Columbia River System Operations
Environmental Impact Statement

Appendix U
Fish and Wildlife Coordination Report on the Columbia River System Operations

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 Report on the Columbia River System Operations* 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

JAN 1 4 2020

Jesse Granet, Program Manager, Columbia River System Operations EIS
U.S. Army Corps of Engineers, Northwestern Division
P.O. Box 2870
Portland, Oregon 97208-2870

Dear Mr. Granet:

In accordance with the Scope of Work from May 2018, the U.S. Fish and Wildlife Service (Service) has completed a draft of the Fish and Wildlife Coordination Act 2(b) Report (FWCAR) for the CRSO Project. The Service understands that the draft FWCAR will be released in February 2020 for public comment as an appendix to the draft Columbia River System Operations (CRSO) Environmental Impact Statement (EIS).

This draft 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 the five CRSO EIS alternatives (the No Action Alternative and Multi-objective alternatives 1 through 4) would impact fish and wildlife species and their habitats. The draft FWCAR also includes conservation recommendations that would benefit species impacted by dam modifications and operations included in CRSO EIS alternatives. Both the analysis and conservation recommendations described in the draft Report were informed by input from experts across the Columbia River Basin.

We will work with you to address comments and finalize this report before the Final EIS is released in June 2020.

We appreciate the opportunity to conduct this important work for you and provide information for the selection of your preferred alternative in the forthcoming Final EIS. If you have any questions regarding the enclosed draft Report, please contact our CRSO FWCA Coordinator, Lee Corum (telephone: 360-753-5835; email: Lee_Corum@fws.gov).

Sincerely,

Mary M Abram

Acting Regional Director

Enclosure

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DRAFT Fish and Wildlife Coordination Report

on the

Columbia River System Operations

Prepared for:
U.S. Army Corps of Engineers – Portland District
Bonneville Power Administration
Bureau of Reclamation

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

January 2020

ACRONYMS AND ABBREVIATIONS

AEP	annual exceedance probability
Basin	Columbia River Basin
BCC	Bird of Conservation Concern
BMC	Bird of Management Concern
BO	Biological Opinion
Bonneville	Bonneville Power Administration
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
ESA	Endangered Species Act
EVT	existing vegetation type
FCRPS	Federal Columbia River Power System
Feasibility Study	Juvenile Salmon Migration Feasibility Study
final EIS	Environmental Impact Statement
FRM	Flood Risk Management
FWCA	Fish and Wildlife Coordination Act
FWCAR or report	Fish and Wildlife Coordination Act Report
GIS	geographic information system
H&H	Hydrology and Hydraulics
HMU	Habitat Management Unit
LANDFIRE	Landscape Fire and Resource Management Planning Tools database
MBTA	Migratory Bird Treaty Act
MIP	Minimum Irrigation Pool
MO alternative or MOs	Multiple Objective alternative
MO1	Multiple Objective 1
MO2	Multiple Objective 2
MO3	Multiple Objective 3
MO4	Multiple Objective 4
MOP	Minimum Operating Pool
NAA	No Action Alternative
NEPA	National Environmental Policy Act
NLCD	National Land Cover Data
NMFS	National Marine Fisheries Service
NWHI	Northwest Habitat Institute
NWI	National Wetlands Inventory
NWR	National Wildlife Refuge
Reclamation	Bureau of Reclamation
Rkm	river kilometers

RM	river mile
SOW	Scope of Work
System Operation Review	Columbia River System Operation Review
TDG	Total Dissolved Gas
U.S.	United States
EPA	U.S. Environmental Protection Agency
Service	U.S. Fish and Wildlife Service
WPA	Waterfowl Protection Area
WMA	Wildlife Management Area

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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, and recreation. 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 CRSO.

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

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 FWCAR focuses exclusively on identifying additional impacts on fish and wildlife resources from both current operations and the five alternatives identified in the co-lead agencies' scoping process for the Draft Environmental Impact Statement (DEIS) for the CRSO. The alternatives considered in this analysis include the No Action Alternative or NAA (i.e., current operations) and four Multiple Objective (MO) alternatives or MOs (see "CRSO DEIS Alternatives").

In development of this FWCAR, 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 CRSO Federal projects. This FWCAR includes the Service's evaluation of the potential positive and negative impacts of the alternatives on the overall health of landscapes (rivers, lakes and reservoirs, riparian, wetlands, and uplands) in the study area (see "Study Area and Basin Extent" and Appendix B). In this analysis, the Service used indicators of ecological and physical processes (Table 4) that support habitats, subhabitats, and fish and wildlife resources (Appendix F and G). This report includes summary tables (Tables 15, 16, 17, and 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 (see "Impacts on Fish and Wildlife Resources" and Appendix G).

The Service concludes that each of the alternatives will continue to negatively impact the overall health of landscapes, to one degree or another. Thus, each of the alternatives has some negative impacts on fish and wildlife resources that depend on these landscapes. For example, the Service identified primarily decreasing trends in the overall health of river, lakes and reservoirs, riparian, and wetlands 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 is 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 co-lead agencies implement additional conservation measures that are likely to result in increasing trends in the overall health of landscapes (Appendix G).

The Service shares a prioritized list of measureable conservation recommendations intended to provide guidance and assistance to the co-lead agencies in identifying actions to mitigate, avoid, or minimize negative impacts of the alternatives. Many of these conservation recommendations were proposed as components of the five alternatives presented by the co-lead agencies. The Service grouped the conservation recommendations into six major categories, followed by a number of specific actions, in this FWCAR (see "Conservation Recommendations"):

- 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) affected by CRSO operations, such as ensuring sustainability of current NWR 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 management, such as improving coordination between biologists and engineers working together on dam operations.

Reducing negative impacts on specific processes and habitats, which characterize various landscapes, effectively reduces associated impacts on fish and wildlife resources that live in and depend on those landscapes.

PURPOSE, SCOPE, AND AUTHORITIES

PURPOSE

The Corps – Portland District, Reclamation, and Bonneville (co-lead agencies) have prepared a DEIS for the CRSO in accordance with the National Environmental Policy Act (NEPA). 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 2(b) FWCAR for the CRSO and 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 public) in the Basin. 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).

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 USACOE 2018, pp. 1, 6). The SOW clarifies the geographic scope of the Service's analysis, which includes the Basin, the mainstem Columbia River, major Columbia River tributaries, and portions of their tributaries affected by dam modifications and operations identified in the DEIS as of March 2018, including an approximate 0.5 mile (0.8 km) terrestrial habitat buffer along the river and tributary banks.

This FWCAR 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 USACOE 2018, p. 8). The "Study Area and Basin Extent" section and Appendix B further define areas covered and excluded by this analysis.

On April 25, 2018, the Corps, acting on behalf of the co-lead agencies, signed the final SOW (USFWS and USACOE 2018, p. 1). Appendix A (Table A1) includes a timeline that illustrates key milestones in the Service's engagement among its programs, and with stakeholders and the co-lead agencies for FWCAR development.

CRSO DEIS Alternatives

In accordance with NEPA, the co-lead agencies developed five alternatives for the operations, maintenance, and configuration of the 14 Columbia River System (CRS) projects to meet authorized project purposes and to balance competing demands for water (USACOE et al. In prep.). The Service considered these alternatives in their analysis.

The co-lead agencies defined eight objectives to guide alternatives development. The final set of alternatives included the No Action Alternative (NAA) and four action Multiple Objective alternatives or MOs. The NAA describes ongoing CRSO operations under current conditions, and the MOs describe modifications to one or more aspects of CRSO 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 salmon, varying levels of hydropower production, and differing actions to support the needs of resident fishes (e.g., native trout, suckers) and migratory fishes.

Alternatives are summarized here and described in more detail in the CRSO DEIS (USACOE et al. In prep.).

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.

Multiple Objective Alternative 1

Multiple Objective Alternative 1 (MO1) is intended to benefit ESA-listed Pacific salmon and ESA-listed resident fishes. MO1 proposes implementation of a juvenile fish passage spill operation ("Block Spill" test), which includes alternating spill at the Lower Snake and Lower Columbia River projects. MO1 also includes changes to water-management, power generation, irrigation, and navigation.

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 operations with a target of 110 percent total dissolved gas (TDG), the lowest end of the range of juvenile fish passage spill operations.

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. MO3 would breach the earthen portions of the four Lower Snake River dams (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.

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 includes proposed changes to water-management, hydropower production, and water supply. MO4 would also limit juvenile fish passage spill operations to no more than 125 percent TDG.

Draft Preferred Alternative

The co-lead agencies will be selecting a Draft Preferred Alternative for the CRSO DEIS (USACOE et al. In prep.). The Service evaluated the impacts on fish and wildlife resources based on conditions of the NAA and structural and operational measures of the four MOs, and, through this FWCAR, provides conservation recommendations for each of the MOs. The Service did not evaluate the co-lead agencies' Draft Preferred Alternative in this report because it was not available during the period of analysis.

AUTHORITIES

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 fish and wildlife resources, assess possible damage to wildlife resources associated with the implementation of Federal water resource development projects like the CRSO, and define protective and enhancement means and measures for those resources.

The FWCA recognizes the importance of fish and wildlife resources and their value and significance to stakeholders. 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 FWCAR in their project designs 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. 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 or 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 are issued in the future.

Congressional Authority

The U.S. Congress provides the authority for the Corps and Reclamation to construct, operate, and maintain the 14 Federal CRSO projects to meet multiple purposes (Table 1). Purposes include flood control (i.e., FRM), power generation, water supply, irrigation, navigation, and recreation. 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 (USACOE 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	Albeni Falls Dam Bonneville Dam Chief Joseph Dam The Dalles Dam Dworshak Dam Ice Harbor Dam John Day Dam Libby Dam Little Goose Dam Lower Granite Dam Lower Monumental Dam McNary Dam
Reclamation	Grand Coulee Dam Hungry Horse Dam

The co-lead agencies are reviewing and updating the long-term, coordinated management of the Federal 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 enables the co-lead agencies to collaboratively evaluate the costs, benefits, and tradeoffs of various measures and alternatives as part of reviewing and updating the management of the Federal projects and the CRSO (USACOE 2017).

COOPERATING AGENCIES AND TRIBES

Early in the NEPA process, the co-lead agencies requested cooperation from Federal, state, tribes, and local agencies that either have jurisdiction by law or special expertise on relevant environmental issues to participate in DEIS development (40 CFR § 1501.6). The co-lead agencies and several of the designated cooperating agencies and tribes collaborated with the Service in this reporting effort (Table 2). Other agencies, tribes and non-governmental partners contributed to this report, but were not cooperating agencies (see "Coordination and Information-Sharing").

Table 2. Cooperating agencies and tribes that contributed to the FWCAR

General Affiliation	Specific Tribes and Agencies
Tribes	Confederated Tribes of the Grand Ronde Community of Oregon Cowlitz Indian Tribe Kootenai Tribe of Idaho Yakama Nation
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

RELEVANT PRIOR FWCA REPORTS IN THE BASIN

The Service has previously developed FWCARs, planning aid letters, and general memos in response to Federal agency-led water resource development activities and their potential impacts on fish and wildlife resources in the Basin. Prior FWCAR reporting efforts, described below, identify the Federal Columbia River Power System (FCRPS) as the coordinated operation of 14 specific 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, para. 3). The name change (from FCRPS to CRSO in reference to the 14 CRS projects) is meant to eliminate past confusion. The term FCRPS is used in this section ("Relevant Prior FWCA Reports in the Basin") because it was also used in past FWCARs, however, outside of this section, the Service used the term CRSO rather than FCRPS.

Past FWCARs for FCRPS can be assigned to two time periods: pre-dam construction and post-dam construction. When the Federal Basin hydropower projects or dams were first designed and constructed, FWCARs, 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 proposed action did not include the impacts of dams, as the dams were not yet constructed. The Service's FWCARs of 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 Basin 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 FWCARs with narrow scopes for individual project structural improvements and operational changes. Few FWCARs addressed the 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).

1995 FWCAR FOR SYSTEM OPERATION REVIEW

The Service's 1995 System Operation Review FWCAR for the Corps evaluates resources for the FCRPS. Through a comprehensive evaluation of the FCRPS, this review made recommendations to promote recovery of Pacific salmon newly listed under the ESA. The 1995 FWCAR 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 proposed action. 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 FWCAR presented a broad ecosystem planning and management approach for evaluating and addressing operational and biological impacts of the proposed action (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.

