higher winter flows, the banks and shoreline of the mainstem Kootenai River would become inundated, and any riparian vegetation (i.e., cottonwood and willow) seeds and seedlings deposited during the summer months would be carried downstream as flows recede in January. Lower spring freshets would likely reduce deposition of riparian seeds onto banks and shorelines, thereby reducing the potential for cottonwood and willow establishment. Higher water levels in the mainstem during the winter could freeze water in and around the shoreline, which would increase the likelihood of bank sloughing and erosion, degrading water quality.

Under MO2, the co-lead agencies will draft Dworshak Reservoir for power generation, and pool elevation will likely decrease from approximately 2.5 ft to 3.0 ft (76 cm to 91 cm) during the winter, spring, and summer (January to August). In this scenario, water surface elevation would be reduced at Silcott Island while it would be maintained at current levels on the Snake River and Palouse River deltas further downstream.

G.4.3.3 MO2 Impacts on Key Sites

<u>Key Island Sites</u>

Lower Columbia River: Reed Island, Steigerwald Lake NWR, and Sauvie Island Wildlife Area

In the Lower Columbia River, operational measures associated with MO2 (Ramping Rates for Safety and John Day Full Pool) may expose wetlands landscape on island sites to various negative ecological impacts. On average, water levels immediately downstream of Bonneville Dam, at Reed Island, Steigerwald Lake NWR, and the Sauvie Island Wildlife Area, will likely be slightly higher in the winter (November through January) and approximately 0.5 ft (15 cm) lower in the spring and summer. The reduction in water surface elevation during the spring and summer would limit water availability as it is needed to sustain critical wetland vegetation, thereby reducing the quality of wetland habitats in comparison to the NAA.

Mid-Columbia River: Hanford Reach and Wells Wildlife Area

Under MO2, the Planned Draft Rate at Grand Coulee and Slightly Deeper Draft for Hydropower operational measures will likely result in measurable negative impacts on the wetlands landscape at key island sites in the Mid-Columbia River. The Winter System FRM Space operational measure, in particular, could also lead to negative impacts by influencing water levels upstream of McNary Dam. The projected increase in water levels during the winter and the decrease in water levels during the spring and summer would be less than 0.5 ft (15 cm) different in comparison to those expected under the NAA. These changes, compared to those associated with the NAA and other MOs (MO3 and MO4) will likely lead to a faster rate of decrease in quality of the wetlands landscape in the Hanford Reach, whereas the potential impacts of these changes would likely be less drastic at the Wells Wildlife Area.

Upper Basin: Everett Island and Kootenai NWR

Proposed structural and operational measures associated with MO2 will likely cause measurable changes in outflow from Libby Dam in almost every season. However, as a result of the December Libby Target Elevation operational measure, changes to the wetlands landscape and associated species inhabitants will likely be most evident during the winter.

During the winter, higher water levels at Kootenai NWR and in the Kootenai River could lead to increased bank sloughing and erosion, resulting in degraded water quality. Implementing the Ramping Rates for Safety operational measure at Hungry Horse Dam will likely influence flow conditions and water surface elevation, but in a less significant way, at Albeni Falls Dam. Everett Island in the Pend Oreille River and similar wetland habitats throughout the Upper Basin will also likely experience moderate negative impacts, including reduced abundance and limited distribution of wildlife that live and use the wetlands landscape. Lastly, in comparison to the NAA, changes in ramping rates under MO2 will likely alter patterns of seed dispersal, germination and establishment, and the long-term viability of wetland vegetation at key island sites.

Lower Snake River: Silcott Island

The implementation of other operational measures in association with MO2, with potential negative impacts to the wetlands landscape in the Lower Snake River include: Spill to 110% TDG, Ramping Rates for Safety, Full Range Reservoir Operations, Slightly Deeper Draft for Hydropower, Full Range Turbine Operations, Contingency Reserves in Fish Spill, Winter System FRM Space, and Zero Generation Operations. At Silcott Island, in comparison to the NAA, changes in water surface elevation as projected under MO2ill likely result in reduced hydrologic connectivity among wetlands habitats, leading to desiccation and potential transitions in plant community structure and status.

Key River Delta Sites

Lower Columbia River: Sandy River Delta

Under MO2, water levels immediately downstream of Bonneville Dam would be less than 1.0 ft (30 cm) higher in the winter and approximately 0.5 ft (15 cm) lower in the spring and summer. In comparison to the NAA, wetland habitats and subhabitats at the Sandy River Delta and elsewhere (e.g., Walla Walla River Delta) will likely experience minor negative impacts due to fluctuating water levels. Under MO2, these impacts may become progressively muted downstream, near the Columbia River Estuary.

Mid-Columbia River: Lower Crab Creek and McNary NWR

Wetlands landscape at the Lower Crab Creek and other key river delta sites in the Mid-Columbia River will, similar to what is occurring in current conditions, likely remain intact under MO2. McNary NWR, for instance, will not likely experience negative impacts as a result of changes in water levels or flow conditions.

Upper Basin: Pack River Delta

In the Upper Basin, mudflats and barren zones, emergent and forested wetlands, scrub-shrub wetlands, and submerged aquatic beds are most likely to be negatively impacted by fluctuating water levels. The implementation of MO2, in comparison to the NAA, will likely increase exposure of these areas to erosion from boat wakes, wind, and waves. Under MO2, these impacts may be exacerbated at the Pack River Delta due to increased desiccation of submerged aquatic vegetation and emergent wetland plants, which could lead to decreased productivity and changes to plant composition in wetland habitats over time.

Lower Snake River: Snake River Delta and Palouse River Delta

The implementation of the Ramping Rates for Safety and Winter System FRM Space operational measures associated with increased power generation will likely negatively impact the wetlands landscape in the Lower Snake River more than other key river delta sites. Wetland habitats that characterize the Snake River Delta will remain intact, as changes in water surface elevation will likely be less drastic downstream toward the confluence of the Snake River.

G.4.3.4 MO2 Impacts on Evaluation Species and Other Species

Under MO2, in the Lower Columbia River, a 1.0-ft (30-cm) rise in water surface elevation in the winter and a 0.5 ft (15 cm) decrease in the spring and summer may threaten the survival of

American bittern and Western painted turtle local populations, especially at Reed Island, Steigerwald Lake NWR, and the Sauvie Island Wildlife Area. Other species at the Sandy River Delta site, for instance, may not be affected by structural and operational measures associated with MO2.

Under MO2, in the Mid-Columbia River, both an increase in water surface elevation during the winter and a decrease in water surface elevation during spring and summer will be less than 0.5 ft (15 cm) in comparison to that under the NAA. These changes will likely be most evident in terms of impacts observed at the wetlands landscape at the Hanford Reach, downstream of Priest Rapids Dam. While proposed changes in water surface elevation may remain within the current range of variability, mallard and Woodhouse's toad may be displaced from existing narrow segments of wetland habitats due to decreased water availability in the spring and summer. Additionally, off-channel wetlands connected to the Columbia River may become disconnected, negatively influencing the ability of amphibians to breed and successfully rear their young (USFWS 2019c).

In the Upper Basin, proposed changes in ramping rates and draft conditions at Albeni Falls Dam will likely change water surface elevation at Lake Pend Oreille and the Pend Oreille River, downstream of the dam. While proposed operational measures at Libby Dam will likely result in higher winter flows and lower spring flows, the current trend of degrading wetland vegetation and habitat conversion would likely continue (Kootenai 2009, p. 2-64). Mallard foraging opportunities might be more readily available as a result of higher winter flows, however sora nesting and Western toad rearing could be negatively impacted. Changes in water surface elevation on Lake Pend Oreille, particularly at the Pack River Delta, will likely further alter the availability and quality of critical wetland vegetation and suitable nesting habitat for the American bittern, mallard, and sora.

Under MO2, American bittern, mallard, and Western toad will likely experience measurable impacts at Silcott Island in the Lower Snake River. In response to changes in water surface elevation at this key site, wetland evaluation species may relocate to areas with more suitable foraging habitat. Impacts to other species at the Snake River and Palouse River deltas will likely be negligible.

In the study area, proposed changes to Federal CRS project reservoirs regarding MOP will likely negatively impact wetland vegetation growth and survival by increasing opportunities for invasion and establishment of non-native species and predators (Rosen and Schwalbe 1995, p. 453).

G.4.4 MO3

G.4.4.1 MO3 Summary of Wetlands Landscape Findings

- Structural and operational measures related to breaching of the earthen portions of the four dams on the Lower Snake River will lead to negative short-term and positive long-term impacts to ecological and physical processes that support the structure and function of the wetlands landscape throughout the study area.

- Under MO3, discrete wetland habitats and subhabitats could become desiccated, resulting in negative impacts to some species analyzed in this CAR. However, if the co-lead agencies implement wetland restoration activities and monitor them long-term, then wetland habitat quality may be enhanced.

G.4.4.2 MO3 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

Under MO3, changes in water levels and patterns of inundation and seasonal drying may drown out wetland vegetation in some areas. The four structural and operational dam breaching measures associated with MO3, if implemented, will likely restore a portion of the Lower Snake River to a free-flowing state and, thus, over time, will support a pre-dam hydrograph and more natural flood regime (Grill et al. 2019, p. 215).

The implementation of the dam breaching measures could result in sediment deposition at the Snake River Confluence in the McNary Pool. This deposition, over time, would likely support the reestablishment of wetland habitats and subhabitats downstream of the confluence. However, in the short-term, breaching the earthen portions of the four Lower Snake River dams would likely reduce habitat complexity and ecosystem function.

The implementation of structural and operational measures under MO3 will likely change the composition, quantity, and quality of wetland vegetation in the study area, especially in the Lower Snake River. Reservoir drawdown will likely threaten existing wetland habitats, now perched higher in the tributaries, with extended periods of drying. Additionally, non-native vegetation could spread and establish in drawdown zones if active habitat restoration does not occur.

G.4.4.3 MO3 Impacts on Key Sites

Key Island Sites

Lower Columbia River: Reed Island, Steigerwald Lake NWR, Sauvie Island Wildlife Area

Structural measures associated with MO3, if implemented, will be unlikely to negatively impact wetland habitats throughout the Lower Columbia River. Under MO3, key island sites might experience minor changes in water surface elevation, similar to those described in the other MOs. These changes would be most evident in the Columbia River Gorge, downstream of Bonneville Dam.

In the Lower Columbia River, lower water levels in the spring and summer will likely limit the quantity and quality of wetland vegetation at managed wetlands (e.g., Reed Island, Steigerwald Lake NWR, and the Sauvie Island Wildlife Area). In comparison to the NAA, those wetland habitats with less water availability will lose more wetland vegetation during the spring and summer due to desiccation.

Mid-Columbia River: Hanford Reach and Wells Wildlife Area

MO3 includes five operational measures (Ramping Rates for Safety, Update FRM Calculation, Planned Draft Rate at Grand Coulee Dam, Grand Coulee Maintenance Operations, and Lake Roosevelt Additional Water Supply) that propose changes in operations likely to result in impacts to wetland habitats in the Mid-Columbia River. These measures will likely result in operations similar to those in current conditions rather than those under MO1 or MO4. Collectively, the Service does not anticipate the aforementioned measures to result in measurable impacts on existing conditions at the Hanford Reach and Wells Wildlife Area, among others, apart from those due to a decrease by 1.0 ft (30 cm) in water surface elevation from April to October.