1999 FWCAR FOR IMPROVED FISH PASSAGE IN THE LOWER SNAKE RIVER

In the proposed Lower Snake River fish passage improvements, the Corps – Walla Walla District analyzed an alternative for breaching the four Lower Snake River dams: Ice Harbor Dam, Lower Monumental Dam, Little Goose Dam, and Lower Granite Dam. Federal listing of several stocks of Pacific salmon in the mid-1990s due to overharvest, habitat loss and degradation, construction of dams and reservoirs prompted the NMFS to issue two BOs on FCRPS operations (NMFS 1995, 2000). The BOs outlined measures to avoid jeopardizing the continued existence of ESA-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 (USACOE 1992a, p. ES-2).

The Feasibility Study evaluated the technical, environmental, and economic feasibility of structural alternatives that would increase survival and improve the prospects for recovery of Pacific salmon in the Snake River and allow 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 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 Environmental Impact Statement (EIS) developed four alternatives (USACOE 1992b, pp. 3-2-3-22).

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, however the agencies did not request that the Service revisit its analysis with new or different information.

STUDY AREA AND BASIN EXTENT

The study area includes the Basin, and its tributaries and infrastructure affected by the CRSO. Thus, the study area is comprised of the mainstem Columbia River, the Lower Snake River (beginning approximately 9 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 USACOE 2018, p. 8).

The Basin covers approximately 258,000 square miles (668,217 km^2) and includes major portions of Washington, Oregon, Idaho, 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 kcfs [7,503 m^3s^{-1}]) 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 and Cascade Mountain ranges.

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 (Hadley, H., in litt. 2019). Stream flow 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 (Hadley, H., in litt. 2019).

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 Cascade Range separates 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 (Hadley, H., in litt. 2019). 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 proposed CRSO action: Snake River, Clearwater River, Kootenai River, and Pend Oreille River. Appendix B includes a detailed description about the focal tributaries and how the Service further defined the study area for the FWCAR.

Figure 1. The Columbia River Basin

METHODS

This FWCAR analyzed and described impacts of the co-lead agencies' proposed changes to modifications, operations, and configurations of CRSO Federal 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 (see "Impacts on Fish and Wildlife Resources" and Appendix G).

For this analysis, the Service identified key ecological and physical processes that support Basin landscape structure and function. Based on those 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 (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 Dam The Dalles Dam John Day Dam McNary Dam
Mid-Columbia River	Confluence of the Snake River to the Canadian border	Chief Joseph Dam Grand Coulee Dam
Upper Basin	Pend Oreille, Kootenai, and Clark Fork Rivers and Reservoirs	Albeni Falls Dam Libby Dam Hungry Horse Dam
Lower Snake River	Confluence of the Columbia River to Dworshak Reservoir	Ice Harbor Dam Lower Monumental Dam Little Goose Dam Lower Granite Dam Dworshak Dam

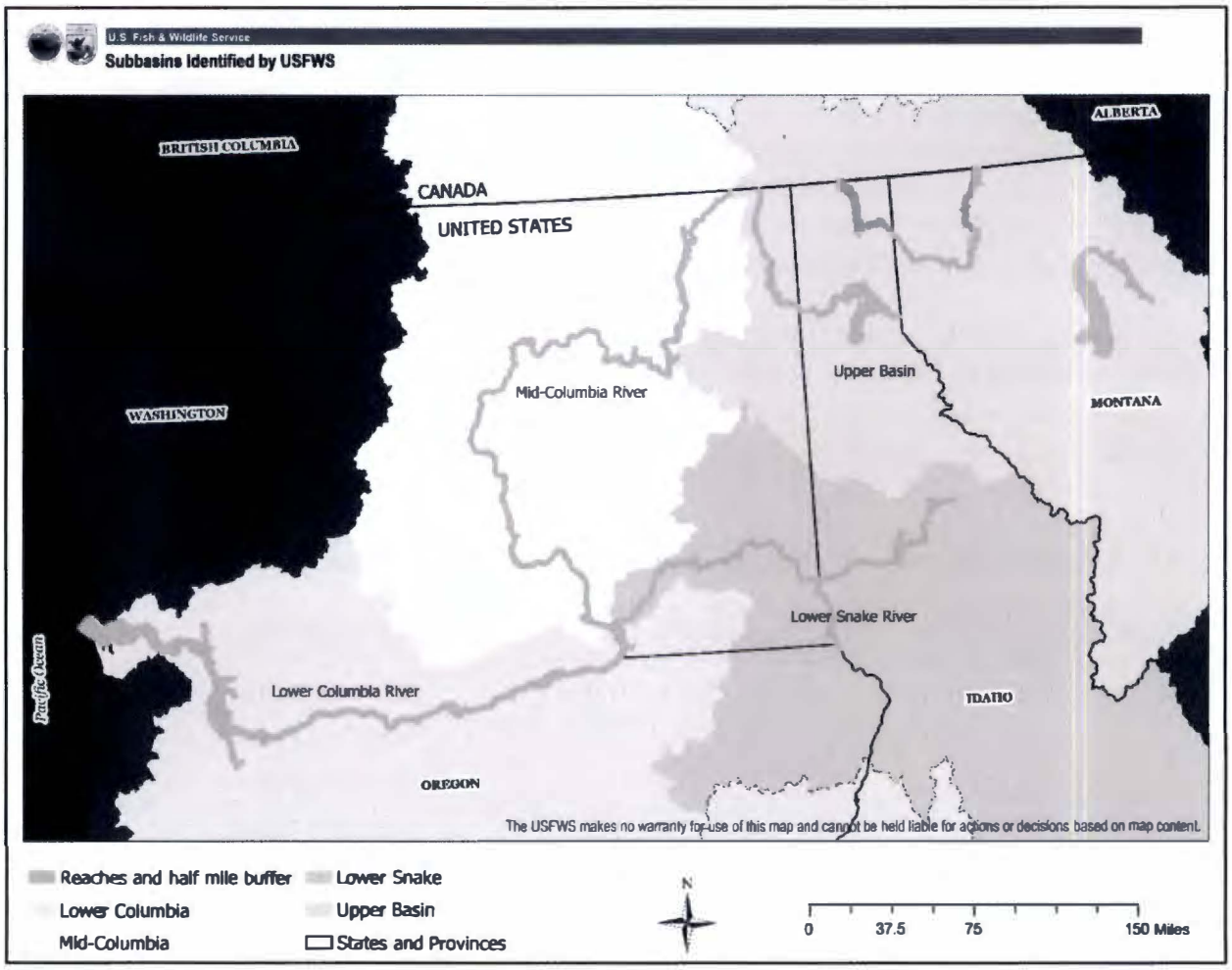

Figure 2. Subbasins identified by the Service for the FWCAR analysis

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 FWCAR 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 indicators identified by the Service for the FWCAR 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	Natural flood regime

Ecological and Physical Processes	Indicators
Storing water (e.g., floodwater) Water flow	
Natural disturbance (e.g., storms) Precipitation Storing water (e.g., floodwater) Water flow (e.g., base flow, subsurface flow)	Pre-dam hydrograph
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 [TDG])
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 "large woody debris," this report uses "large wood" 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)

LANDSCAPES

To address the diverse range of ecological communities in the study area and their values to fish and wildlife resources, the Service identified landscapes that could be impacted by the ecological and physical processes changed under the proposed CRSO actions (see "Resources" and Appendix F).

Using 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 CRSO proposed action: lakes/reservoirs/rivers, riparian, wetlands, and uplands (EPA 2017). These landscapes helped refine the evaluation species, habitats, subhabitats, and key sites selected for this analysis (USFWS and USACOE 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 (see "Quantitative Key Site and Location Selection").

A given landscape may contain features similar to those that also characterize other landscapes, however this analysis 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. 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.

EVALUATION SPECIES

For the FWCAR, 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 and non-consumptive human uses such as fishing, hunting, and birdwatching; environmentally sensitive species; species performing a key ecological role; species affected by Federal water resource development; and species that represent groups of species using 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. A preliminary list of approximately 100 evaluation species were evaluated and then prioritized 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 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 basin-wide, within each landscape, the Service selected representative species that inhabit landscapes occurring across four 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).

- **Not listed as threatened or endangered under the ESA**. Impacts on ESA-listed fishes (bull trout [*Salvelinus confluentus*], Kootenai white sturgeon [*A. transmontanus*], and 12 stocks of Columbia River Basin salmon and steelhead), wildlife, and plant species will be addressed in consultations under section 7(a)(2) of the ESA and, thus, are outside the agreed upon scope of this FWCAR. Species that have state listing status (e.g., endangered, threatened, candidate, of concern) and do not have Federal threatened or endangered status were prioritized (NMFS 2019, pp. 5-6). Analyzing potential impacts on these species would likely be mutually beneficial to the Service and state agency partners in strengthening collaborative conservation efforts.
- **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.

Service experts, the co-lead agencies, and other state, local, tribal, and private partners participated in a review of the prioritized species list. Based on their reviews, the Service developed an initial list of landscapes and evaluation species (Table 5). This initial, focused list of evaluation species was approved in the SOW (USFWS and USACOE 2018, p. 9).

Table 5. Focused list of landscapes and evaluation species in the approved 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 (*Onchorhynchus 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*)

Landscapes	Evaluation Species
	White bluffs bladderpod (*Physaria douglasii* spp. *tuplashensis*)

Source: USFWS and USACOE 2018, p. 9

RELATING AND REFINING LANDSCAPES AND SPECIES

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

- the proposed action and alternatives and their potential impacts on the study area and fish and wildlife resources;
- important ecological and physical processes (biological, chemical, physical), 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.

The Service created an interim list of five landscape groupings (rivers, lakes and reservoirs, riparian, wetlands, and uplands) and 78 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 proposed CRSO action and alternatives, ecological and physical processes, landscapes and habitats, and species life history stages and ecological niches. This refinement of the landscapes and evaluation species lists reflected the following changes:

- **Reconsideration of landscapes**. Separation of "lakes and reservoirs" and "rivers" landscapes based on a discussion of the unique biological, chemical, and physical processes, habitats and subhabitats, and ecological features that differentiate rivers from lakes and lake-like environments such as reservoirs. For this FWCAR, 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 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 orchid (*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 experts and other state, local, tribal, and private partners. See the "Resources" section and Appendix F for more detailed information about landscapes, habitats and subhabitats, and their relationships to ecological and physical processes. Appendix F also includes descriptions of the final evaluation species the Service selected for, and analyzed in, the FWCAR.

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

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*)
Wetlands	Woodhouse's toad (*Bufo woodhousii*)
Uplands	Long-billed curlew (*Numenius americanus*) Sage thrasher (*Oreoscoptes montanus*)

Other Guilds, Communities, and Species

The Service also 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, the Service highlighted Bullock's oriole (*Icterus bullockii*) and willow flycatcher (*Empidonax traillii*), along with the yellow warbler (*Setophaga petechia*), representing a large and diverse guild of riparian songbirds and serving 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.

COORDINATION AND INFORMATION-SHARING

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, local entities, and tribes to augment its understanding of the potential impacts of the proposed alternatives on fish and wildlife resources. This coordination enhances the information available for analysis and yields 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. Due to the size and scope of this action, 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. This maximized capturing various perspectives and insights the Service's research and analyses for the FWCAR. To enhance coordination and gather input, the Service planned and hosted a series of multi-stakeholder technical workshops in the summer of 2019.

The Service designed and facilitated five 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 Service's workshop focus topics, dates, and locations

Workshop Focus	Dates	Location
Wetlands	May 20-21	Mid-Columbia River NWR 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 NWR 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

Appendix C includes the Service's outreach and communications associated with these 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 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 Natural Resources and Conservation Montana Department of Fish, Wildlife, and Parks Oregon Department of Fish and Wildlife Washington State Department of Ecology Washington Department of Fish and Wildlife
Tribes	Confederated Tribes of Grand Ronde Cowlitz Indian Tribe Kalispel Tribe of Indians

General Stakeholder Group	Affiliation within General Stakeholder Group
	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 FWCAR approach, 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 resources;
- key sites and locations defined by ecological and physical processes that either do, or could, support resources; and,
- measurable and achievable actions to conserve, protect, and enhance the identified resources.

Each workshop provided an opportunity for participating stakeholders to learn about the CRSO proposed action 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 their agencies; 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 knowledge gaps. Appendix D includes the Service's workshop agendas and questions.

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 above-described workshops, draft and final Service (e.g., consultations) and Corps reports (e.g., 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 these assessments for the FWCAR.

QUANTITATIVE KEY SITE AND LOCATION SELECTION

The Service worked with stakeholder participants during various 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 contribution 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 experts and through communications with cooperating agencies and workshop participants regarding specific fish and wildlife resources (e.g., Caspian tern [*Hydroprogne caspia*]).

As part of the analysis of impacts, key sites and locations were evaluated by subbasin (Table 3 and Figure 2) and landscape. 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.

Key sites associated with the remaining four landscapes (rivers, lakes and reservoirs, riparian, and wetlands) are summarized in Table 9, shown in Figure 3, and discussed in more detail in the "Resources" and "Impacts on Fish and Wildlife Resources" sections and appendices G and H.

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

Landscape	Subbasin	Key Sites
	Lower Snake River	26. Catholic Creek Confluence 27. Tucannon River Confluence 28. Big Flat Recreation Area
Wetlands	Lower Columbia River	29. Reed Island 30. Steigerwald Lake and Sauvie Island Wildlife Area 31. Sandy River Delta
	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

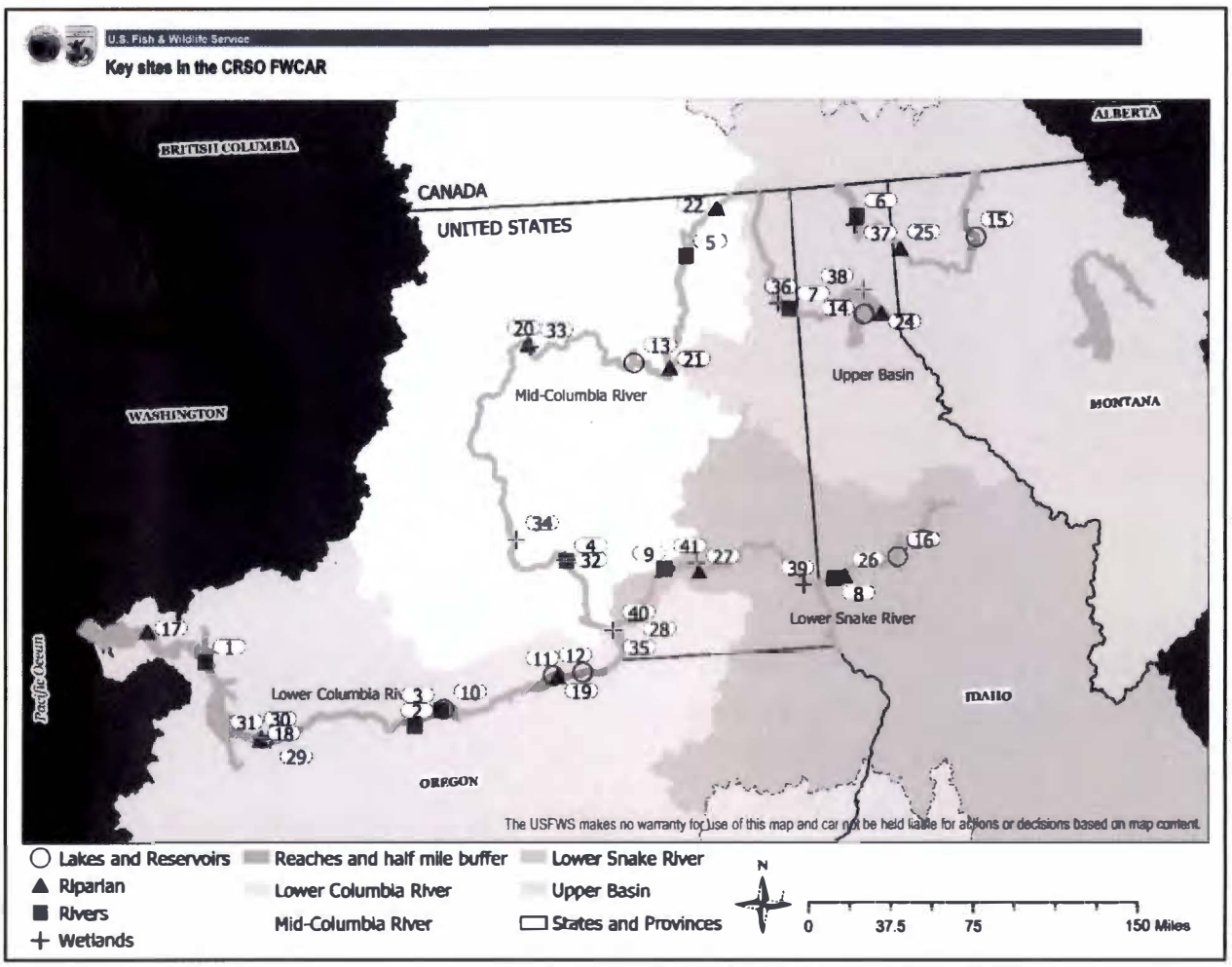

Figure 3. Key sites and locations analyzed in the FWCAR

RESOURCES

Evaluation species (Table 6), according to their close association with these processes and habitats, will be affected by proposed CRSO changes outlined in the "CRSO DEIS Alternatives" section, and they are representative of other species that are also reliant on those habitats. Additional guilds, communities, and species were considered and are described within relevant landscapes.

The Service selected a list of aquatic and terrestrial landscapes, divided into habitats and subhabitats, in the study area that are likely to be affected by the CRSO proposed changes (Table 10). A more detailed description of each landscape and its habitats and subhabitats is included 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

RIVERS

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

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. Appendix F includes more details on river resources in the study area.

Trends in River 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, 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;).

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 Appendix F.

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 (NWSRS 2018).

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 proposed alternatives on the river landscape and evaluation species at these key sites are described in the "Impacts on Fish and Wildlife Resources" section and Appendix G.

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)

LAKES AND RESERVOIRS

Lakes are naturally occurring low points in the landscape that contain 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. Appendix F includes more details on lakes and reservoir resources in the study area.

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.

Currently, due to dam construction and related infrastructure, and continuing CRSO project operations and maintenance, river habitats have degraded and reduced 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 as 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.

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 Appendix F.

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 reservoir landscape and evaluation species at these key sites are described in the "Impacts on Fish and Wildlife Resources" section and Appendix G.

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

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 this report and analysis, the Service divided the riparian landscape into three habitats (emergent, scrub-shrub, and forest) (USFWS 2019a, pp. 7-8). Appendix F includes more details on riparian resources in the study area.

Trends in Riparian Landscape and Habitat Quality

Currently, riparian areas comprise 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 serve as a continuous corridor and provide dense cover and rich food resources, thus are critically important for breeding, feeding, dispersal, and migration of wildlife species. These corridors help connect otherwise isolated habitats and reduce genetic isolation and extirpation of sub-populations (Everest and Reeves 2007, p. ix).

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 cottonwood and willow recruitment 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 inch (2.5 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 FC) functional flow regimes adopted in 2003 at Libby Dam in Montana to benefit the Kootenai River white sturgeon have also resulted in anecdotal evidence of increased cottonwood recruitment (Burke et al. 2009, p. S235; USACOE 2006, pp. S-3-S-9; USFWS 2019b).

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 Appendix F.

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 the "Impacts on Fish and Wildlife Resources" section and Appendix G.

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

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

Trends in Wetland Landscape and Habitat Quality

Wetlands habitat 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).

As previously stated, wetland habitat 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), current resources may differ from those naturally supported, historically. In some cases, Federal projects in the study area create 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, projects may create slower-moving water conditions in general, which can support wetland habitats in discrete areas within the Basin.

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 Appendix F.

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 Wetlands Workshop (see "Workshops"), 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 (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 the "Impacts on Fish and Wildlife Resources" section and Appendix G.

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

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

UPLANDS

In general, upland habitats are located outside waterbodies (i.e., 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 and arid uplands. Subhabitats within forested and arid uplands in the study area are described in Appendix F.

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 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, loss of native grasslands and reduction in grassland cover is the result of livestock grazing, the spread of non-native species (e.g., cheatgrass and cowbirds), and fire frequency and intensity changes. 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 (*Artemisia tridentata*) and bunchgrass cover types in the Basin have experienced greater losses than any other habitats and will likely continue to decline with the impacts of present land uses, including increased fire frequency, livestock overgrazing, 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 Sparrow (*S. breweri*), and sagebrush sparrows (Martin and Carlson 1998; Rotenberry et al. 1999; Schroeder et al. 1999).

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 Appendix F.

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 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 (see "Impacts on Fish and Wildlife Resources" section and Appendix G).

OTHER HABITATS

Three landscapes (rivers, lakes and reservoirs, and wetlands) share other habitats identified as important to consider in this evaluation: barren lands, islands, and river deltas. As a product of dam presence, reservoir drawdown, and water release timing and magnitude, any of which may change as a result of the proposed CRSO DEIS alternatives, these habitats and the fish and wildlife resources that rely on them are considered in this analysis.

Barren Lands

Barren lands (i.e., drawdown zones) are so frequently inundated as to preclude vegetation growth. This may include reservoir drawdown zones and the 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 estuary includes extensive mudflats, numerous islands and bars, tidal marshes, and tidal swamps.

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 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 waterfowl (USFWS 2018a).

The Blalock Island complex, one of the key sites related to 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 [Rkm 441] to RM 276 [Rkm 444]). The Blalock Island complex supports several wildlife guilds in the John Day Pool. For example, the Blalock Island complex supports multiple waterbird breeding colonies, including Caspian terns, Forster's terns (*Sterna forsteri*), California gulls (*Larus californicus*), ring-billed gulls (*L. delawarensis*), great blue herons (*Ardea herodias*), great egrets (*A. alba*), and black-crowned night-herons (*Nycticorax nycticorax*) (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 and continues to place dredge material on some of these islands, maintaining open, sandy habitats for species such as streaked horned larks (*Eremophila alpestris strigata*) (USACOE et al. 2018, pp. 119-135; USFWS n.d., p. 3).

River Deltas

River deltas occur at confluences, where a river may join the ocean (i.e., estuary), lake, reservoir, or other river. They 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.

IMPACTS ON FISH AND WILDLIFE RESOURCES

The Service's analysis of impacts for the FWCAR 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 sixteen evaluation species (Table 6). Additional guilds, communities, species, and key sites were identified based on whether they were most likely to experience significant ecological change under all proposed CRSO alternatives (see"Methods").

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 analysis is organized first by landscape and then by MO. The following subsections present table summaries 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.

SUMMARY OF LANDSCAPE FINDINGS

The Service analyzed impacts of the proposed CRSO alternatives on the overall health of the rivers landscape. Tables 15, 16, 17, and 18 include a qualitative summary of the rivers, lakes and reservoirs, riparian, and wetlands landscape findings and shows the trend of overall health of this 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 rivers landscape 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 proposed alternatives on 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 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, and 18 to illustrate the projected impacts of the CRSO. Instead, a detailed description of the impacts of proposed alternatives on the wetlands landscape is included in Appendix G.

Table 15. Summary of projected trends of overall health of the rivers landscape under all CRSO alternatives, 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 Monumen-tal 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 all CRSO alternatives, 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 all CRSO alternatives, 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

Subbasin	Key Site	NAA Trend	MO1 Trend[1/]	MO2 Trend[1/]	MO3 Trend[1/]	MO4 Trend[1/]
	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
	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 in Table 17 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 (see "Conservation Recommendations").

Table 18. Summary of projected trends of overall health of the wetlands landscape under all CRSO alternatives, 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
	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 in Table 18 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

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, the 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, physical, and chemical 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 region-wide, multi-program workshops and meetings to develop specific, measurable, time-oriented conservation recommendations for the co-lead agencies to protect fish and wildlife resources associated with the proposed action. The conservation recommendations address the impacts of one or more of the proposed MOs and their measures presented in the CRSO DEIS, 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. This does not mean that off-site mitigation be excluded from consideration. Rather, the Service believes avoiding and minimizing impacts have a higher probability of success. The following conservation recommendations are ordered within this hierarchy, where possible. Conservation recommendations are grouped into six categories, each defined by a goal statement that illustrates the Service priority to support diverse ecological and physical processes, resilient habitats, and sustainable fish and wildlife resources.