Upper Basin: Everett Island and Kootenai NWR

Under MO3, operational measures including Ramping Rates for Safety, Sliding Scale at Libby and Hungry Horse, Modified Draft at Libby, December Libby Target Elevation, and the Hungry Horse Additional Water Supply will likely influence the wetlands landscape throughout the Upper Basin in the following ways.

Outflows near Everett Island and Kootenai NWR will likely increase by 10 percent to 35 percent in early winter (November and December) and decrease by 5 percent to 40 percent during the rest of the year. As a result, water surface elevation on the Pend Oreille and Kootenai Rivers will likely fall in the range between 0.5 ft to 2.0 ft (15 cm to 61 cm) higher in the early winter and between 0.5 ft to 3.0 ft (15 cm to 91 cm) lower during the rest of the year, in comparison to those conditions under the NAA.

High winter flows will likely inundate river banks at Everett Island and Kootenai NWR and redistribute seeds from existing wetland habitats and subhabitats. High water levels may also lead to increasing bank sloughing and erosion, which could degrade water quality. Lower spring flows will likely reduce the moisture content of wetland soils, thereby reducing the suitability of shorelines in the spring and summer to support successful seed deposition and wetland plant establishment.

Lower Snake River: Silcott Island

The structural and operational dam breaching measures associated with MO3, if implemented, have the potential to result in widespread, long-term positive impacts on the wetlands landscape in the Lower Snake River, especially at key island sites. Under MO3, water surface elevation will drop from approximately 95.0 ft to 110 ft (29.0 m to 33.5 m), exposing approximately 13,800 acres (56.000 km^2) of substrate (mostly sand and silt) along the banks of the Lower Snake River. According to the co-lead agencies H&H modeling output and GIS modeling, the quality of the wetlands landscape will decrease and the availability of other landscapes will increase compared to current conditions. Beyond MO3, wetland vegetation could be reestablished as a result of focused restoration efforts and long-term monitoring.

Because most emergent wetland subhabitats are linked to hydrologic regimes associated with the Snake River in this subbasin, transitioning from a reservoir system to river system with lower water elevation will likely negatively impact long-term wetland habitat quantity, quality, and distribution throughout the 140-mile (225-km) section of river. Where wetlands already occur in the NAA, these wetlands may be influenced by proposed CRS operations to transition to uplands. Beyond MO3, with the assistance of habitat restoration efforts and related activities, over time, new wetland habitats and subhabitats could establish, especially at Silcott Island.

Key River Delta Sites

Lower Columbia River: Sandy River Delta

Under MO3, wetland habitat will likely remain intact at the Sandy River Delta in the Lower Columbia River. Patterns of flooding or inundation and erosion, and the resulting impacts of these ecological and physical processes on wetland habitats and subhabitats, would not substantively change from those in current conditions.

Mid-Columbia River: Lower Crab Creek and McNary NWR

Structural and operational measures under MO3, if implemented, will lead to negligible impacts to downstream flows through the Mid-Columbia River. Wetland habitats at Lower Crab Creek, for instance, will likely remain intact.

The four structural and operational dam breaching measures associated with MO3, however, will likely result in high levels of sedimentation at McNary NWR. In the short-term, many of the submerged aquatic vegetation beds that occur at this key site will be degraded or lost due to sedimentation or a subsequent transition to more a more riverine landscape. At McNary NWR, existing infrastructure for wetland management and cooperative farming will be severely compromised (Healy, F., in litt. 2019). In the long-term, focused restoration efforts and long-term monitoring beyond, or in conjunction with, the implementation of MO3 could assist in reestablishing wetland vegetation and increasing the quality of wetland habitats throughout the Basin.

Upper Basin: Pack River Delta

In the Upper Basin, the implementation of the Hungry Horse Additional Water Supply operational measure will reduce flows on the Flathead, Clark Fork, and Pend Oreille Rivers by 90.00 kcfs (2,549 m^3/s) in the winter and spring, however, this measure will have negligible impacts to water surface elevation in Lake Pend Oreille and river reaches downstream of the

Albeni Falls Dam. The Hungry Horse Additional Water Supply operational measure will not influence the quantity, quality, and distribution of wetland vegetation adjacent to the reservoir or rivers landscape.

Lower Snake River: Snake River Delta and Palouse River Delta

In the Lower Snake River, in the short-term, changes in water surface elevation resulting from reservoir drawdown will lead to reductions in wetland habitat quantity and quality. However, in the long-term, the four structural and operational measures associated with dam breaching will create additional areas for wetland reestablishment. Post dam-breaching, deep sediment deposits adjacent to the mainstem Snake River will be more suitable for wetland reestablishment than the rocky, shallow soils that characterize existing shorelines.

At the Palouse River Delta, a major drop in water surface elevation will result in greater accumulation of sediment in the mainstem. Over time, as ecological and physical processes are restored, erosion and nutrient transport would support the development of more wetland habitats and subhabitats distributed throughout the Lower Snake River (Cushing 1993, p. iii; Keeler 2015, p. 15).

G.4.4.4 MO3 Impacts on Evaluation Species and Other Species

MO3 will not severely impact wetland species that inhabit most general areas within the Lower Columbia River. At key island sites like Reed Island, Steigerwald Lake NWR, and the Sauvie Island Wildlife Area, where managers maintain the wetlands landscape to support wetland species (e.g., Western pond turtle), a reduction in water surface elevation during the spring and summer could lead to declines in wetland habitat quantity and quality.

On average, at the Sandy River Delta, near RM 123 (RKM 198), the change in water surface elevation is expected to be less than 3.0 inches (7.6 cm) and, thus, will remain within the current range of variability. Regardless, this minor change could affect wildlife resources' (i.e., mallards, Western painted turtles) use of wetland habitats and subhabitats at this key river delta site. Under MO3, there may be seasonal occurrences when this average reduction in water surface elevation is exceeded, thereby limiting foraging and breeding opportunities for wetland species.

Lower spring and summer flows on the Kootenai River in the Upper Basin could lead to reduced water levels in off-channel sloughs and backwaters from May to late June, drying out amphibian (i.e., Western toad) eggs. Reduced water surface elevation is also likely to be detrimental to the breeding success of birds such as the American bittern, mallard, and sora. Further, changes to the frequency of wetting and drying cycles in wetland habitats at key island and river delta sites will likely negatively impact the availability of, and accessibility to, wetland vegetation required for nest construction.

In the short-term, MO3 will negatively impact wetland reptiles and amphibians during, and immediately following, implementation of the dam breaching measures and reservoir drawdown. Reptiles are generally more mobile than amphibians and, thus, are less dependent on certain accessibility to aquatic landscapes, with the exception of turtles. A permanent reduction in water surface elevation and loss of riparian and wetlands landscapes could isolate amphibian populations and lead to the desiccation of eggs. Past studies show that amphibian eggs exposed to desiccation for approximately one day are no longer viable (McMenamin et al. 2008, p. 16989). Thus, amphibians could experience population-level declines following a widespread, generational loss of eggs along some stretches of the Lower Snake River. Over time, however, wetland species abundance may increase as shallow water habitats and wetland subhabitats reestablish. In the long-term, contiguous wetland habitats will enhance habitat connectivity to support dispersal of, and movement for, reptiles and amphibians.

In the long-term, MO3 will result in a greater abundance of wetland habitats on key island sites in the Lower Snake River and, thus, more support for diverse wildlife resources. Wintering mallard will likely experience disturbance during dam breaching, causing individuals to potentially relocate. In the short-term, degraded water quality and sediment transport processes would limit foraging success and the abundance of aquatic prey resources for waterfowl both during and immediately following dam breaching and reservoir drawdown. The drawdown, however, may expose and lead to greater access of new food resources (e.g., benthic invertebrates) for native species (EAS 2014, p. 2). In regard to wetland vegetation, there will likely be a transition from submerged aquatic plants (e.g., pondweeds and waterweeds) in slower-moving reservoirs to those plants that characterize higher-velocity riverine systems.

Similar to those structural and operational measures associated with other MOs, the measures associated with MO3 include changes that lower water surface elevation in the Lower Snake River following potential dam breaching, which will negatively impact the abundance of benthic organisms and could make it easier for non-native species to invade and establish self-sustaining populations in resulting drawdown zones (Chen et al. 2016, p. 1; Cushing 1993, p. 27).

G.4.5 MO4

G.4.5.1 MO4 Summary of Wetlands Landscape Findings

- Under MO4, some structural and operational measures may positively impact growth and expansion of the wetlands landscape, especially in the Upper Columbia River (e.g., Kootenai River) and Lower Snake River.
- Proposed operations of some Federal CRS project reservoirs regarding MOP will likely hinder efforts to increase wetland habitat complexity and ecosystem function, especially in the Lower Columbia River where significant reductions in water surface elevation are projected to occur below McNary Dam.

G.4.5.2 MO4 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

The Drawdown to MOP operational measure will lower the water surface elevation at Bonneville Dam, John Day Dam, The Dalles Dam, and McNary Dam between April and July, and between March and August, in dry years. Under MO4, MOP operations, specific to the NAA, will continue at these projects. Pool elevations will be between approximately 0.5 ft and 1.5 ft (15 cm and 46 cm) lower upstream of McNary Dam, and the change in pool elevation will increase progressively downstream until a potential decrease (between approximately 2.3 ft and 4.0 ft [70 cm and 1.2 m] lower in comparison to the NAA) in the Bonneville Reservoir.

Under MO4, the Columbia River Estuary below Bonneville Dam will experience minor changes in water surface elevation in average years and wet years, similar to those described in MO1. In very dry years (80 percent AEP to 99 percent AEP) the May and June freshet could increase water surface elevation from 0.5 ft to 1.5 ft (15 cm to 46 cm), in comparison to the NAA. In most years, the Service expects changes in water surface elevation, with an increase in winter water levels by approximately 2.0 inches to 4.0 inches (5.0 cm to 10 cm) and a decrease in water levels during the spring and summer by approximately 2.0 inches to 7.0 inches (5.0 cm to 18 cm), resulting in negative impacts to the wetlands landscape. However, these impacts will likely be slightly less severe further downstream of Bonneville Dam, toward the Columbia River Estuary.

Changes in water surface elevation will result in negative impacts to wetland habitats and subhabitats in the study area. In the Upper Basin, for example, changes in water levels during the spring and summer have the potential to inundate and desiccate narrow bands of emergent vegetation in wetland habitats, which could negatively influence the abundance and distribution of aquatic and semi-aquatic species near the Kootenai NWR. However, these changes will likely be offset in part by the implementation of the Winter Stage for Riparian and McNary Flow Augmentation operational measures. These measures will likely benefit, and could even reverse the trend of widespread losses in, riparian and wetland vegetation along the Kootenai River (Kootenai 2009, p. 2-6). Changes in the hydrograph and flood regime based on these measures will likely yield long-term benefits to the wetlands landscape throughout the Upper Basin.

The implementation of the Drawdown to MOP operational measure will lead to major changes in operations at Ice Harbor Dam, Lower Monumental Dam, Little Goose Dam, and Lower Granite Dam such that pool elevation will be drawn down so that it would be, on average, approximately 4.0 inches (10 cm) above the pool elevation under the NAA. Due to aggressive drafting before raising the water surface elevation for the summer months, reservoir pool elevation at all sites in the Lower Snake River will be lower by approximately 1.0 ft (30 cm) in late March than what is proposed under the NAA, thereby supporting a pre-dam hydrograph and more natural flood regime.