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

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 significantly alter 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 natural flood regime could be implemented. The following conservation recommendations aim to avoid or minimize impacts and, thus, are the Service's highest priorities:

- 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.
- 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.
- 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 be no more than 1 inch 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 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 discharge 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, 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 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).
- 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.
- 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).

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 populations 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 necessary 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 CRSO projects remain. Minimizing these impacts, consistent with these conservation recommendations, will begin to address impacts associated with future operations:

- To the maximum extent practicable, reconnect rivers and tributaries to their floodplains, side channels, and associated wetlands, including barrier removal, breach, or setbacks.
- 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.
- 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.
- 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.
- 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.
- 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*]).

- 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 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.
- 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-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.
- 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, 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 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.
- 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.

MAINTAIN FUNCTIONALITY OF NATIONAL WILDLIFE REFUGES AFFECTED BY CRSO 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 has 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 CRSO configuration will likely impact the structure and function of some NWRs and other lands. The following recommendations support NWR functionality despite changing conditions from the CRSO proposed action:

- 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 depending on the alternative that is eventually implemented.

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 has 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 large wood 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 niches to maintain habitat mosaics that support waterbirds, wetland, and riparian species.
- 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 Snake River.
- 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.
- 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 as needed at other dams if cottonwood seedling mortality is observed due to rising winter ice (USACOE et al. In prep.).
- 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 stream flows 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 large wood 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 (i.e., 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 post-implementation of breaching measures. Determine and implement restoration activities that preserve remaining 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, 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.

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 reservoir and wetland environments, 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 exacerbate future invasions.

The Service recognizes CRSO 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 environmental impacts, economic impacts, and 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 (e.g., aquatic invertebrates and plants).

- 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.
- 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.

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 are 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 (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.
- 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 socioeconomic 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 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 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 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 anadromous salmonids and ESA-listed 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 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.

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APPENDIX A. TIMELINE

The timeline (Table A1) in this appendix highlights key milestone activities in the Service's engagement in CRSO FWCAR development from spring 2017 through summer 2020.

Table A1. Service activities related to CRSO FWCAR 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 FWCAR for the CRSO
2018	
March 21	The Service sought input on landscapes and evaluation species from Service Program staff and the co-lead agencies for the FWCAR
April 23	The Corps formally requested a FWCAR for the CRSO and asked the Service to finalize the SOW for the project
April 25	The Service delivered the SOW to the Corps
May 15	The Service and the Corps approved the SOW
August 8	The Service and the 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
October 3	Service staff participated in a half-day FWCA training webinar
October 25	Secretaries of the Interior, Commerce, and Energy, and the Assistant Secretary of the Army for Civil Works received a Presidential Memorandum, "Promoting the Reliable Supply and Delivery of Water in the West" (207 FR 53961 [October 25, 2018]), directing the co-lead agencies to develop a schedule to complete the CRSO final EIS, BO, and FWCAR 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 ends, and work resumed

Date of Activity	Activity Description
February 25	Based on the Presidential Memorandum (207 FR 53961), the Corps revised the schedule for the following deliverables and deadlines: • CRSO DEIS due February 2020; • final EIS due June 2020; • associated BOs due June 2020; • final FWCAR due June 2020; and, • the Record of Decision in September 2020.
May 20 to 22	The Service hosted the "Wetlands" workshop in Burbank, Washington
May 28 to 29	The Service hosted the "Upper Basin" workshop and "Uplands" discussion in Kalispell, Montana
June 5 to 7	The Service hosted the "Riparian" workshop in Burbank, Washington
June 24 to 26	The Service hosted both the "Rivers" and "Lakes and Reservoirs" workshops in Vancouver, Washington
August	Service staff analyzed the CRSO alternatives
September 9	Service finalized conservation recommendations and mitigation strategies
September 30	The Service's Regional Leadership was briefed on FWCAR status and upcoming review opportunities
October 1	The Service began internal review of the FWCAR
October 9	The Service submitted a Planning Aid Letter to the Corps including the Service's draft conservation recommendations from the FWCAR
2020	
January 14	The Service delivered the FWCAR to co-lead agencies

APPENDIX B. CRSO STUDY AREA, FURTHER DEFINED

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

FOCAL TRIBUTARIES

The Snake, Clearwater, Kootenai, and Pend Oreille rivers represent the focal tributaries in the proposed CRSO action.

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 all seven Basin-intersected states. The Snake River has an average annual discharge of 57 kcfs (1,614 m^3s^{-1}) or 21 percent of the Columbia River's discharge. The study area and, thus, this analysis include only the lower portion of the Snake River affected by CRSO operations (i.e., beginning approximately 9 miles (14 km) below its confluence with the Salmon River, to the Snake River's confluence with the Columbia River).

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 kcfs (425 m^3s^{-1}).

Kootenai River

The Kootenay or Kootenai River basin contains approximately 16,180 square miles (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 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^3s^{-1}]), 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).

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 kcfs (736 m^3s^{-1}) (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 square miles (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-square mile (668,217 km^2) Basin.

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 kcfs (566 m^3s^{-1}), draining over 22,000 square miles (56,980 km^2) (USGS 2019b).

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 (Public Law 90-542 § 1[b]; 16 U.S.C. § 1274 [1968]; 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 kcfs (340 m^3s^{-1}) and contributes over half of the Clark Fork River's flow (Confederated Salish and Kootenai Tribes and Montana FWP 2004, pp. 5-6).

COLUMBIA RIVER SYSTEM OF FEDERAL PROJECTS

The study area 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 USACOE 2018, pp. 1, 8).

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

River System and Tributaries	Operating Agency	Federal Project
Columbia River mainstem	Corps	Bonneville Dam

River System and Tributaries	Operating Agency	Federal Project
		The Dalles Dam John Day Dam McNary Dam Chief Joseph Dam
Columbia River mainstem	Reclamation	Grand Coulee Dam
Snake River	Corps	Ice Harbor Dam Lower Monumental Dam Little Goose Dam Lower Granite Dam
Clearwater River	Corps	Dworshak Dam
Kootenai River	Corps	Libby Dam
Pend Oreille River	Corps	Albeni Falls
Flathead River	Reclamation	Hungry Horse Dam

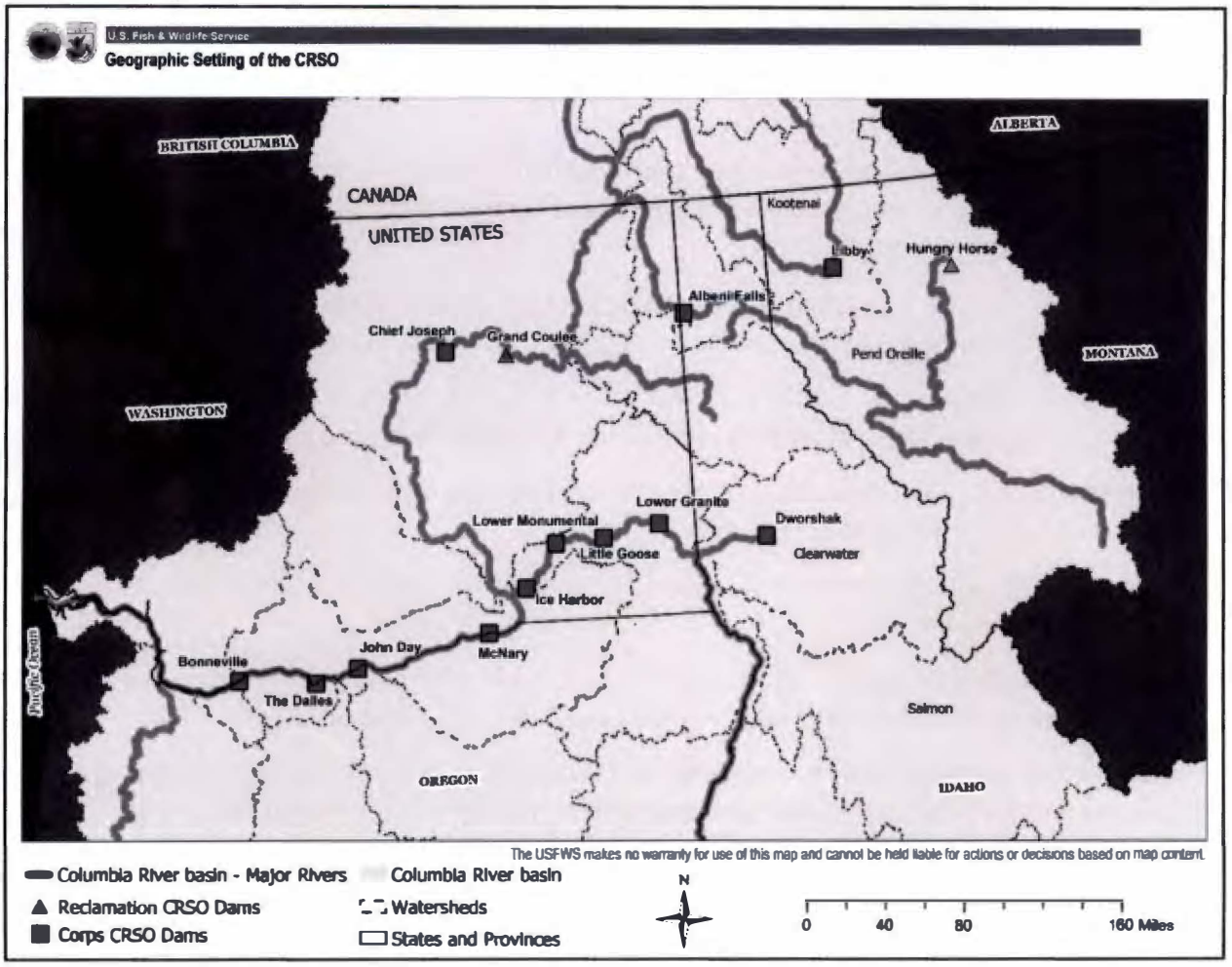

Figure B1. Geographic setting of the CRSO (USACOE n.d.)

The co-lead agencies coordinate operation of these 14 Federal projects with Canada reservoir projects pursuant to the Columbia River Treaty and several nonfederal, 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 includes 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 are excluded (see "Excluded Areas" in this appendix) in this analysis.

RIVER SEGMENTS (OR REACHES)

The study area also 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 USACOE 2018, p. 8). Within that scope, the Service's analysis of the impacts of CRSO Federal project proposed alternatives was confined by 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 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 CRSO Federal 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 one half mile of the terminus of the banks) (Table B2 and Figure B2). Table B2 lists these reaches in order from the Pacific Ocean to headwater stream segments.

Table B2. River reaches included in the FWCAR 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 [382]

Rivers and Focal Tributaries	Number related to Figure B2	Reach Name	From River Mile	To River Mile	Length (miles [km])	Area (acres [km²])[1/]
	1	Quinn Island to Bonneville Dam	30	146	429 [690]	348,935 [90]
	2	Bonneville Dam to The Dalles Dam	146	191	103 [166]	55,805 [280]
	3	The Dalles Dam to John Day Dam	191	217	54 [87]	27,884 [165]
	4	John Day Dam to McNary Dam	217	291	188 [303]	121,892 [80]
	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]
	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]

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	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]
	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]

Rivers and Focal Tributaries	Number related to Figure B2	Reach Name	From River Mile	To River Mile	Length (miles [km])	Area (acres [km²])[1/]
	24	Albeni Falls to Cabinet Gorge Dam	89	156, 2 (Pack River) and 15 (Clark Fork River)	189 [304]	172,539 [698]
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 [346]	102,100 [413]
	31	Upstream of Libby Dam	220 (Kootenai River)	220 (Kootenai River)	48 [77]	67,058 [271]

[1/]The acres and km² listed are rounded to the nearest whole number

Source: USGS n.d.

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 (Appendix G) (Hadley, H., in litt. 2019).

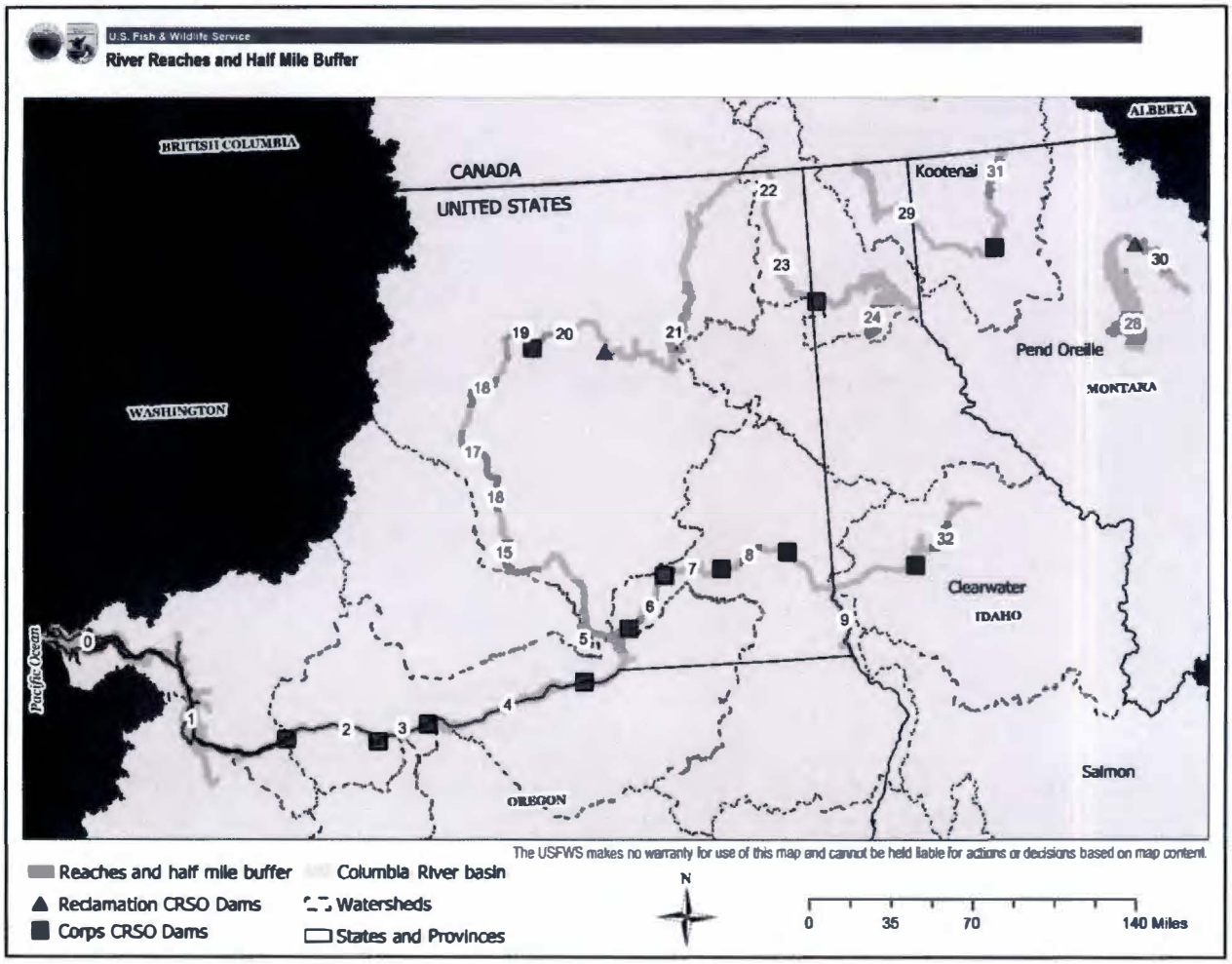

Figure B2. River reaches included in the FWCAR analysis and 0.5 mile (0.8 km) buffer

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 reaches influenced by dams operated by nonfederal entities (e.g., Wanapum Dam, Rock Island Dam), this report analyzes 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 this analysis because they are outside the scope of the project.

APPENDIX C. SERVICE OUTREACH AND COMMUNICATIONS

The following documents represent the Service's outreach to stakeholders. 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.

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: State upervisor, 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 stem Operations or CRSO). The Corps has pro ided 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 proce ses and diverse ecological communities affected by dam modifications and operation in the Columbia River basin by providing technical assistance and recommendations to the co-lead agencie ."

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 con ultation. To that end, the USFW 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 specie to illustrate the effects of changing dam operations. Specie were selected through two phases. In the first phase, SFWS staff from the Washington Fish and Wildlife Office identified pecies 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 pecies with special status under state law, but are not listed under the Endangered pecies Act since the effects of dam operation to E A-listed species will be analyzed through con ultation with SFWS and OAA. 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
	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

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.

APPENDIX D. SERVICE WORKSHOP AGENDAS

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

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**	

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: 40am	**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?** Discussion: *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**	

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**	

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

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**	

APPENDIX E. DATA SOURCES

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

WATER HYDROLOGY AND HYDRAULICS (H&H) MODELS

The Service referred to outputs from the co-lead agencies H&H modeling efforts. The Service focused on reviewing summary hydrographs for each alternative (see "CRSO DEIS Alternatives") to compare discharge over time at various locations, in identified reaches, in the study area.

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 their H&H model, which is a combination of two hydro regulation models, Hydro Simulation Program (HYDSIM) and the Reservoir System Simulation (HEC-ResSim). 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. Each modeling spreadsheet included information specific to each of the CRSO dams, each dam reservoir and dam outflow, and a small number of intermediate points between dams. Each spreadsheet also had summary information displayed in chart format. Summary categories are defined in this 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**. In this, 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 (i.e., 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.

GEOGRAPHIC INFORMATION SYSTEMS (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.

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 data set. 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 this analysis on the impacts of proposed alternatives.

For areas outside of the NWI data and within a 0.5 mile (0.8 km) buffer, the Service used LANDFIRE data. Other GIS data sets were considered for this analysis, such as the Northwest Habitat Institute (NWHI) and National Land Cover Data (NLCD) (MRLC n.d.). The scale and resolution of these datasets were either coarser (NLCD has 30-meter [98-ft] resolution) or more generally characterized (NWHI habitat categories were considered to generalized for this 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 analysis.

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.

Landscape Fire and Resource Management Planning Tools (LANDFIRE) 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 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).

Species Occurrence Data

Species occurrence GIS data is a foundation of the FWCAR analysis and was gathered through many sources. The co-lead and cooperating agencies and tribes 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 workshop period. Much of the species occurrence data originated from state Natural Heritage Programs or surrogate data sets, such as the Washington Department of Fish and Wildlife's Priority Habitats and Species and Wildlife Survey Data Management system. Other data sources the Service used came from 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).

APPENDIX F. DETAILED DESCRIPTION OF LANDSCAPES AND THEIR EVALUATION SPECIES AND STATUSES

This appendix includes detailed descriptions, organized by landscape, of the evaluation species the Service selected for the FWCAR.

RIVERS

Landscape, Habitats, and Subhabitats

This landscape includes river, estuary, and nearshore marine environments, which are often characterized by streams and tributaries, edges of rivers and sloughs, and temporary impoundments. For this report, common river subhabitats in the Basin include 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 due to dam operations; 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 zones of river and marine environments that are often brackish
Nearshore Marine Environment		Waters outside the mouth of the river (e.g., Columbia River) that are still influenced by riverine processes and dynamics

Rivers

In rivers, water flows at a relatively rapid rate compared to water in lentic (i.e., still or slower-moving) 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 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 altered hydrology from project operations, and these alterations can affect floodplain connectivity, river morphology, and sediment transport capacity (Hadley, H., in litt. 2019).

The eight major Federal reservoirs on the Lower Columbia River and the Lower Snake River are part of the "rivers landscape" because these projects operate as run-of-river. Thus, although impounded, there is flow through the reservoirs that varies in velocity depending on operations and location in the reservoir.

Related structures, such as canals and sloughs, are not part of this analysis.

Estuaries

Estuaries are transition zones that separate one or more rivers from the nearshore marine environment. These areas are tidally influenced and are often brackish, slower-moving water. The Service's analysis of impacts on estuary habitat is 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.

Nearshore Marine

The nearshore marine environment includes waters beyond the mouth of the river, yet are still influenced by the river, and features ranging from submerged high-relief rocky reefs to broad expanses of intertidal mudflats, soft sandy and 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.

Evaluation Species

Pacific Lamprey (E. tridentatus)

Pacific lamprey are a Service trust species and are important to Federal, state, and tribal partners. Though Pacific lamprey are not currently listed under the ESA, 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 river habitat and some estuary and nearshore marine environment habitat to complete all life history stages (i.e., recently 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 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., larval stage of the lamprey) remain in tributaries and undergo metamorphosis from 4 through 7 years (Close et al. 2002, p. 20). Ammocoetes are known to use slow depositional areas along stream banks 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., anadromous juvenile lamprey), they move from slower-moving waters with fine substrate to faster-moving waters with a moderate current and silt covered gravel. From there, after they are fully transformed, Pacific lamprey move into even faster-moving river waters with moderate to strong current and 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 listed salmonids, face considerable threats in the Basin (e.g., reduced access to high quality habitat, degradation of spawning and rearing areas, loss of emigrating juvenile lamprey 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 Federal dams as part of the CRSO will likely negatively impact the river landscape that supports the Pacific lamprey and all of its life history stages. This reflects various threats including: barriers to effective passage, dewatering and stream flow 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).

Western Pearlshell Mussel (M. falcata)

Western pearlshell mussel prefer clear, cold water and are able to complete all of their life history stages throughout the study area (Jepsen et al. 2012, p. 7). They are normally located at depths between 1.5 feet and 5 feet (between 0.5 and 1.5 m), and they tend to congregate in aquatic habitats with 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 and trout (e.g., Chinook salmon [*Oncorhynchus tshawytscha*], Coho salmon [*O. kisutch*], kokanee [*O. nerka*], 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 adverse impacts on habitats and processes that support these host fishes also affect the western pearlshell. The average lifespan for the western pearlshell mussel is approximately 60 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 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 conservation of other aquatic species. Western pearlshell mussel is not listed under the ESA, however it is monitored by the Pacific Northwest Freshwater Mussel Workgroup, of which the Service and state and tribal partners are members.

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 is found downstream of Bonneville Dam, where the Lower Columbia River, estuary, and nearshore marine environment habitats 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). These sturgeon are broadcast spawners and release eggs and milt into the river over gravel, cobble, and boulder substrate for fertilization (Parsley et al. 1993, pp. 223-224). Average spawning depths can exceed 19 feet and water velocities near the bottom of the water column average approximately 4.6 ft per sec (1.4 m per sec) (Parsley et al. 1993, p. 220).

Changes in the operations and maintenance of the Federal projects as part of the CRSO have impacted, and will likely continue to impact, both juvenile and adult life stages of white sturgeon. The CRSO operations reduce or eliminate connectivity among populations and decrease or eliminate essential habitats and processes necessary to support all life history stages of the white sturgeon (Beamesderfer and Anders 2013, pp. 76-77).