G.4.5.3 MO4 Impacts on Key Sites

<u>Key Island Sites</u>

Lower Columbia River: Reed Island, Steigerwald Lake NWR, and Sauvie Island Wildlife Area

The implementation of the Drawdown to MOP operational measure will lower water surface elevation at reservoir pools associated with Bonneville Dam, The Dalles Dam, John Day Dam, and McNary Dam between April and July and, in dry years, between March and August. For example, at Bonneville Dam, water surface elevation will fluctuate between approximately 2.3 ft and 4.0 ft (70 cm to 1.2 m) lower than that in current conditions. As a result of this measure, wetland subhabitats at key island sites in the Lower Columbia River could dry out, negatively impacting vegetation that support wetland species analyzed in this CAR.

Mid-Columbia River: Hanford Reach and Wells Wildlife Area

While structural and operational measures associated with MO4 may influence Grand Coulee Dam and Chief Joseph Dam operations, they are not expected to result in measurable differences in outflow or water surface elevation in comparison to those predicted under the NAA.

Upper Basin: Everett Island and Kootenai NWR

Implementing the McNary Flow Target operational measure, however, will lead to an increase in water surface elevation on the Pend Oreille River downstream of Albeni Falls Dam during the spring summer in average and low water years. This change in water surface elevation will likely inundate a small portion of wetland habitat at Everett Island, however the impacts may be muted since this site is further downstream of Albeni Falls Dam. At Libby Dam, changes in water surface elevation during the spring and summer have the potential to inundate and desiccate narrow bands of emergent vegetation, which could negatively influence species analyzed in this CAR. Outside of the spring and summer, these changes, and the resulting impacts, will be less severe.

Lower Snake River: Silcott Island

Due to aggressive drafting, water surface elevation at all key island sites the Lower Snake River will likely decrease by approximately 1.0 ft (30 cm) in late March. According to the co-lead agencies H&H modeling output, however, wetland habitats and subhabitats will remain wet for longer periods of time, especially during the spring and summer, in comparison to what is predicted under the NAA, MO1, and MO2. As a result, the quantity and quality of habitat for ground-nesting birds, like waterfowl, which breed along well-concealed streambanks or on islands with wetland habitat (e.g., Silcott Island), may decrease.

Key River Delta Sites

Lower Columbia River: Sandy River Delta

The implementation of structural and operational measures associated with MO4 is not expected to impact protected lands or upland habitats behind levies downstream of Bonneville Dam. However, lower river levels in the spring and summer could reduce the quantity and quality of wetland habitats at the Sandy River Delta and other similar wetland habitats throughout the Lower Columbia River.

Mid-Columbia River: Lower Crab Creek and McNary NWR

While operational measures associated with MO4, if implemented, will likely influence operations of the Grand Coulee Dam and Chief Joseph Dam, they are not expected to result in changes in outflow or water surface elevation that are measurably different from those predicted under the NAA. Consequently, the implementation of related measures will have negligible impacts to water availability and, thus, wetland habitats (e.g., at Lower Crab Creek) or wildlife resources in the Mid-Columbia River subbasin.

Under MO4, the implementation of the Drawdown to MOP operational measure will likely lower water surface elevation at reservoir pools associated with McNary Dam between April and July and, in dry years, between March and August. Upstream of McNary Dam, water surface elevation will decrease by 0.5 ft to 1.5 ft (15 cm to 46 cm). As a result of this operational measure, wetland subhabitats at key river delta sites such as McNary NWR and the affiliated Walla Walla River Delta will experience lower water levels during critical time periods, which will impair the refuge's ability to manage water to irrigate moist soil wetlands and cooperatively farmed fields and support breeding waterfowl (Stenvall, C., in litt. 2019a). At the refuge, MO4 (similar to MO1) will promote the introduction and establishment of non-native species and compromise wildlife-dependent recreation opportunities (Healy, F., in litt. 2019).

Upper Basin: Pack River Delta

Operational measures will likely negatively impact wetland habitats and subhabitats at the Pack River Delta in the Upper Basin. This key river delta site has a complex alluvial fan, and it is characterized by adjacent wetland habitats that are either connected or disconnected from the mainstem Pack River. In dry years, the Pack River Delta will likely experience a summer stage drop in water surface elevation of approximately 2.6 ft (79 cm). In comparison to the projected drops associated with the other MOs, this projected drop is most extreme.

Lower Snake River: Snake River Delta and Palouse River Delta

Under MO4, pool water surface elevation will likely be higher along the Lower Snake River during the spring and summer months, and there may be a slight increase in the quantity and quality of wetland habitats and off-channel pools along the shorelines at the Snake River and

Palouse River key river delta sites. Under MO4, the Service projects a more rapid improvement in quality or overall health of the wetlands landscape at the Palouse River Delta in comparison to the NAA, MO1, and MO2.

G.4.5.4 MO4 Impacts on Evaluation Species and Other Species

The implementation of the Drawdown to MOP operational measure will likely result in negative impacts to the American bittern, mallard, and Western painted turtle. This operational measure, if implemented, will lead to an overall reduction in water surface elevation at Reed Island, Steigerwald Lake NWR, and the Sauvie Island Wildlife Area, and the Sandy River Delta, thereby impacting the survival, growth, and reproduction of wetland species analyzed in this CAR. These negative impacts will likely be more pronounced upstream at the McNary NWR.

Evaluation species that inhabit wetland habitats and subhabitats in the Mid-Columbia River will likely retain the same population status as that in current conditions.

In the Upper Basin, a decrease in water surface elevation of 2.6 ft (79 cm) during dry years would affect many wetland species, limiting their ability to successfully forage and reproduce, especially at the Pack River Delta site. At the Kootenai NWR, however, changes in operations (due to the Winter Stage for Riparian and McNary Flow Augmentation operational measures) and the resulting periodic inundation of narrow bands of wetlands will potentially benefit the mallard, sora, and Western toad in the long-term.

American bittern, mallard, and Western toad that inhabit key island and river delta sites in the Lower Snake River may all benefit from the modest increase in water surface elevation in the spring and summer, proposed under MO4. However, in the short-term, the initial increase in water surface elevation could disrupt foraging, breading, and rearing activities of these and other species (USFWS 2019c).

Under MO4, depending on the location in the study area, reductions in water surface elevation in Federal project reservoirs to MOP will likely negatively impact the abundance of available shallow-water habitat that often supports non-native aquatic predators like Northern pike.

G.5 UPLANDS

G.5.1 NAA

G.5.1.1 NAA Summary of Uplands Landscape Findings

- Structural and operational measures associated with the NAA will not have measurable impacts on native grassland and sagebrush subhabitats and uplands species analyzed in this CAR.

- In the future under the NAA, native grasslands and sagebrush subhabitats in the CRS will continue to be negatively impacted by land use management and policy decisions.

G.5.1.2 NAA Impacts on Indicators of Ecological and Physical Processes and Subhabitats

Grassland and Sagebrush Subhabitats

Though native grassland and sagebrush subhabitats characterize areas surrounding the Mid-Columbia River and Lower Snake River, no significant changes to grasslands and sagebrush in the study area are expected as a result of the NAA. Much of the uplands landscape in the Basin is physically and functionally separate from the mainstem Columbia and Snake Rivers and, thus, unlikely to be impacted due to continued dam operations and maintenance.

Natural Bluff Landforms

Though natural bluff landforms occur throughout the uplands landscape in the Columbia and Snake River valleys, no significant changes to natural bluffs are expected in current conditions, within the scope of the Service's analysis. Though current dam operations and maintenance do not directly affect natural bluffs that are high above fluctuating river water levels, other actions facilitated by the presence of dams may have negative impacts on natural bluff landforms. In particular, natural bluffs and other uplands landforms may be impacted by irregular groundwater levels and perched groundwater that seeps out at the face of bluffs. The NAA will maintain irregular groundwater levels and will not alleviate perched soil moisture resulting from irrigation that can destabilize bluff faces. Thus, the NAA will sustain the risk of losing natural bluff landforms to sloughing.

G.5.1.3 NAA Impacts on Evaluation Species

Long-Billed Curlew

The structural and operational measures associated with the NAA are not expected to impact long-billed curlew or other uplands species with similar ecological niches or habitat needs. Apart from existing threats to long-billed curlew (e.g., increasing fire frequency), no further loss of long-billed curlew, as a result of continued dam operations and maintenance, is expected.

Sage Thrasher

Sage thrasher population abundance is not expected to change as a result of continued CRS project operations and maintenance. Sage thrashers require intact expanses of sagebrush for breeding and nesting habitat. No proposed modifications associated with the NAA will result in further loss or degradation of sagebrush habitat, upon which this species and others depend.

G.5.2 MO1

G.5.2.1 MO1 Summary of Uplands Landscape Findings

- Structural and operational measures associated with MO1 will not have measurable impacts on native grassland and sagebrush subhabitats and uplands species analyzed in this CAR.
- In the Basin, the uplands landscape is physically separated from the mainstem Columbia and Snake Rivers by slope, other landscapes, and development, which prevents fluctuations in water levels from impacting this landscape.

G.5.3 MO2

G.5.3.1 MO2 Summary of Uplands Landscape Findings

- Structural and operational measures associated with MO2 will not have measurable impacts on native grassland and sagebrush subhabitats and uplands species analyzed in this CAR.

G.5.4 MO3

G.5.4.1 MO3 Summary of Uplands Landscape Findings

- Structural and operational measures associated with dam breaching may potentially affect the uplands landscape by creating areas with more newly exposed soil during times when the water surface elevation is low.
- Without active uplands restoration and management following potential dam breaching, the quantity and quality of uplands landscape adjacent to the Lower Snake River will likely be compromised.

G.5.4.2 MO3 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

The dam breaching structural and operational measures specific to MO3 may impact uplands landscape and evaluation species in the Basin. The proposed removal of the earthen portions of the four Lower Snake River dams will result in flushes of water being released at various times, which will result in inundation of land. These rapid flushes of water, depending on the timing, magnitude, and duration, have the potential to temporarily flood existing uplands vegetation. These measures may also lead to long-term impacts to soil exposure, as once impounded water, held at artificial levels above dams, transitions to flowing water. Under MO3, lower water surface elevation could create areas in the Basin that are devoid of uplands vegetation and promote the establishment of non-native species.

In March 1992, drawdown tests were conducted at Lower Granite and Little Goose reservoirs to observe the physical impacts of substantial drawdown or lowering of the reservoirs. According to the tests, the reservoirs were drawn down (Lower Granite by 37 ft [11 m] below MOP and Little Goose by 15 ft [4.6 m] below MOP) for one month. Aside from testing physical impacts of the drawdowns, the Corps conducted several studies to determine biological impacts. One study analyzed the drawdowns and their impacts to fish resources and vegetation, concluding that the drawdowns led to significant changes in overall fish survival (i.e., stranding, blocked passage) and vegetation community structure (i.e., reductions in plant diversity). Conditions of low pool elevation upstream of Lower Granite Dam and Little Goose Dam led to changes in substrate that supported the growth of some pioneering grass species and non-native vegetation (e.g., cheatgrass) (Dauble and Geist 1992, p. 1.1).

Thus, if uplands landscape restoration activities beyond those specified in MO3, including invasive plant management, follow dam breaching and uplands vegetation is reestablished, then wildlife resources may be better supported throughout the study area.

G.5.5 MO4

G.5.5.1 Summary of Uplands Landscape Findings

- Structural and operational measures associated with MO4 will not have measurable impacts on native grassland and sagebrush subhabitats and uplands evaluation species.
- In the Basin, the uplands landscape is physically separated from the mainstem Columbia and Snake Rivers by slope, other landscapes, and development, which prevents fluctuations in water levels from impacting this landscape.

H APPENDIX H: COMMENT LETTERS ON THE CRSO CAR

The following documents represent comment letters on the CRSO CAR, received by the Service.

H.1 COMMENT LETTER FROM THE SPOKANE TRIBE OF INDIANS

Corum, Lee Z

From: Brent Nichols <bnichols@SpokaneTribe.com>
Sent: Friday, April 24, 2020 1:58 PM
To: Dexter, Nathan L; Corum, Lee Z
Cc: Billy Joe Kieffer
Subject: [EXTERNAL] RE: CRSO FWCA Report

Good Morning Nathan and Lee,

Thank you for sharing the information regarding the USFWS CRSO FWCA draft report that analyzed the No Action Alternative and four multi-objective alternatives. The Spokane Tribe of Indians would request that the USFWS when considering recommendations for mitigation include passage and reintroduction. The USFWS could explicitly call for the inclusion of salmon/steelhead/lamprey reintroduction above Chief Joseph and Grand Coulee Dams in the "Increase Habitat Connectivity and Improve Fish Passage" sections on Page 49/50 of the CRSO FWCA draft report.

To support this request, I have attached the Upper Columbia United Tribes "Fish Passage and Reintroduction Phase 1 Report: Investigation Upstream of Chief Joseph and Grand Coulee Dams" and the Independent Scientific Advisory Board's "Review of Upper Columbia United Tribes' Fish Passage and Reintroduction Phase 1 Report…" Please consider these and other supporting documents available at the UCUT website https://ucut.org/habitat/fish-passage-and-reintroduction-phase-1-report/ When making your final recommendations.

lemlmt,
Brent

--
P. Brent Nichols, Ph.D., Division Director
Spokane Tribe of Indians
Department of Natural Resource
Fisheries and Water Resource Division
P.O. Box 100
Wellpinit, WA. 99040
Office: 509-244-7031 | Mobile 509-220-5377
Email ~ bnichols@spokanetribe.com

From: Dexter, Nathan L <nathan_dexter@fws.gov>
Sent: Friday, April 24, 2020 9:08 AM
Subject: CRSO FWCA Report

The Fish and Wildlife Coordination Act (FWCA) provides a formal method for coordination between the U.S. Fish and Wildlife Service (Service) and tribal, state, and other federal agencies on projects that impact fish and wildlife resources. In accordance with the FWCA, the Service requests a letter of support from your tribe for our Columbia River System Operations (CRSO) Fish and Wildlife Coordination Act Report (FWCA Report).

The draft CRSO FWCA Report was released to the public with the draft Environmental Impact Statement (EIS). The draft CRSO FWCA Report analyzes the impacts of the No Action Alternative and four multi-objective alternatives on fish and wildlife species not listed under the Endangered Species Act and their habitats, as well as conservation recommendations to benefit species and habitats impacted by CRSO. The analyses and recommendations contained in the draft CRSO FWCA Report incorporated biological information from tribal, state, and federal agency staff, academics, and consultants that we received through a series of workshops held in May and June 2019.

The Service will make the final CRSO FWCA Report available for your review when we send it to the co-lead agencies at the end of May, about one month before the final EIS is released to the public. We can add letters of support to the final CRSO FWCA Report until June 10th, and can provide example letters to you if that would be helpful. We do not expect to make significant changes to the conclusions or recommendations in the draft CRSO FWCA Report (attached). We will base edits for the final CRSO FWCA Report on any additional biological information received since the draft and public comments submitted on the draft EIS. If you have additional biological information that you would like us to consider, it would be helpful for us to receive by April 24th.

If you have any questions, please contact the CRSO FWCA Coordinator, Lee Corum (Lee_Corum@fws.gov, 360-753-5835). Thank you for your continued work toward our shared conservation goals.

Nathan L. Dexter
Native American Liaison
Columbia - Pacific NW Region
U.S. Fish and Wildlife Service
911 N.E. 11th Ave.
Portland, OR 97232
office: (503) 736-4774
mobile: (503) 780-8867
nathan_dexter@fws.gov

Corum, Lee Z

From: Billy Joe Kieffer <bjk@SpokaneTribe.com>
Sent: Friday, April 24, 2020 2:07 PM
To: Brent Nichols; Dexter, Nathan L; Corum, Lee Z
Cc: Theodore Knight
Subject: [EXTERNAL] Re: CRSO FWCA Report
Attachments: Attachment 14.pdf; Attachment 15.pdf

Nathan,
We would fully anticipate the USFWS to review these two documents also in consideration of your CRSO review as well.

Thanks

B.J. Kieffer - Director
Department of Natural Resources
Spokane Tribe of Indians
PO Box 480
Wellpinit, Wa 99040

bjk@spokanetribe.com
(509) 626-4426
(**Please note Phone No. Change**)
Voice is currently Inactive

From: Brent Nichols
Sent: Friday, April 24, 2020 1:57 PM
To: nathan_dexter@fws.gov; Lee_Corum@fws.gov
Cc: Billy Joe Kieffer
Subject: RE: CRSO FWCA Report

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lemlmt,
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If you have any questions, please contact the CRSO FWCA Coordinator, Lee Corum (Lee_Corum@fws.gov, 360-753-5835). Thank you for your continued work toward our shared conservation goals.

Nathan L. Dexter
Native American Liaison

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mobile: (503) 780-8867
nathan_dexter@fws.gov

Attachments:

ISAB (Independent Scientific Advisory Board). 2019. Review of Upper Columbia United Tribes' Fish Passage and Reintroduction Phase 1 Report: Investigations Upstream of Chief Joseph and Grand Coulee Dams (Reintroduction Report). Report 2019-3. Northwest Power and Conservation Council, Portland, Oregon, November 1, 2019, 82 pp.

UCUT (Upper Columbia United Tribes). 2019. Fish Passage and Reintroduction Phase 1 Report: Investigations Upstream of Chief Joseph and Grand Coulee Dams. Upper Columbia United Tribes, Spokane, Washington, May 2, 2019, 154 pp.

H.2 COMMENT LETTER FROM THE WASHINGTON DEPARTMENT OF FISH AND WILDLIFE

State of Washington
DEPARTMENT OF FISH AND WILDLIFE
Mailing Address: P.O. Box 43200, Olympia, WA 98504-3200 • (360) 902-2200 • TDD (360) 902-2207
Main Office Location: Natural Resources Building, 1111 Washington Street SE, Olympia, WA

April 24, 2020

Lee Corum
U.S. Fish and Wildlife Service
CRSO FWCA Coordinator
Via email: Lee_Corum@fws.gov

Dear Mr. Corum,

Thank you for the opportunity to submit comments on the draft Columbia River System Operations Fish and Wildlife Coordination Act Report (CRSO FWCAR). The Washington Department of Fish and Wildlife (WDFW) appreciates our partnership on this and other fish and wildlife and habitat management matters across Washington state.

As the State of Washington's recent comments on the CRSO draft Environmental Impact Statement (DEIS) noted,

> "the health of the Columbia River system is central to the environmental, economic, and cultural well-being of Washington state and the Pacific Northwest. The Columbia River System Operations Environmental Impact Statement should serve as an historic jumping off point for the modernization of the CRSO to make it compatible with the restoration of healthy, harvestable runs of Columbia Basin salmon and steelhead, while retaining and enhancing the benefits it provides for electricity, water supply, navigation, and recreation. The draft CRSO EIS contains the seeds for meeting this purpose, but it lacks analytical clarity and falls short in setting forth an ambitious vision for advancing salmon recovery in a manner that optimizes the value of the Columbia River System for the region as a whole."

More specifically, the flexible spill component of the CRSO DEIS preferred alternative can be expected to provide salmon and steelhead survival benefits above and beyond past hydrosystem management actions, but it is less likely than Multiple Objective Alternatives (MO) 3 (breaching the lower Snake River dams) or 4 (higher spill) to meet Northwest Power and Conservation Council survival targets as measured by smolt-to-adult ratios. For that reason, Washington and WDFW support the flexible spill operation contained within the preferred alternative as the centerpiece of a near-term hydrosystem operation over the next three-to-five years. Concurrently, however, it is essential for the federal action agencies and natural resource agencies to support a regional dialogue, recently requested by a coalition of energy utilities and NGOs, on how to meet regional principles related to energy, transportation, agriculture while also implementing actions that provide more certainty that salmon and steelhead recovery goals will be attained.

The fish and wildlife habitat focus of the FWCAR adds valuable information to the analysis of the CRSO DEIS preferred alternative and its effect on key habitats and species. Now that the preferred alternative is available, WDFW urges you to dig into the habitat, fish, and wildlife effects of its different components, some of which were not included in the other DEIS alternatives.

Please also consider how the final FWCAR might contribute technical information to inform the developing regional dialogue around stronger measures like lower Snake River dam breaching or additional spill. To that end, it would be helpful if there could be more information provided in the final report on how the different components of MO3 and MO4, as well as the preferred alternative, "increase" or "decrease" different aspects of ecosystem function as described in the draft report's tables 15, 16, and 17. As it is, it is difficult to decipher what actions within the multi-faceted MOs one should credit or blame for the increase or decrease in ecosystem function. It would also be helpful to see more attention on what role increases in salmon and steelhead abundance may play in supporting the overall health of aquatic and terrestrial species throughout the Columbia Basin's "anadromous zone."

Overall, the draft FWCAR contains important basin-wide information on much of the range of habitats and species affected by the CRSO, and we look forward to the final draft.

Thank you for this opportunity to comment, and please contact me if you have any questions at Michael.Garrity@dfw.wa.gov or 360-810-0877.

Sincerely,

Michael D. Garrity
Energy, Water, and Major Projects Division Manager

I APPENDIX I: LITERATURE CITED

This appendix includes the literature cited in the CRSO CAR.

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Columbia River System Operations
Final Environmental Impact Statement

Appendix U, Fish and Wildlife Coordination Act

Part 2, Support for Fish and Wildlife Coordination Act Report

Note: The Section 508 amendment of the Rehabilitation Act of 1973 requires that the information in federal documents be accessible to individuals with disabilities. The Agency has made every effort to ensure that the information in *Appendix U: Fish and Wildlife Coordination Act, Part 2 Support for Fish and Wildlife Coordination Act Report* is accessible. However, if readers have any issues accessing the information in this appendix, please contact the *U.S. Army Corps of Engineers* at (800) 290-5033 or info@crso.info so additional accommodations may be provided.

State of Washington
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May 29, 2020

Lee Corum
U.S. Fish and Wildlife Service
CRSO FWCA Coordinator
Via email: Lee_Corum@fws.gov

Dear Mr. Corum,

I am writing to express the Washington Department of Fish and Wildlife's (WDFW) support for the Columbia River System Operations Fish and Wildlife Coordination Act Report (CRSO FWCAR). WDFW appreciates our partnership on this and other fish and wildlife and habitat management matters across Washington state.

WDFW appreciates the work, analysis, and collaboration that went into preparing and finalizing the CRSO FWCAR. The report provides a comprehensive and unique look at the effects of federal Columbia River hydrosystem operations across the basin and in a variety of ecosystems, and is a helpful supplement to the CRSO Environmental Impact Statement (EIS) prepared by the U.S. Army Corps of Engineers, Bureau of Reclamation, and Bonneville Power Administration. Thank you in particular for quickly working to include some analysis the CRSO draft EIS preferred alternative in your final version of the report, as well as clarifying some other aspects of the draft report.