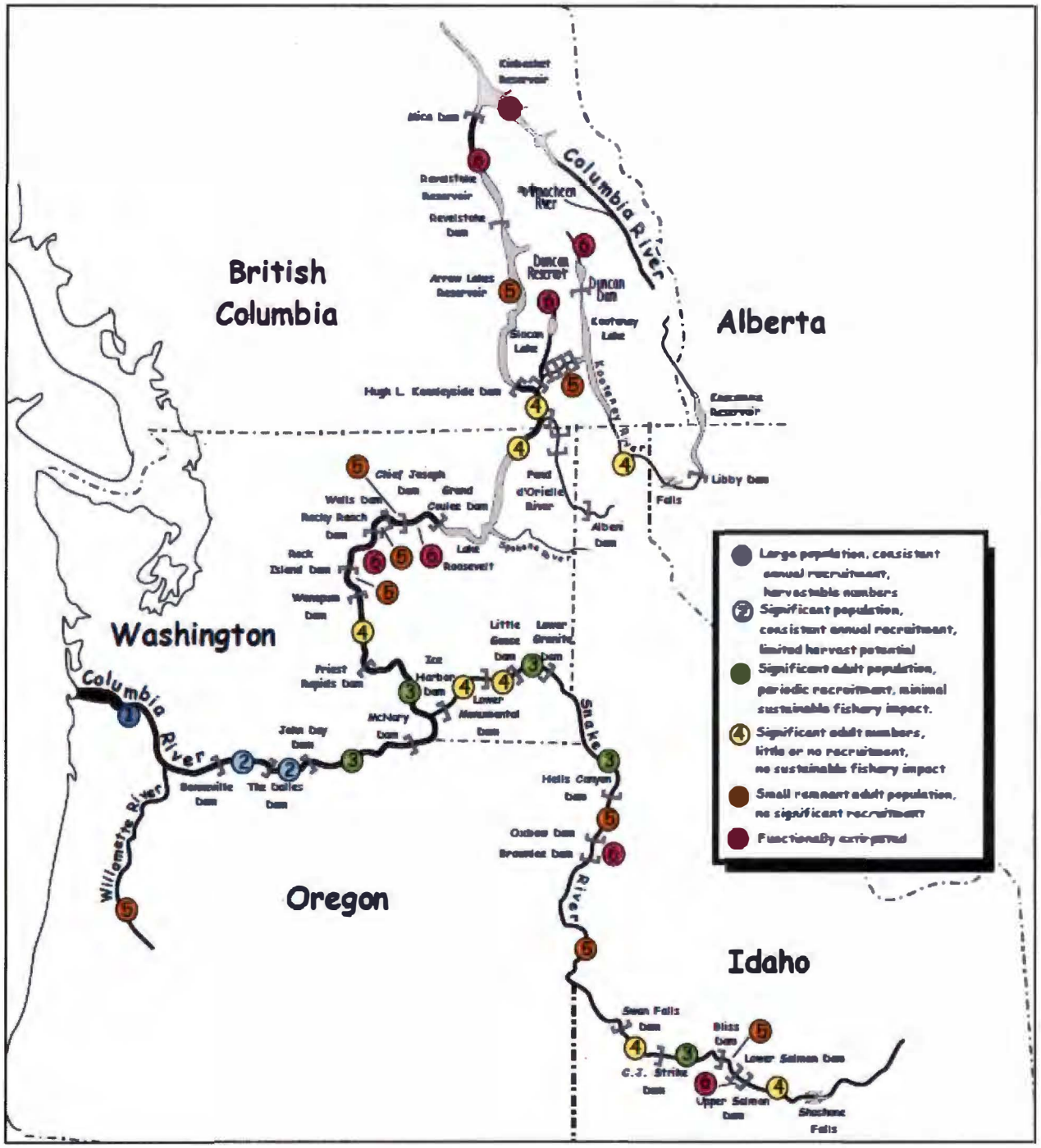

Figure F1. Distribution of white sturgeon subpopulations in the Columbia and Snake Rivers
Source: Beamesderfer and Anders 2013, p. 58

LAKES AND RESERVOIRS

Landscape and Habitats

Lakes are naturally occurring low points in the landscape that contain 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.

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 the hydropower projects that regulate their outflow. For example, Albeni Falls Dam is a CRSO Federal project that controls the outflow of Lake Pend Oreille. The outlet of Flathead Lake is regulated by the Confederated Salish and Kootenai Tribes' Seli'š Ksanka Qlispe' Dam, but this non-Federal project is outside the scope of this report.

Reservoirs

Reservoirs, man-made impoundments, rather than natural lakes, are prevalent in the Basin. Typically, reservoirs store large volumes of water, have large operating ranges (hydraulic heads) and long water retention (hydraulic residence) times in comparison to rivers. However, reservoirs are formed as a result of the damming of a river and conversion of lotic (i.e., fast-moving) waterbodies. Reservoirs may also flood and convert to lentic waterbodies 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, reservoirs tend to 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 analysis. Table F2 includes the natural lakes and reservoirs natural landscape considered in this analysis.

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 (e.g., rivers);
Reservoirs	Artificial or man-made freshwater lakes that store and supply water for naturally occurring waterbodies (e.g., rivers and lakes)

As part of the CRSO, there are two types of reservoirs in this system: storage (Table F3) and run-of-river reservoirs (Table F4) (BPA et al. 2001, pp. 9-13). 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	Federal Project
Lake Roosevelt	Grand Coulee Dam
Lake Pend Oreille	Albeni Falls Dam
Lake Koocanusa	Libby Dam
Hungry Horse Reservoir	Hungry Horse Dam
Dworshak Reservoir	Dworshak Dam

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

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

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]), are not addressed as part of this landscape. Rather, they are addressed part of the rivers landscape.

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

Evaluation Species

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 (i.e., non-breeding individuals) 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).

Clark's grebe and western grebes were historically considered 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 reproduction 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). However, trends in grebe population abundance in

Oregon and the western North American survey area, which have larger sample sizes, also show sizable declines and 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).

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 picking food from the water's surface or probing in the mud. 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 fish. In both environments, dunlin are limited in forage hours, dependent significantly on tidal fluctuation.

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). The total population that migrates and winters in this area is estimated to be approximately 550,000 individuals (Andres et al. 2012, p. 187). 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 or 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 and some river habitats (i.e., estuary and nearshore marine environment) in the Pacific Northwest (Warnock and Gill 1996).

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 use or require a specific host fishes, floaters are not highly host-specific, meaning they can

likely use native fish like Westslope cutthroat trout, sculpin, or stickleback as necessary 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 (*Anodonta 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 Cascades or Rockies 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 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 like 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).

Other Guilds and Communities

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 breeding pairs in 2009 to a minimum census estimate of 10,580 breeding pairs in 2018 (Peterson et al. 2017a, p. 8; Peck-Richardson et al. 2019, p. 1). Two management plans have been implemented to reduce the predation on ESA-listed juvenile salmonids by reducing available

nesting habitat and therefore the size of breeding colonies of Caspian terns in the Columbia River Estuary and in the Columbia Plateau Region (USACOE 2014a; 2015). In addition, the second largest Caspian tern colony site will likely have all nesting habitat removed in 2020 due to human health and safety concerns (Lawrence, M., in litt. 2019). An additional 1,100 breeding pairs will be searching and competing for limited nesting locations throughout the Pacific Flyway. This would reduce the size of the Pacific Flyway breeding population if they do not relocate.

The latest version of the 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 reduced the 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 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).

An average of 422 breeding pairs of Caspian terns (average peak number) have 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). There was an increase in colony size at the Blalock Island complex after implementation of tern management actions at Crescent Island. The 2018 peak colony size was 313 breeding pairs (Collis et al. 2019, p. 34).

RIPARIAN

Landscape, Habitats, and Subhabitats

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 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 distinctively 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 this report and 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 (approximately 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 ft (6 m)tall
Forest	Zones with more than 30 percent canopy cover of woody riparian vegetation greater than 20 ft (6 m) tall

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

Evaluation Species

Black Cottonwood (P. trichocarpa)

The 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). It 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 large wood associated with riparian and river interactions. It 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).

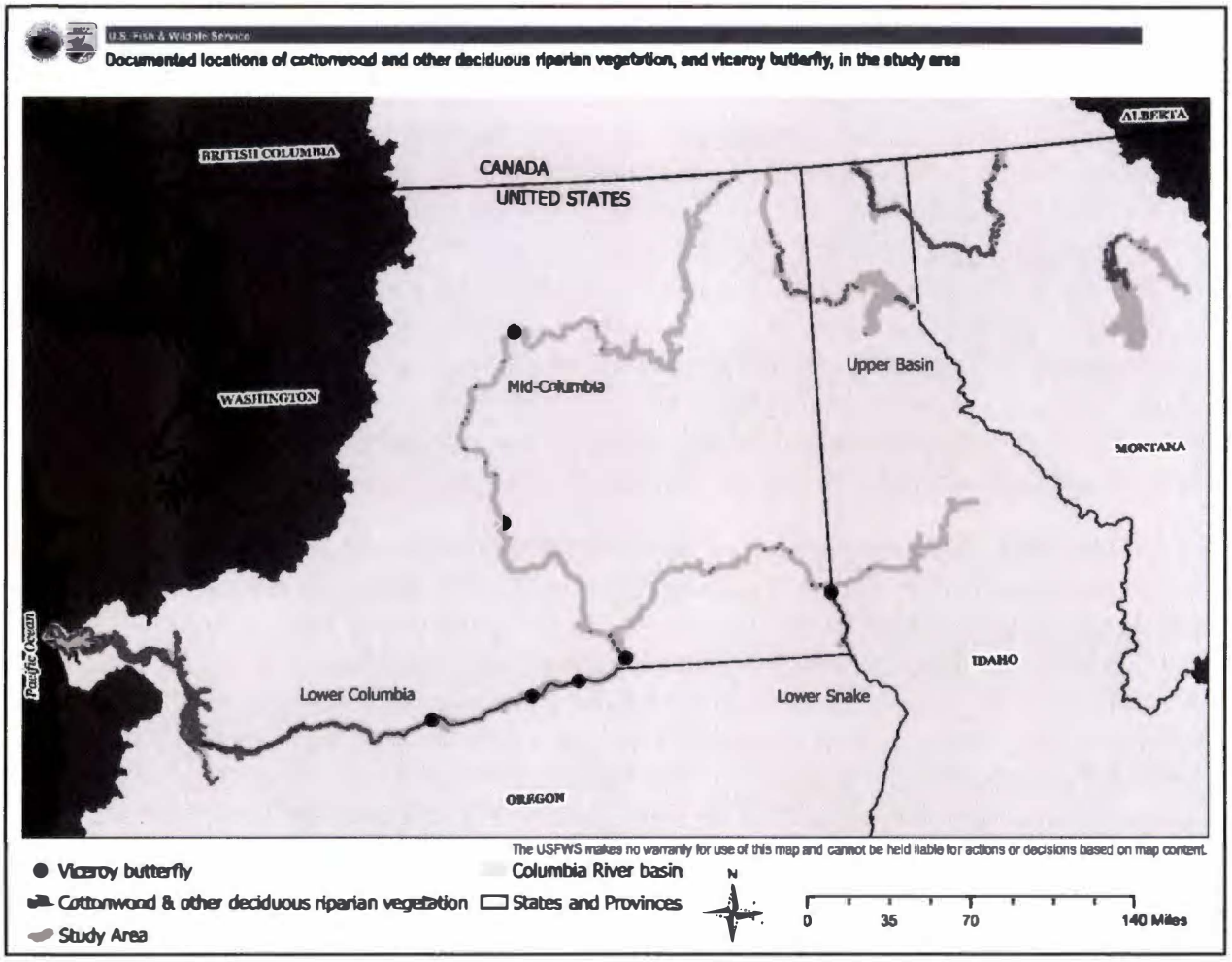

Figure F2. Documented presence of black cottonwoods, other deciduous riparian vegetation, and viceroy butterflies in the study area

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 installation 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 due to 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, as a result of continuing CRSO Federal project operations, black cottonwood are negatively affected by related impacts associated with 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-obligates, black cottonwoods are indicators of riparian health, and the loss of these specialized components from the riparian forest often indicates habitat degradation, which has many anthropogenic causes (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 stream flow and, thus, contributes more to diversifying streambed morphology, which, in turn, benefits the overall aquatic ecosystem (Castro and Thorne 2019, p. 319).

Viceroy Butterfly (L. archippus)

The viceroy butterfly is a riparian-obligate, 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 viceroy butterfly larvae feed, overwinter, and complete metamorphosis, this species 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 Ranges east throughout the rest of the U.S. (Lotts and Naberhaus 2017). Viceroy butterflies need 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 is 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 this analysis, the Service found little 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.

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 shrub associations for feeding, breeding, 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 m and 11 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 ft and10 ft

(ranging from 0 ft to 50 ft [0 m to 16 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 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 state-wide, including Idaho, Montana, Oregon, and Washington (Ballard et al. 2003, p. 742; Sauer et al. 2017).

Other Guilds and Communities

Cottonwood-Willow Communities

There has been less focus on willows (*Salix* spp.) 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 1 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 on willows caused by altered hydrologic flow regimes, flood control, development projects, and irrigation practices are similar to those on 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 abundance of willow (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 often may 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 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 like changes in hydrology, cattle grazing, and the introduction of invasive plant species (Braatne et al. 1996, pp. 74-76; Obedzinski et al. 2001, p. 169). "By disrupting the fluvial geomorphic regime – the principal organization force creating and maintaining floodplain and riverine habitats – we pose a major, perhaps the single most important impediment to riparian forest regeneration" (Dykaar and Wigington 2000, p. 101). 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 complexity in 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).