Thank you for this opportunity to voice WDFW's support for the CRSO FWCAR, and please contact me if you have any questions at Michael.Garrity@dfw.wa.gov or 360-810-0877.

Sincerely,

Michael D. Garrity
Energy, Water, and Major Projects Division Manager

Region One
490 N. Meridian Road
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10 June 2020

Mary Abrams, Acting Regional Director
US Fish and Wildlife Service
911 NE 11th Ave.
Portland, OR 97232-4181

RE: Fish and Wildlife Coordination Act Section 2(B) Report for Columbia River System Operations

Dear Director Abrams:

Thank you for the opportunity to provide technical input as a cooperating agency on the Columbia River System Operations Fish and Wildlife Coordination Act Report (CRSO FWCAR). The CRSO FWCAR provides an important assessment of the environmental effects likely to be realized under the range of Alternatives presented in the CRSO Environmental Impact Statement and offers ecological recommendations for reducing and mitigating impacts to fish and wildlife affected by construction and operation of the Federal Columbia River hydrosystem.

We support an emphasis on conservation measures that reestablish or mimic vital components of natural hydrologic regimes. This approach to hydrosystem mitigation offers a greater chance of providing sustainable solutions to restoring ecosystem function. Continued implementation of the Montana Operations at Libby and Hungry Horse dams, including infrastructure repairs and improvements to the selective withdrawal structures, will impart more normative thermal and hydrologic conditions for resident fish in the Kootenai and Flathead, while providing summer flow augmentation for the benefit of downstream anadromous fishes.

Actions that protect or enhance habitat complexity and heterogeneity are critical to partially offset hydrosystem induced losses of instream and riparian habitat. Conservation measures should be prioritized in regions of the Columbia Basin that are projected to maintain cold-water refugia and, thus, offer native fish species the greatest buffering capacity and resiliency to climate change. These areas, and especially those containing large interconnected drainages, provide strongholds for native fish and opportunities for mitigation measures to build from strength.

We support and encourage conservation measures that reduce the harmful effects of non-native and invasive species on the Columbia Basin ecosystem. Non-native species management and mitigation actions will be most sustainable and effective where eradication and prevention of re-invasion are most achievable. Left unmanaged, nonnative species may compromise gains made from prior mitigation investments, such as habitat protection and restoration.

Conservation measures supporting long term monitoring of species affected by the Columbia hydrosystem are crucial to adaptively inform operational strategies that provide the optimal balance of flood control, power generation, and ecosystem function services. Continued improvements to winter operations will aid riparian forest succession and regeneration, particularly cottonwood sapling recruitment.

We appreciate the work of the Fish and Wildlife Service to engage regional stakeholders in the collaborative effort to restore and conserve fish, wildlife, and riparian habitat that have been affected by the Columbia River hydrosystem. We look forward to our continued partnership on this important endeavor.

Sincerely,

Matt Boyer
Fisheries Mitigation
Coordinator

Alan Wood
Wildlife Mitigation
Coordinator

Brian Marotz
Hydropower Mitigation
Coordinator

Columbia River System Operations
Final Environmental Impact Statement

Appendix U, Fish and Wildlife Coordination Act

Part 3, Co-Lead Agencies' Responses to Final Coordination Act Report Recommendations

Final Coordination Act Report Recommendation	Co-Lead Agency Response
Restore or mimic critical components of natural hydrological regimes	
Raise and maintain John Day Reservoir elevations between 264.5 ft and 266.5 ft during April and May. All habitat for colonial nesting waterbirds (e.g., Caspian tern) will be inundated during typical peak nest initiation times, potentially resulting in waterbird relocation to other breeding colony sites during peak juvenile salmonid outmigration	The predation disruption measure is consistent with this recommendation; this measure has flexibility in its end date (up to June 15). Effects of implementation of this measure will be monitored and coordinated USFWS and NMFS.
Operate at the lowest reservoir levels feasible from June to September, which would potentially allow for late successful colonial nesting waterbird productivity, after most of the ESA-listed juvenile salmonids have outmigrated.	In the Preferred Alternative, John Day Dam operates in the bottom of the pool from June through August with a 2 foot operating range, consistent with the 2019 NMFS BiOp. The operating range in the John Day Reservoir is 6 inches higher than NAA. The Snake River reservoirs continue to operate at minimum operation pool elevations April through August with a 1.5 foot operating range, which is 6 inches higher than NAA, consistent with the 2019 NMFS BiOp. Those operations are continued in the 2020 NMFS and USFWS CRS BiOps.
Establish a functional flow regime by managing river flows to mimic the pre-dam hydrograph in the following ways: Allow seasonally appropriate high water events once or twice per decade (i.e., to achieve natural conditions suitable for successful riparian seedling establishment)	Overland flows, environmental flows, intentional overbanking, and natural seasonal thermal pattern flows were eliminated during alternatives development and from proposed mitigation because intentionally flooding areas does not meet our P&N to provide FRM. Actions are taken to enhance flows such as spring and summer flow augmentation and VARQ FRM operations at Hungry Horse and Libby. Additionally, due to the multiple purposes of the CRS, a natural seasonal thermal pattern would not be achievable because it could interfere with the Corps' ability to operate these facilities for the multiple purposes authorized by Congress. Those purposes include flood risk management, navigation, hydropower generation, fish and wildlife conservation, irrigation, recreation, water quality, and municipal and industrial water supply, though not every facility is authorized for every one of these purposes.

Final Coordination Act Report Recommendation	Co-Lead Agency Response
Establish a functional flow regime by managing river flows to mimic the pre-dam hydrograph in the following ways: During high flow years, drawdown and ramping rate (i.e. stage recession) should be no faster than one inch per day, which will promote the growth and survival of newly-established riparian seedlings.	Existing operations include minimum flows, temperature operations where possible, ramping rate restrictions. For minimum flows at headwater projects ramping water levels, minimum flows, and temperature operations are guided by the 2006 USFWS BiOp. Those operations are continued in the 2020 USFWS CRS BiOp. Additionally, actions are taken to enhance flows such as spring and summer flow augmentation and VARQ FRM operations at Hungry Horse and Libby. Restoring hydraulic regimes to pre-dam conditions is outside of the scope of this EIS. The Preferred Alternative includes mitigation measures involving riparian plantings and co-lead agencies would continue to coordinate with project sponsors in the upper basin. The co-lead agencies will work with project sponsors on System Operation Requests through the regional forum.
Establish a functional flow regime by managing river flows to mimic the pre-dam hydrograph in the following ways: Monitor riparian vegetation recruitment and respond to years of high cottonwood and willow recruitment. This could be accomplished by limiting winter water levels to not exceed the previous peak-flow water level associated with high riparian recruitment for at least two winters following the year of high riparian recruitment.	Existing operations include minimum flows, temperature operations where possible, ramping rate restrictions. For minimum flows at headwater projects ramping water levels, minimum flows, and temperature operations are guided by the 2006 USFWS BiOp. Those operations are continued in the 2020 USFWS CRS BiOp. Additionally, actions are taken to enhance flows such as spring and summer flow augmentation and VARQ FRM operations at Hungry Horse and Libby. Restoring hydraulic regimes to pre-dam conditions is outside of the scope of this EIS. The Preferred Alternative includes mitigation measures involving riparian plantings and co-lead agencies would continue to coordinate with project sponsors in the upper basin. The co-lead agencies will work with project sponsors on System Operation Requests through the regional forum.
Constrain ramping rates at all projects to avoid large stage fluctuations, especially in June during cottonwood and willow seed dispersal and recruitment.	Existing operations include minimum flows, temperature operations where possible, ramping rate restrictions. For minimum flows at headwater projects ramping water levels, minimum flows, and temperature operations are guided by the 2006 USFWS BiOp. Those operations are continued in the 2020 USFWS CRS BiOp. Additionally, actions are taken to enhance flows such as spring and summer flow augmentation and VARQ FRM operations at Hungry Horse and Libby. Restoring hydraulic regimes to pre-dam conditions is outside of the scope of this EIS. The Preferred Alternative includes mitigation measures involving riparian plantings and co-lead agencies would continue to coordinate with project sponsors in the upper basin. The co-lead agencies will work with project sponsors on System Operation Requests through the regional forum.

Final Coordination Act Report Recommendation	Co-Lead Agency Response
Decrease ramping rates used below Libby to one inch per hour per stage increase or decrease to mimic the natural water recession rate.	Existing operations include minimum flows, temperature operations where possible, ramping rate restrictions. For minimum flows at headwater projects ramping water levels, minimum flows, and temperature operations are guided by the 2006 USFWS BiOp. Those operations are continued in the 2020 USFWS CRS BiOp.
Minimize stage drop of 2.6 ft in Lake Pend Oreille to smaller increments from June through September of dry years to maintain native vegetation.	Lake Pend Oreille is operated to stay in its summer operating range until mid-September.
Operate downstream projects to maintain natural water surface elevation and avoid rapid fluctuations in Lake Pend Oreille and Flathead Lake.	Lake Pend Oreille is held above its natural summer drawdown elevation for recreation. The Lake's drawdown is restricted by a channel constriction upsteam of Albeni Falls Dam. Flathead Lake is not a federal project.
Support continuation of Montana operations at Libby (i.e., VarQ discharge and spring pulse) and establish normative flows for white sturgeon (MFWP et al. 2017, pp. 12-14).	The Preferred Alternative at Libby and Hungry Horse Dams contains measures informed by the Montana Operations at Libby and Hungry Horse Dams paper (nwcouncil.org/ reports/2017mtops), which was produced in 2017 by Montana Fish, Wildlife, and Parks, the Montana office of the Northwest Power and Conservation Council; and in consultation with the Confederated Salish and Kootenai Tribes. The Sturgeon Pulse remains unchanged from the No Action Alternative to the Preferred Alternative.
Invest in energy storage infrastructure and technology to minimize flow fluctuations in response to short-term changes in power demand. If pump storage is implemented, ensure stored water does not negatively affect the natural hydrology of river or natural lake environments.	Bonneville cannot invest in storage technology absent a demonstrated need for meeting its obligations. If another entity developed pump storage, FERC and other authorities would regulate the project.
Work with new and existing partners to maintain or establish normative flow regimes on tributary streams wherever possible as these tributaries contribute natural sediment that nourishes floodplains and backwater deltas. Specifically and where applicable, ensure water surface elevations of reservoirs are below the elevation of tributary mouths during the fall in order to capitalize on weather events that minimize the accumulation of	Regulation of tributary flows are outside the scope of this EIS; however, the co-lead agencies continue to support Tributary Habitat restoration actions in the Preferred Alternative. In 2021, co-lead agencies will contribute funding for an initial assessment of blocked passage to bull trout key spawning tributaries, or perched tributaries, identified by USFWS on Kootenai River. The assessment may cover a range of water year types but must include a dry water year to adequately understand the problem. Upon completion of the initial assessment, co-lead agencies, in collaboration with local stakeholders and USFWS will develop an action plan and prioritization process for tributaries identified as

Final Coordination Act Report Recommendation	Co-Lead Agency Response
sediments through scour thereby providing safe, effective, and volitional fish passage at tributary mouths	having blocked passage. Co-lead agencies will work with USFWS and stakeholders to identify and initiate a process to address two restoration and/or improvement projects benefitting upstream passage opportunities over the period from 2021 to 2026.
When restoring pre-dam hydrologic regimes is not feasible, mimic natural hydrology to provide flushing flows, channel maintenance flows, and sediment transport annually or biannually. Develop and implement flow and temperature recommendations to meet this objective in addition to other objectives (e.g., juvenile fish downstream migration), including: minimizing hourly and daily flow fluctuations; considering the timing and frequency of peaks; and providing recommendations across all water year types (e.g., deficit, normal, and abundant). Consider the approach taken on large river systems elsewhere in the western U.S. (e.g., Green River below Flaming Gorge Reservoir, Colorado River below Lake Powell).	Existing operations include minimum flows, temperature operations where possible, ramping rate restrictions. For minimum flows at headwater projects ramping water levels, minimum flows, and temperature operations are guided by the 2006 USFWS BiOp. Those operations are continued in the 2020 USFWS CRS BiOp. Additionally, actions are taken to enhance flows such as spring and summer flow augmentation and VARQ FRM operations at Hungry Horse and Libby. Restoring hydraulic regimes to pre-dam conditions is outside of the scope of this EIS. Multiple flow regimes were considered during the EIS process along with their effects on the multiple Congressionally authorized purposes of the CRS as well as the objectives of the EIS.
Regardless of MO, for the Sandy River Delta and associated riparian habitat during implementation of the first summer stage decline, time water surface elevation drops to coincide with normal peak flow recession (i.e., in early to mid-June following natural peak flood timing). The rate of recession should be gradual (i.e., no more than 1 inch [2.5 cm] per day) to help promote the establishment of native riparian vegetation instead of invasive species on exposed shoreline.	The Sandy River is an undammed river and outside the scope of this EIS.
Similarly, in the case of MO4, plan the timing and rate of drawdown to mimic natural peak flow recession for Umatilla NWR, Threemile Creek to Sixmile Creek confluences, Little Sheep Creek Confluence, and other riparian habitat in the vicinity (refer to the previous conservation recommendation).	In the Preferred Alternative, John Day Reservoir level will be operated for the Predator Disruption Measure up to June 15 and then at lower elevations for faster reservoir travel times for the remainder of June and through August.

Final Coordination Act Report Recommendation	Co-Lead Agency Response
Increase habitat connectivity and improve fish passage	
To the maximum extent practicable, reconnect rivers and tributaries to their floodplains, side channels, and associated wetlands, including barrier removal, breach, or setbacks.	The agencies continue to support Tributary Habitat restoration actions in the Preferred Alternative.
Improve connectivity between the riparian habitat along mainstems and in tributaries. Maintain or improve existing riparian vegetation or establish new vegetation through functional flows or planting.	The agencies continue to support Tributary and Estuary Habitat restoration actions in the Preferred Alternative. In addition, mitigation measures are proposed in the Preferred Alternative to plant riparian vegetation downstream of Libby Dam and near Bonners Ferry, Idaho.
To the maximum extent practicable, set back or remove structures such as levees, dikes, riprap, and bank stabilization measures that constrain lateral movement of rivers, and reconnect rivers and tributaries to floodplains, associated wetlands, side channels, and oxbows to rivers and side channels	The agencies continue to support Tributary and Estuary Habitat restoration actions in the Preferred Alternative.
Where appropriate, consider removing structures like dikes and revetments and purchasing floodplain properties to reconnect floodplain and side channel habitat in the Columbia River estuary, thus creating and expanding shallow water habitat.	The agencies continue to support Estuary Habitat restoration actions in the Preferred Alternative.
Remove obsolete dams, barriers, and other infrastructure to improve habitat connectivity. Prioritize these actions according to potential ecological benefit, in locations such as tributaries with habitat that supports cold-water aquatic species (e.g., Columbia River redband trout [Oncorhynchus mykiss gairdneriii] and Westslope cutthroat trout [O. clarki lewisi])	Removing private dams or other federal projects was not in the scope of this EIS.
Revise the Section 408 process (authorized in the River and Harbors Appropriation Act of 1899 [33 U.S.C. § 14]) to allow more efficient and less expensive levee set-back and removal projects to increase habitat connectivity with floodplains and side channels. Currently, few projects are completed because of the cost and time spent per project	Recent improvements have been made to the Section 408 process and are included in Engineering Circular 1165-2-220. These are highlighted at https://www.usace.army.mil/Media/Fact-Sheets/Fact-Sheet-Article-View/Article/1623978/section-408-process/ Basic requirements for proposed alternations to federally authorized Civil Works projects, including levees, under 33 USC 408 (Section 408) are that the alteration

Final Coordination Act Report Recommendation	Co-Lead Agency Response
and serious consequences (e.g., fines per project) if coordination with the Corps does not occur. Investigate and implement, if feasible, a revised, programmatic approach for the co-lead agencies to undertake in future projects.	must not be "injurious to the public interest" or "impair the usefulness" of the project. This requires that the existing Civil Works project continues to deliver the public benefits for which they were authorized and constructed, and ensuring that any alteration does not have unintended negative impacts to the public. Any alterations must also meet USACE engineering requirements. In part, this is to ensure life safety standard are met. This is especially applicable to alterations to levees which often require a formal Safety Assurance Review. The Corps has other authorities outside of the Section 408 program that can be used for levee setbacks if there is a cost-sharing sponsor. Depending on the scope and scale of the setback being considered, the Corps Continuing Authority Program (CAP) could be utilized. Section 206 and Section 1135 are specific to ecosystem restoration. If the scope and scale exceeds the CAP limits, a larger ecosystem restoration study may be able to be conducted through the General Investigations program. Again, a cost-share sponsor is required. If USFWS is aware of any potential cost-share sponsors, we would be happy to engage in further discussions with these entities.
Improve, build, or modify the Pacific lamprey passage structures at all projects in the Lower Columbia and Snake Rivers. Evaluate passage structure efficacy and make improvements, if necessary.	The Preferred Alternative includes lamprey improvement measures: • Modify turbine intake bypass screens that cause juvenile lamprey impingement. The Corps will replace existing extended-length bar screens with screens designed to reduce juvenile lamprey entanglement at Little Goose and Lower Granite dams. The upgrades would occur when existing screens need replacement; • Expand network of Lamprey Passage Structures in fish ladders at Bonneville, The Dalles and John Day dams, and modify existing structures; • Modify turbine cooling water strainer systems to safely exclude juvenile lamprey; and, • Modify existing fish ladders, incorporating lamprey passage features and criteria into ladder modifications at lower Snake and Columbia River dams. Modifications may include ramps to submerged weir orifices, diffuser plating to provide attachment surfaces, diffuser grating with smaller gaps, refuge boxes, wetted walls, rounded weir caps and closure of floating orifice gates.

Final Coordination Act Report Recommendation	Co-Lead Agency Response
Install and maintain bird wire arrays at all dam tailraces and consider additional non-lethal control methods	As stated in the 2020 Columbia River System Biological Assessment (Appendix V) for the Preferred Alternative from the CRSO EIS regarding avian predation deterrence operations at the Lower Columbia and Lower Snake River dams, the Corps will continue to implement and improve, as needed, avian predator deterrent programs at lower Snake and Columbia River dams to reduce avian predation on juvenile salmonids. At each dam, bird numbers will continue to be monitored, birds foraging in dam tailraces will be hazed (to include, in some circumstances, lethal reinforcement) and passive predation deterrents, such as irrigation sprinklers and bird wires, will be deployed. Hazing typically involves launching long-range pyrotechnics at concentrations of feeding birds and occurs primarily near the spillway and powerhouse discharge areas, and juvenile bypass outfall areas. The Corps has been experimenting at McNary Dam with laser systems to haze avian predators near the bypass outfalls; if proven biologically and cost effective, this tool may be used in the future. The avian deterrent programs (including upgrades to existing facilities such as bird wires at McNary Dam and sprinklers at Ice Harbor Dam) will be coordinated through the FPOM and included in the annual Fish Passage Plan.
To better inform future analyses of impacts in dam operation changes in the Basin on migratory fishes, conduct studies on native aquatic species survival including white sturgeon and other non-ESA-listed aquatic species throughout all life history stages and passage routes. Focus on collecting information about migration timing, duration of migration, movements and reversals, use of habitat during migratory periods, and overall connectivity and how these variables contribute to overall survival and fitness.	The co-leads will continue to support aquatic species studies within the Columbia Basin. The adaptive management implementation plan for the flex spill operations is proposing some monitoring of non-salmonid, native fish species.
Create and implement effective reintroduction plans for native aquatic species above projects with little to no access or connectivity. For instance, assist migration of white sturgeon to enhance adult population levels, as white sturgeon populations upstream of Bonneville Dam are small and have limited recruitment. Additionally,	Co-lead agencies lack the authority to oversee or implement reintroduction except as necessary to comply with ESA and other applicable laws. Reintroduction is an important and complex, large-scale concept. Its consideration, evaluation, and implementation should involve multiple tribal, federal, state, and other entities. A coordinated approach among water users, tribes, states, multiple federal agencies, and others would be necessary. To allow

Final Coordination Act Report Recommendation	Co-Lead Agency Response
consider reintroducing Western pearlshell mussel and other aquatic invertebrates in appropriate river, lake, and reservoir landscapes, since they are limited in their own abilities to recolonize areas from which they have been extirpated.	so many differing interests to coordinate on such a complex topic, a decision-making framework and a series of regional workshops would be necessary just to approach the first step of defining reintroduction objectives.
In regard to MO2, if the co-lead agencies modify operations for salmonid passage, they should also consider developing and carrying out restoration projects that restore access to disconnected side channels and wetlands created by reductions in water surface elevation. They should also maintain the functionality of wildlife corridors that connect wetlands to uplands and are important for reptiles and amphibians such as Western pond turtle and Woodhouse's toad, respectively.	MO2 was not identified as the Preferred Alternative; however, planting of riparian vegetation downstream of Libby and near Bonners Ferry, ID and providing access to two perched tributaries in the Kootenai River are in the Preferred Alternative.
In regard to MO3, if the co-lead agencies breach the four lower Snake River dams, then the greatest ecological benefits for evaluation species and other migratory mainstem, migratory corridor, and localized, non-migratory species may be realized. These benefits would, in many cases, be dependent on implementation of associated restoration projects	MO3 was not identified as the Preferred Alternative.
Maintain functionality of National Wildlife Refuges affected by CRS operations	
Ensure sustainability of current management operations on NWRs as needed to meet system mission, goals, and refuge purposes (i.e., 601 FW 1) including, but not limited to, conservation and protection of migratory birds and the "Big Six" fish- and wildlife-dependent public uses (e.g., hunting, fishing, wildlife observation, photography, interpretation, and environmental education).	The proposed operational measure at Libby would create higher flows in the summer in dry years, resulting in a minor adverse effect on the Kootenai National Wildlife Refuge (NWR). Wetland habitats would continue to support regionally important migratory waterfowl overwintering in the Umatilla NWR by providing forage opportunities and prey resources. Similarly, at Franz Joseph, Pierce, Steigerwald, Ridgefield, Julia-Butler Hansen, and Lewis and Clark NWRs, wetland habitats would remain consistent with existing conditions despite minor changes in water surface elevations