Riparian Songbirds

An estimated 95 percent of all riparian habitats in the western U.S. has 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, has 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 loss or degradation of cottonwood-willow riparian habitat has 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 complex and heterogeneous 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 increases 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 to yellow warblers and other riparian breeding birds (Scott et al. 2003, pp. 290-291) (Figure F3). 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).

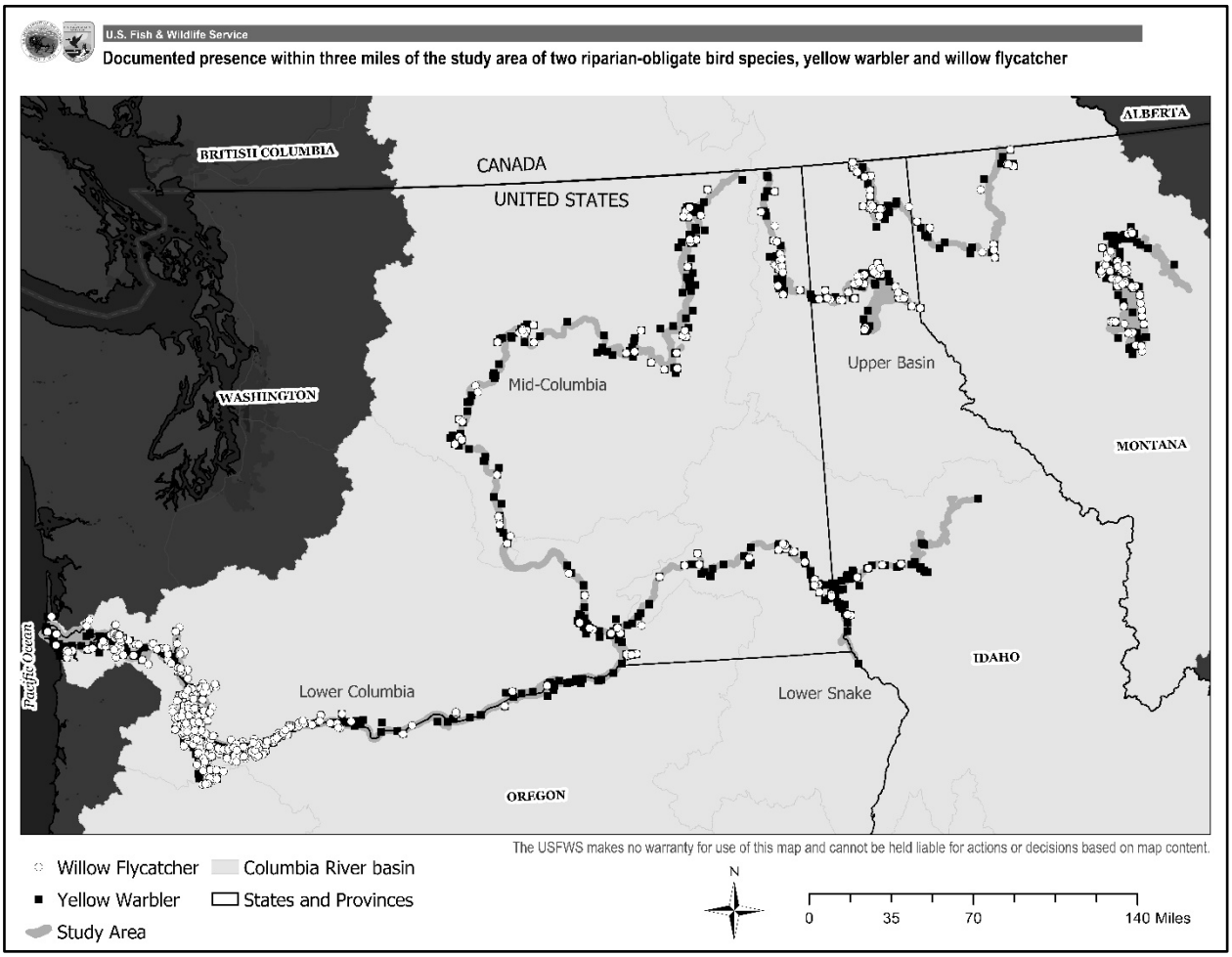

Figure F3. Documented presence of yellow warbler and willow flycatcher within 0.8 miles (5 km) of the study area

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 9 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, has led to some regrowth of willow and cottonwood, and several formerly-extirpated bird species reestablished in the regenerated forest (Hinojosa-Huerta et al. 2008, pp. 75, 80-81).

WETLANDS

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 National Wetland Inventory (NWI) and the U.S. Department of Agriculture and U.S. Department of Interior Landscape Fire and Resource Management Planning Tools database (LANDFIRE) to identify and classify wetland habitats in the Basin for this analysis. The resulting wetland habitats 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 such as islands:

- 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 ft (6 m) in height
	Scrub-shrub	Wetlands that are dominated by woody plants less than 20 ft (6 m) in height; shrubs may include true shrubs, young trees that have not yet reached 20 ft (6 m) 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 categories 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 in shallow water with groundwater input or in areas subjected to flooding

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 shoreward of lakes, river channels, or estuaries, on river floodplains, in isolated catchments, or 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.

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 this report, the Service classified those areas as either lakes, reservoirs, or rivers.

Emergent Wetlands

Emergent wetlands are found throughout the study area except for in marine systems like the Pacific Ocean. Like marshes and wet meadows, emergent wetlands include a number of areas subject to extended periods of flooding. Due to significant groundwater contributions, emergent wetlands are fairly 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 Wildlife Management Areas (WMAs) employ several management strategies to maintain and enhance wetland function in specific locations to the extent possible for wetland-obligate species. For example, some Service refuges and WMAs manage wetlands by pumping water in and out to control water levels and vegetation. 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).

Evaluation Species

American Bittern (B. lentiginosus)

American bittern is protected under the MBTA. American bittern is a marshbird with a breeding range that includes the study area as well as much of the northern continental U.S. This species has been observed to frequent 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, Paterson, Oregon. In the study area, the greatest number of American bittern observations occur in wetland habitats below Bonneville Dam in the Lower Columbia River, at Steigerwald Lake NWR in Washougal, Washington, and 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 prey 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 ac [3 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, they 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.

Mallard (A. platyrhynchos)

The mallard is protected under the MBTA, and the western mallard population is part of the Service's BMC list. As part of the BMC list, mallards, like other bird species on the list, poses special management challenges due to many factors (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, and it 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 seem to prefer ephemeral, seasonal, and semi-permanent ponds and marshes. From April through June, they typically build their nests on dry land close to water and, occasionally, on floating platforms of vegetation (Barnes 2017). Mallard populations have responded positively to changes in the amount of wetland habitat, associated vegetation, and to changes in water levels and sedimentation (Krapu et al. 1997, p. 743).

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 the 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, this species will likely respond negatively to changes in wetland habitat amount, as well as associated vegetation and woody material, water level elevation, and changes in sedimentation, flow regimes, and habitat fragmentation in a given area.

Woodhouse's Toad (B. woodhousii)

Woodhouse's toad is a medium-sized true toad of the family *Bufonidae*, and it is found in many western-central states in the U.S. The toad's range extends from Mexico to Montana, but the species occupies only a few small areas within the Basin. In the study area, Woodhouse's toad occurs in a small area of the Columbia Plateau Ecoregion along the Snake River, and also along the Columbia River between Priest Rapids Dam and John Day Dam (Leonard et al. 1993, p. 114; WDFW 2019). They inhabit areas in the stretch of the Columbia River from Richland to Roosevelt 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 egg laying and fertilization occurs (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) for breeding. Outside the breeding season, Woodhouse's toads are most often located in river valleys in grassland and shrub-steppe habitats. They are sensitive to hydrological fluctuations in spring and early summer, such as changes in wetland availability, lack of 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, however, the only known populations of Woodhouse's toad in the Pacific Northwest occur in the study area (Jones et al. 2005, p. 169).

Other Species

Columbia Yellowcress (R. columbiae)

Columbia yellowcress, a low growing perennial herb in the mustard family, is threatened in Washington State. 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 other vegetation types. Population 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). This population occurs throughout the Hanford Reach of the Columbia River, the Lower Columbia River, couth-central Oregon, and the Modoc Plateau in northeastern California. 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).

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 easily observed because it is often hidden in dense marshy growth or wet meadows. It forages by picking items from the surface of the ground, water, or plants, and will periodically probe with its bill in the mud or among vegetation. 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, it feeds exclusively on seeds, including those of smartweeds, sedges, grasses, and other wetland plants. Sora also consumes a variety of insects, snails, and other aquatic invertebrates (Melvin and Gibbs 2012).

Courtship displays by both members of a pair involve ceremonial preening and sometimes bowing, facing toward and then away from each other. Nesting sites are often located in dense marsh vegetation, especially cattails, sedges, and bulrushes. 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 breeds, and stops over on migration and during winter, in portions of the study area.

Sora depends 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. This species is particularly sensitive to manipulations in water surface elevation, which reduce habitat quality in wetlands.

UPLANDS

Landscape, Habitats, and Subhabitats

In general, upland habitats are located outside waterbodies (i.e., 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 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
	Grasslands	Lands that are too dry to support shrubs, where the primary vegetation is grass
	Shrub-Steppe	Lands with limited moisture, where the primary vegetation are shrubs

Forest Uplands

Forested uplands generally support more than ten percent tree canopy cover and are categorized by plant species and structural features. This analysis is based 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 Cascade Mountain Range (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.

Arid Uplands

In this analysis, arid uplands include human-influenced subhabitats such as agricultural lands, native grasslands, and shrub-steppe. Agriculture is a common land-use practice on private as well as 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 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 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).

Evaluation Species

Long-Billed Curlew (N. americanus)

Long-billed curlews are 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 grass. In Idaho, researchers 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 habitats is thought to be the greatest threat to population stability and, thus, long-billed curlews 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).

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., it is a sagebrush obligate, and is thus dependent on large patches of sagebrush steppe habitat for successful breeding. Sage thrashers primarily feed on insects on the ground and nest 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 birds and other species and has fragmented other formerly contiguous shrub-steppe dominated subhabitats (Reynolds et al. 1999).

APPENDIX G. DETAILED DESCRIPTION OF LANDSCAPE FINDINGS

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

RIVERS

NAA

NAA Summary of Rivers Landscape Findings

- Current operations and maintenance of the CRSO Federal projects would continue to negatively affect overall habitat complexity, water quantity, water quality, and connectivity.
- Current operations and maintenance would 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.

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 CRSO Federal projects greatly influence the river 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 the ecosystem function of remaining unimpounded river reaches (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, the current operation of storage reservoirs, which contain varying amounts of water at different times during the year, result in fluctuations in water temperature, which negatively affect 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 river landscape related to historic flows and timing of peak flows (Figure G1) (Volkman 1997, p. 31).