Final Coordination Act Report Recommendation	Co-Lead Agency Response
Support the Service in monitoring impacts on habitat, natural resources, and fish- and wildlife-dependent recreational opportunities on NWRs and mitigate impacts that constrain the ability of those lands to meet their individual mission, goals, and purposes; of particular consideration should be those impacts that compromise migratory bird use or the "Big Six" public uses of NWR lands.	This recommended monitoring at NWRs is not part of the Preferred Alternative.
Minimize impacts of operations to existing infrastructure that maintains critical refuge system habitats. As necessary, add, replace, and modify infrastructure to ensure its long-term functionality. Infrastructure changes could include, but are not limited to, the installation of pump sites and fish screens as needed to enable NWRs to function and meet establishment purposes.	The co-lead agencies did not identify any effects to water supply or pumping in the Preferred Alternative.
Maintain existing waterbird (e.g., waterfowl and shorebirds) use areas and, through restoration and conservation projects or activities, enhance habitat diversity for waterfowl use, specifically, throughout all life history stages (e.g., migrating, wintering, and breeding stages)	With the Preferred Alternative, wetland habitats would continue to support regionally important migratory waterfowl overwintering in the Umatilla National Wildlife Refuge by providing forage opportunities and prey resources. Similarly, at Franz Joseph, Pierce, Steigerwald, Ridgefield, Julia-Butler Hansen, and Lewis and Clark NWRs, wetland habitats would remain consistent with existing conditions despite minor changes in water surface elevations
Support the Service in protecting and replacing any existing waterbird areas lost or rendered dysfunctional due to potential impacts associated with operational change such as sedimentation, flooding, and the invasion and establishment of non-native species.	With the Preferred Alternative, wetland habitats would continue to support regionally important migratory waterfowl overwintering in the Umatilla National Wildlife Refuge by providing forage opportunities and prey resources. Similarly, at Franz Joseph, Pierce, Steigerwald, Ridgefield, Julia-Butler Hansen, and Lewis and Clark NWRs, wetland habitats would remain consistent with existing conditions despite minor changes in water surface elevations
Support the Service in providing additional open water migratory bird sanctuaries in the Columbia River adjacent to existing refuge system habitats to mitigate for loss of open water habitat as a result of sedimentation. To be effective, new sanctuary habitat should mimic existing habitats and include particular landscape features (e.g.,	The co-lead agencies did not identify this as an impact and did not propose additional mitigation.

Final Coordination Act Report Recommendation	Co-Lead Agency Response
moist soil, shoreline and shallow water habitats for shorebirds, and open water habitat of various depths with submerged aquatic vegetation) to adequately support migratory birds.	
Support monitoring and management of invasive species on NWRs as needed to maintain the structure and function of various habitats	The agencies continue to support invasive species management actions in the Preferred Alternative.
Acquire water rights to project the ability of NWRs to meet establishment purposes and, especially, keep intact the structure and function of certain areas on refuge lands that support migratory birds.	Acquiring water rights to protect NWRs is beyond the scope of this analysis. Bonneville does fund the Columbia Basin Water Transactions Program as part of its Fish and Wildlife Program, and the FWS could apply for water rights support through that program.
Maintain NWR infrastructure (e.g., water control structures, ditches, and pumping stations) to deliver and distribute water that sustains functional wetlands, like those at Kootenai NWR. Provide sufficient resources to design and implement infrastructure modifications, as necessary to meet refuge objectives depending on the alternative that is eventually implemented.	The co-lead agencies did not identify any effects to water supply or pumping in the Preferred Alternative.
Maintain and enhance habitat complexity and heterogeneity	
Maintain, enhance, and restore habitat complexity and heterogeneity and implement identified measures to increase habitat complexity and heterogeneity. Design and implement actions that increase large wood in the system and maintain vital ecological processes such as sediment transport and tributary delta formation.	The agencies continue to support Tributary and Estuary Habitat restoration actions in the Preferred Alternative.
Evaluate potential for improvements in habitat functionality at a landscape scale and prioritize conservation and restoration projects at sites likely to be responsive to project actions and activities aimed at making such improvements.	The agencies continue to support Tributary and Estuary Habitat restoration actions in the Preferred Alternative.

Final Coordination Act Report Recommendation	Co-Lead Agency Response
Provide sufficient resources and support to acquire or enhance lost or diminished habitats, landscape features, and niches to maintain habitat moscaics that support waterbirds, wetland, and riparian species	The agencies will continue maintaining, enhancing, and restoring habitat where and when the co-leads have the opportunities. In addition, mitigation measures are proposed to plant riparian vegetation downstream of Libby Dam and near Bonners Ferry, Idaho.
Acquire, maintain, and support maintenance of emergent wetland vegetation, shallow water habitat, meadows, and moist foraging areas for waterbirds and shorebirds, frogs, and painted turtles that inhabitat the Lower Columbia River and Snake River regional boundaries.	The agencies continue to support Tributary and Estuary Habitat restoration actions in the Preferred Alternative. In addition, mitigation measures to plant riparian vegetation downstream of Libby Dam and near Bonners Ferry, Idaho are in the Preferred Alternative.
Protect mudflats for migratory shorebirds, including foraging and roosting habitat. Avoid changes in water levels that reduce mudflats downstream near the Columbia River Estuary and Julia Butler Hansen NWR.	At Franz Joseph, Pierce, Steigerwald, Ridgefield, Julia-Butler Hansen, and Lewis and Clark NWRs, wetland habitats would remain consistent with existing conditions despite minor changes in water surface elevations
Restore channel complexity in mainstems, tributaries, and side channels of rivers and implement identified measures to increase side channel complexity. Additional restoration activities should include the removal of structures like dikes and riprap to soften banks and shorelines, thereby improving connectivity and habitat complexity.	The agencies continue to support Tributary and Estuary Habitat restoration actions in the Preferred Alternative.
Reintroduce beaver in areas where beaver were either historically located or can be properly supported to enhance habitat complexity in aquatic and semi-aquatic environments. Cooperate with and support beaver reintroduction efforts, such as those piloted by state agencies in the Basin.	The agencies continue to support Tributary Habitat restoration actions in the Preferred Alternative. Bonneville has also funded the Colville Tribes through Accord funding to do beaver relocation work through the Methow Salmon Recovery Foundation in the Okanogan and Methow subbasins and in partnership with the Washington Department of Fish and Wildlife and US Forest Service.
Work with partners to exclude livestock from riparian areas wherever possible, especially in years following high riparian vegetation recruitment. Other than non-functional flow regimes, livestock grazing is the most immediate threat to riparian habitat, so exclusion is essential to retain riparian restoration progress made by establishing functional flows.	Livestock grazing is not part of the operations included in this EIS, but if there are opportunities to exclude livestock through the Tributary Habitat Program and Columbia Estuary Ecosystem Restoration Programs the co-leads would consider it.

Final Coordination Act Report Recommendation	Co-Lead Agency Response
Promote and fund stream restoration and address operational inefficiencies in irrigation, municipal use, and voluntary water actions to minimize negative impacts associated with water withdrawal from rivers and tributaries.	The agencies continue to support Tributary Habitat restoration actions in the Preferred Alternative. The co-leads will continue to work with Basin partners to implement irrigation efficiencies and water transactions to improve instream flows.
Support monitoring of cottonwood and seedling mortality and implement the Winter Stage for Riparian operational measure at Libby Dam and Hungry Horse Dam and as needed at other dams if cottonwood seedling mortality is observed due to rising winter ice (USACOE et al. In prep.).	To address concerns of riparian vegetation establishment, the Preferred Alternative proposes planting up to 100 acres of riparian forest along the braided and meander reaches of the Kootenai River near Bonners Ferry, using 1-2 gallon cottonwood trees, with the expectation that the larger size trees would be better suited to withstand the higher winter flows.
Create and maintain cold-water refugia (i.e., areas in water bodies that are persistently cooler than other areas) as follows (EPA 2019, pp. 2-4): Review and consider recommendations developed by the EPA in their Columbia River Coldwater Refugia Plan (EPA 2019, pp. 158-162	The co-lead agencies' water quality team have reviewed EPA's report. The agencies continue to support Estuary and Tributary Habitat restoration actions in the Preferred Alternative.
Create and maintain cold-water refugia (i.e., areas in water bodies that are persistently cooler than other areas) as follows (EPA 2019, pp. 2-4): Identify existing cold-water refugia in the study area and propose and implement restoration actions such as installing riparian shading to reduce solar heating, restoring stream flows to increase resiliency of tributary subhabitats, and exploring opportunities to coordinate with partners to release cooler water from upstream dams;	The agencies continue to support Estuary and Tributary Habitat restoration actions in the Preferred Alternative.
Create and maintain cold-water refugia (i.e., areas in water bodies that are persistently cooler than other areas) as follows (EPA 2019, pp. 2-4): Protect cold water refugia where there is an emergence of groundwater.	The agencies continue to support Estuary and Tributary Habitat restoration actions in the Preferred Alternative.
Create and maintain cold-water refugia (i.e., areas in water bodies that are persistently cooler than other areas) as follows (EPA 2019, pp. 2-4): Opportunistically purchase instream water rights in cold water tributaries to restore late-summer instream flows.	The agencies continue to support Estuary and Tributary Habitat restoration actions in the Preferred Alternative. Bonneville would continue to fund the Columbia Basin Water Transactions Program as part of its Fish and Wildlife Program.

Final Coordination Act Report Recommendation	Co-Lead Agency Response
Restore sediment dynamics in prioritized river reaches (e.g., through gravel augmentation or the installation of large wood to better retain sediment)	The agencies continue to support Tributary and Estuary Habitat restoration actions in the Preferred Alternative.
Manage flows and reservoir elevations and use other appropriate management techniques to create or mimic natural sediment transport and depositional regimes.Support fish passage and alleviate issues at tributary deltas where increased sedimentation impedes habitat development and reduces or eliminates connectivity.	The EIS evaluated different operations and their potential impacts on sediment transport and depositional regimes. As part of the Preferred Alternative, providing access to two perched tributaries in the Kootenai River is being proposed.
Conserve colonial nesting waterbird populatins in historical numbers within historical range, and supplement breeding habitat (i.e., at a 2:1 ratio) in the event colonies are displaced or destroyed.	Ongoing avian predator programs would prevent the co-lead agencies from implementing actions to carry out this recommendation.
Reduce the likelihood of land bridge exposures to islands in preservation of waterbird nesting habitat to reduce predation and disturbance during nesting seasons.	The EIS does not identify a concern with an increase in land bridges to islands.
Install signage and develop and enforce regulations (e.g. no wake zones and closures) to protect essential waterbird breeding and nesting habitat.	The co-lead agencies will consider this recommendation; however, at this time, no signage is proposed.
Develop and implement restoration projects at the Pack River Delta that aim to minimize wave action created by recreational boating on Lake Pend Oreille.	Bonneville has an existing agreement with the state of Idaho, *Northern Idaho MOA between the State of Idaho and BPA for Wildlife Habitat Stewardship and Restoration,* where Pack River delta restoration is discussed as a future potential priority after the Clark Fork River and Priest River deltas.
Continue Kootenai River and Lake Kootenay nutrient enhancement efforts.	Ongoing nutrient enhancement projects in both the Kootenai River and Kootenay Lake are being carried forward in the Preferred Alternative.
Post implementation of barrier removal or breaching measures: Evaluate changes in abundance and diversity of native aquatic invertebrates in wetlands habitats post-implementation of breaching measures. Determine and implement restoration activities that preserve remaining and promote natural establishment of wetland habitats	MO3 was not identified as the Preferred Alternative.

Final Coordination Act Report Recommendation	Co-Lead Agency Response
and associated aquatic invertebrate abundance and diversity.	
Post implementation of barrier removal or breaching measures: Promote establishment and survival of native riparian vegetation: Adopt functional flow regimes at Dworshak Dam. Work with partners to establish functional flows at other upstream dams.	MO3 was not identified as the Preferred Alternative.
Post implementation of barrier removal or breaching measures: Promote establishment and survival of native riparian vegetation: Time the initial stage decrease (i.e., following barrier removal or breaching) to coincide with natural peak flow recession. This would promote the establishment of native riparian vegetation for which seed dispersal and normal springtime peak flows occur contemporaneously in an unregulated system.	MO3 was not identified as the Preferred Alternative.
Post implementation of barrier removal or breaching measures: Promote establishment and survival of native riparian vegetation: Maintain and potentially increase, invasive species prevention and control efforts to prevent the invasion and establishment of non-native species in newly exposed shorelines during the first few years until riparian species have established.	MO3 was not identified as the Preferred Alternative.
Post implementation of barrier removal or breaching measures: Promote establishment and survival of native riparian vegetation: Support Operational Loss Mitigation Plan activities to protect and restore riparian habitat on the Flathead River (Bergeron et al. 2018).	MO3 was not identified as the Preferred Alternative.
Post implementation of barrier removal or breaching measures: Plant native wetland vegetation, which establishes quickly in response to new sediment deposition in the McNary Reservoir.	MO3 was not identified as the Preferred Alternative.
Post implementation of barrier removal or breaching measures: If reestablishment of functional flow regimes is	MO3 was not identified as the Preferred Alternative.

Final Coordination Act Report Recommendation	Co-Lead Agency Response
not feasible, apply native seeds or plantings and support non-native species management in newly exposed persistent terrestrial habitats (e.g., uplands, wetlands, and riparian habitat).	
In regard to MO3 and MO4, restore wetland habitat on recently exposed islands resulting from breaching the four Lower Snake River dams or when land is exposed as a result of reservoir drawdown	MOs 3 and 4 were not identified as the Preferred Alternative.
Reduce the spread of invasive species, and prevent future invasions	
Reduce impacts of nonnative fish in the study area, and support northern pike removal program efforts.	The agencies continue to support fish predator management actions (e.g. northern pike and pikeminnow) in the Preferred Alternative. In addition, investigation of american shad deterrence is proposed.
Provide support and resources for additional boat cleaning stations to prevent invasion and establishment of non-native species (e.g., aquatic invertebrates and plants).	The co-lead agencies support this program throughout the region.
Support research to determine potential impacts, including directly or indirectly influencing predation of native species, of American shad (Alosa sapidissima) in the Lower Columbia and Snake Rivers to understand their potential impact on native aquatic species.	The Preferred Alternative includes a measure to investigate American shad. The Corps would investigate the feasibility of deterring adult shad from approaching and entering the Lower Granite Dam adult fish trap, alleviating the need to remove shad from the trap while processing adult salmon and steelhead, and thereby reducing stress and delay for ESA-listed target species. Measures for consideration may include acoustic deterrents and operational changes, such as instituting plunging flows or blocking overflow weirs. If feasible, the Corps would implement operational or small-scale structural measures to address this issue. Any associated evaluations or changes in fishway operations or configurations would be coordinated with the appropriate regional coordination forums (e.g., FPOM).
Coordinate with, and implement prioritized actions identified by, the interagency invasive species teams. The Acquatic Invasive Species Network and the Western Regional Panel can provide direction in regard to aquatic invasive species. Each state in the study area (i.e., Idaho, Montana, Oregon, and Washington) has an invasive species council that can also provide direction on focused	Bonneville provides funding to the Pacific States Marine Fisheries Commission (PSMFC) for the Zebra and Quagga mussel prevention program. PSMFC helps fund the Aquatic Invasive Species Network as part of the program. The Corps also conducts invasive species management on their project lands that are within the scope of the EIS as part of their operation and maintenance program and in compliance with various regulations and executive orders. This program encompasses terrestrial and aquatic invasive species on upland and

Final Coordination Act Report Recommendation	Co-Lead Agency Response
actions in specific geographic areas to eradicate and reduce the spread of invasive species.	submerged lands that effect and impact regional native species. In addition, the Corps is authorized through Section 1039 of the Water Resource Reform and Development Act (WRRDA) of 2014, Section 1178 of the Water Resources Development Act (WRDA) of 2016, and Section 1170 of WRDA of 2018 to implement aquatic invasive species prevention cost-share programs that includes the entire Columbia River Basin. These authorities allow the Corps to cost share 50% of state programs to establish, maintain, and operate water craft inspection stations that are in the states of Idaho, Montana, Oregon, Washington, Wyoming, and Nevada, including personnel costs. It also allows for the Corps and States to conduct risk assessments, monitor for aquatic invasive species, establish watershed-wide plans, and undertake rapid response actions to infestations of aquatic invasive species. Reclamation is concentrating on proactive measures to help reduce the spread and impacts of invasive mussels in the Columbia basin in a number of ways. Intensive early detection and monitoring programs detect the earliest stages of mussel exposure or infestation at Reclamation reservoirs, so that response planning and budgeting for protective measures can be initiated. Funding partnerships, education and outreach, and infrastructure for watercraft inspection and decontamination programs help reduce risk of spread. Targeted research on prevention, early detection and monitoring, control, and impact assessment makes these programs more efficient.
Support long-term monitoring and adaptive approaches to future management	
Monitor water quality (temperature, TDG, pH) to ensure that operations do not result in significant, long-term changes to standards or benchmarks that are environmental cues for successful growth and reproduction of migratory and resident fishes and other aquatic and semi-aquatic species	The existing water quality monitoring at the project will continue; however, at this time, no additional monitoring is proposed.
Monitor Caspian tern breeding colony abundance at the inland Basin system-level (i.e., the Columbia River Plateau Region). This should include monitoring colony abundance at Goose Island and other islands in the Potholes Reservoir, Crescent Island, the ten "at-risk" islands	The co-lead agencies would continue the existing monitoring efforts associated with ongoing avian predation management plan.

Final Coordination Act Report Recommendation	Co-Lead Agency Response
identified in the Inland Avian Predation Management Plan, and the unnamed islands in Lenore Lake (USACOE 2014a, pp. 28-29).	
Provide support and resources for monitoring the John Day and McNary Dam operations impacts on Umatilla NWR and priority public uses identified in the Comprehensive Conservation Plan (USFWS 2007, p. B-2). These monitoring data can inform future adaptive management at this site.	The co-lead will consider this recommendation; however currently, this recommended monitoring at Umatilla NWR is not part of the Preferred Alternative.
Monitor occupancy of riparian birds in restored riparian habitats as measures of efficacy of restoration efforts	The agencies continue to support Tributary and Estuary Habitat restoration actions in the Preferred Alternative. Appropriate monitoring would be developed as part of these actions.
Monitor and catalog wetland and riparian vegetation at reference locations following manipulation of water surface elevations. This monitoring should include various losses and gains in terms of wetland habitat. Monitor long-term plant and animal responses to drawdown to increase understanding of physical changes to habitats and fish and wildlife resources.	The agencies continue to support Tributary and Estuary Habitat restoration actions in the Preferred Alternative. Appropriate monitoring would be developed as part of these actions.
Develop education and outreach materials that illustrate and explain the mutual ecological and socioeconomic benefics associated with overland flows. Share these materials with various entities or stakeholders (e.g., landowners) to help inform them about potential positive impacts (e.g., more fertile soil) resulting from more dynamic flows and changes in water elevation.	Thank you for the recommendation. The co-lead agencies have considered this recommendation; however will not be adopting it.
Coordinate with Xerces Society, state fish and wildlife agencies, land trusts, and citizen science initiatives to monitor native terrestrial invertebrates (i.e., distribution, habitat, life-history needs) and implement restoration and conservation actions or activities in locations where they may be affected by proposed changes in dam operations.	Thank you for the recommendation. The co-lead agencies have considered this recommendation; however will not be adopting it.

Final Coordination Act Report Recommendation	Co-Lead Agency Response
Work with the Service's Pacific Lamprey Conservation Initiative to implement restoration and conservation actions that address the impacts of the Lower Columbia and Snake Rivers operations. Additionally, work with the initiative to support new and ongoing field studies aimed to fill gaps in existing information and knowledge about Pacific lamprey biological and life-history requirements.	In addition to the ongoing programs to benefit lamprey, the Preferred Alternative includes lamprey improvement measures. • Modify turbine intake bypass screens that cause juvenile lamprey impingement. The Corps will replace existing extended-length bar screens with screens designed to reduce juvenile lamprey entanglement at Little Goose and Lower Granite dams. The upgrades would occur when existing screens need replacement; • Expand network of Lamprey Passage Structures in fish ladders at Bonneville, The Dalles and John Day dams, and modify existing structures; • Modify turbine cooling water strainer systems to safely exclude juvenile lamprey; and, • Modify existing fish ladders, incorporating lamprey passage features and criteria into ladder modifications at lower Snake and Columbia River dams. Modifications may include ramps to submerged weir orifices, diffuser plating to provide attachment surfaces, diffuser grating with smaller gaps, refuge boxes, wetted walls, rounded weir caps and closure of floating orifice gates.
Incorporate juvenile and adult Pacific lamprey into research, monitoring, and evaluation of Flex Spill to the extent practicable. The Service can provide technical assistance in developing study design, determining sampling protocols, and conducting statistical analyses to ensure impacts to Pacific lamprey are understood and given full consideration in operational decisions related to Flex Spill.	The co-lead agencies are considering inclusion of lamprey monitoring as part of the flex spill operations. The co-lead agencies will continue to coordinate with USFWS.
Incorporate juvenile Pacific lamprey into their research, monitoring, and evaluation of the improved fish passage turbines, to the extent practicable, at whichever Federal CRS projects receive the new turbines.	The co-lead agencies are considering inclusion of lamprey monitoring as part of the improved fish turbine replacement. The co-lead agencies will continue to coordinate with USFWS.
In proposing future restoration activities in the mainstem Columbia and Snake Rivers, use the Service's, Bureau of Land Management's, and U.S. Forest Service's joint Best Management Practices to minimize impacts on Pacific lamprey.	During construction of any project, best management practices would be implemented.

Final Coordination Act Report Recommendation	Co-Lead Agency Response
Monitor and evaluate operational impacts on species other than anadromous salmonids and ESA-listed fish. Establish an interagency fish and wildlife adaptive management group, or task and support existing interagency forums to consider the impacts of hydropower operations on all species. Provide support and resources to facilitate the interagency groups' or forums' conservation efforts.	The co-lead agencies will continue efforts to coordinate with other entities to monitor species and evaluate operations. The adaptive management implementation plan for the flex spill operations is proposing monitoring of non salmonid species. See Appendix R, Part 2 of the EIS.
Improve coordination efforts between biologists and engineers working together on short term (i.e. daily) dam operations to identify flexibility in operations and, in turn, capitalize on opportunities to restore and conserve habitat that yields environmental benefits to fish and wildlife resources.	The co-lead agencies will continue to coordinate with fish and wildlife Federal and State agencies, tribes, and stakeholders.
Consider climate change impacts to fish and wildlife resources and develop a climate change adaptive management plan to ensure conservation of fish and wildlife resources and their habitat.	Climate change analysis of fish and wildlife is presented Chapters 4 and 7 of the EIS.
In regard to MO3 (measures S1, S2, O1, and O2), monitor native aquatic invertebrates affected by hydropower operations and coordinate with the Pacific Northwest Native Freshwater Mussel workgroup to identify restoration and conservation actions for mitigation purposes.	MO3 was not identified as the Preferred Alternative.