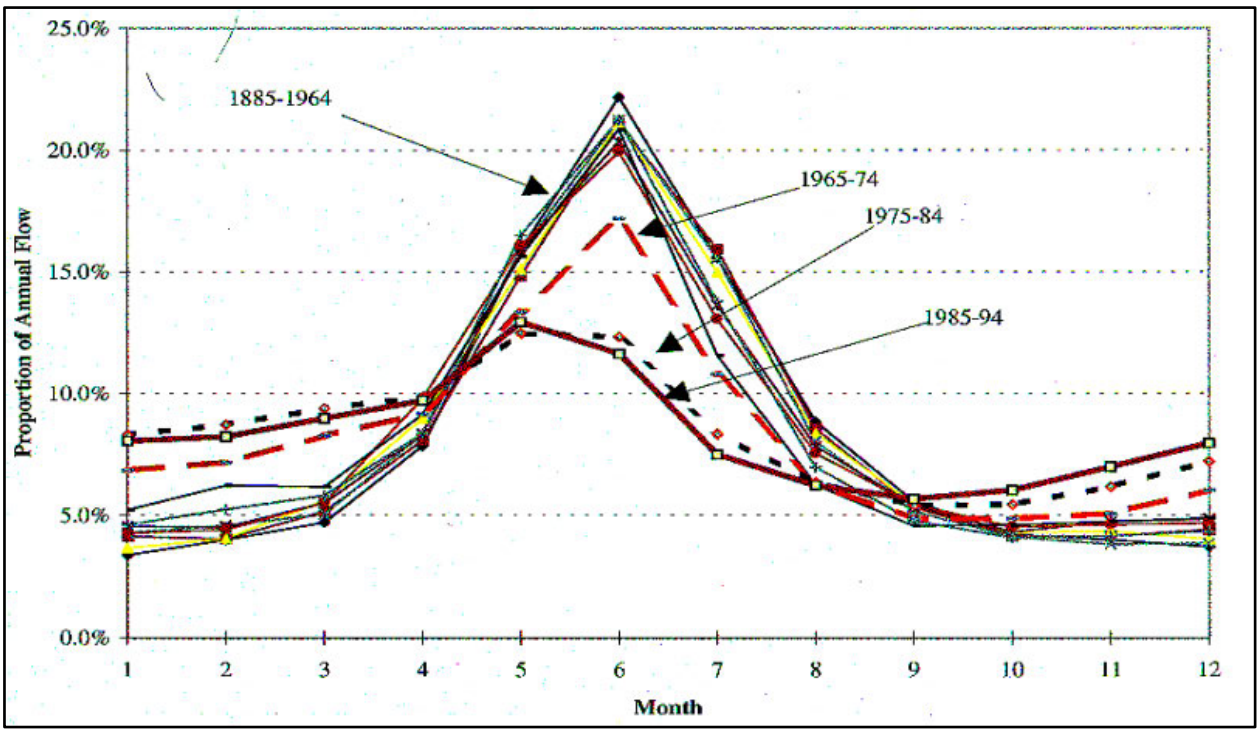

Figure G1. Historic magnitude of flows and peak flows at The Dalles Dam
Source: Volkman 1997, p. 31

These changes are shown by the co-lead agencies' H&H modeling efforts specific to four CRSO projects and adjacent river habitat: McNary Dam and Chief Joseph Dam, and the river habitat 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 like sediment deposition and channel avulsion at these Federal projects in the Upper Basin are likely to have cascading effects on storage reservoirs, downstream of the reservoirs, and throughout each successive run-of-river project in the Lower Snake and Lower Columbia rivers.

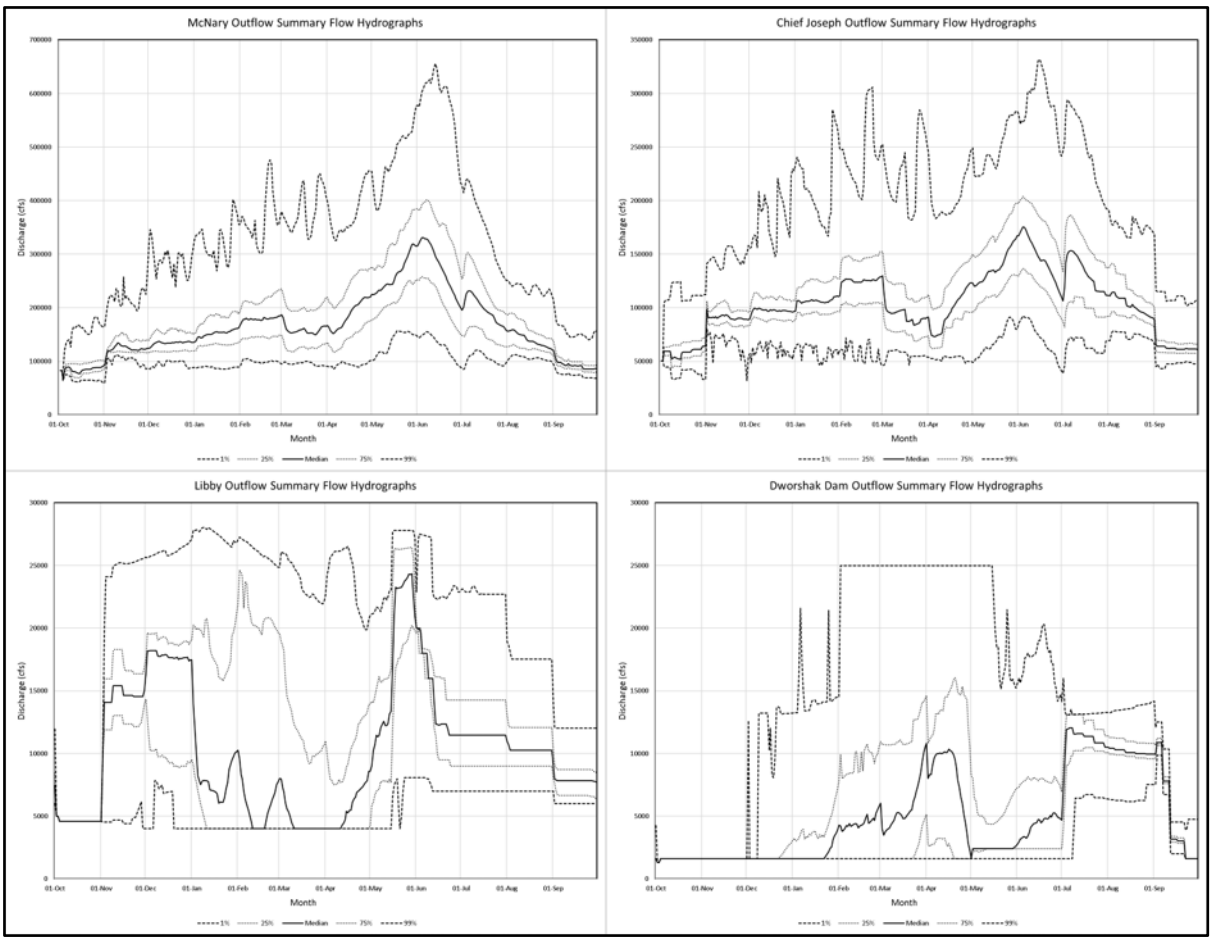

Figure G2. Summary hydrographs for McNary Dam, Chief Joseph Dam, Libby Dam, and Dworshak Dam

Connectivity

Alteration of the pre-dam hydrograph has reduced 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 USACOE 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, CRSO 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 remains (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.

NAA Impacts on Habitats and Subhabitats

Banks and Shorelines

In this analysis, banks and shoreline subhabitat occurs along run-of-river reservoirs, and it supports the growth of aquatic vegetation and recruitment of large wood, which provides 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 would 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 USACOE 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 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 they will likely continue 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 CRSO operations limit the productivity of this river subhabitat 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 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 CRSO, 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 occur. Operations under the NAA would 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. However, many tributary mouths in the Basin have been negatively impacted by ongoing 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 would 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 better functioning of physical processes, resulting in habitat that supports many aquatic species (USFWS 2019e). Under the NAA, unimpounded river reaches would continue to provide the most benefit to aquatic and semi-aquatic species in the Basin.

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 (*Catostomus* spp.), are mainstem migratory fishes. White sturgeon spawn in the spring when water temperature is between 10 ^{o}C and 18 ^{o}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 Lower Columbia River, the estuary, and the marine environment 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 would 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 species that use migratory corridors, rely on specific routes for travel to other river habitats to complete certain life history stages. For instance, at various life history stages, Pacific lamprey may use differing habitats like the nearshore marine habitat for feeding, slow moving, depositional shoreline subhabitat along reservoir and stream banks 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, populations can be found 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). Under the NAA, continued operations and maintenance of the CRSO would continue to pose threats to maintaining habitat connectivity and habitat complexity that enables 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 have 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 Snake and Columbia Rivers, and in the tributaries of each of these rivers to these extents (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). Other aquatic non-migratory species would likely experience adverse impacts from continued operations and maintenance of the CRSO due primarily to changes in water quality as a result of higher water temperatures, channel avulsion, and increased sedimentation.

MO1

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 would have positive impacts on lamprey survival during spawning, rearing, and migratory stages.

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) would 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 ac-ft (1,185 ha-m) of irrigation water, would lead to higher flows in the Kootenai River. Other operational measures, including the Modified Dworshak Summer Draft operational measure, would 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 the NAA. This measure would also negatively impact water quality in transition area subhabitat such as those found at the head of key sites like the John Day Reservoir and the Lower Monumental Reservoir, which may affect habitat complexity and connectivity for mainstem and migratory corridor species that use these areas for extended time periods. These operational measures of MO1 represent changes from current operations, but they still, if implemented, neither represent nor support historic conditions, prior to the dams, of the river landscape.

MO1 Impacts on Evaluation Species

<u>White Sturgeon and Other Mainstem Migratory Fishes</u>

Under MO1, structural and operational measures intended to benefit anadromous salmonids may benefit other mainstem migratory fishes like white sturgeon. The Modify Bonneville Ladder Serpentine Weir structural measure, for instance, would 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) would likely reduce the abundance of transition areas in river habitat at key sites like the John Day Reservoir and the Lower Monumental Reservoir.

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

The following structural measures regarding fish passage outlined in MO1 would 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 modification of turbine intake screens.

However, impacts to Pacific lamprey will remain including the low conversion rates of adult Pacific lamprey passing Bonneville Dam and the level of mortality of juvenile lamprey that encounter the turbine intake screens, which were designed to protect juvenile salmon. These 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) would 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 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 are not intended to 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.

MO2

MO2 Summary of Rivers Landscape Findings

- Structural measures of MO2 would benefit Pacific lamprey, however operational measures that enable operation at full pool and provide no restrictions on ramping rates (i.e., rate of change of water flow, measured in m per sec per hr) could negatively affect this species.

MO2 Impacts on Indicators of Ecological and Physical Processes

Proposed operational measures under MO2 (Slightly Deeper Draft for Hydropower) would result in higher flows out of Dworshak Dam, likely increasing spring flows in the Clearwater and Lower Snake 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 river evaluation species. 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.

MO2 Impacts on Evaluation Species

White Sturgeon and Other Mainstem Migratory Fishes

The implementation of structural measures associated with MO2 would include 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 anadromous salmonids. It is unclear, however, whether or not the proposed structural measures would benefit other mainstem

migratory fishes because they have not been assessed for evaluation species that inhabit the Columbia River such as white sturgeon.

The MO2 operational measure intended to limit fish passage spill associated with TDG at 110 percent (Spill to 110 percent TDG) provides 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). If the co-lead agencies select MO2, then this spill level would 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 river landscape in the study area.

Pacific Lamprey and Other Migratory Corridor Species

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 would also 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) would 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 apart from anadromous salmonids. Ceasing or delaying the installation of fish screens at John Day Dam and McNary Dam would 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 at the four lower Columbia River dams and the four lower Snake River dams (Ramping Rates for Safety) may reduce the stability of these subhabitats. Increases in the flexibility of elevation operating range could lead to decreases in the abundance of transition areas upstream, and no restrictions on ramping rates could lead to rapid fluctuations in the 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 their 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. However, those species that utilize transition areas (e.g., suckers, sculpin) could be negatively impacted by operational measures as those described to impact mainstem migratory and migratory corridor species.

MO3

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 would benefit Pacific lamprey, some of the operational measures in MO3 could negatively impact this species and other migratory corridor species due to a lack of ramping rate restrictions.

MO3 Impacts on Indicators of Ecological and Physical Processes

In comparison to the other alternatives, proposed structural measures (Breach Snake Embankments, Lower Snake Infrastructure Drawdown) and operational measures (Drawdown Operating Procedures, Drawdown Contingency Plans) associated with MO3 provide the potential for the greatest 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) would 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), reduced restrictions on ramping rates (Ramping Rates for Safety), and increased TDG below projects (Spring Spill to 120 percent TDG). This could negatively impact key sites like the mouth of the Deschutes River and John Day Reservoir. However, the overall ecological benefits from dam breaching measures appear to surpass the potential negative impacts of other measures.

MO3 Impacts on Evaluation Species

<u>White Sturgeon and Other Mainstem Migratory Fishes</u>

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 would 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 is unclear whether these proposed structural measures would benefit mainstem migratory fishes because they have not been assessed for evaluation species that inhabit the Columbia River (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 operations. Breaching the earthen portions of the four Lower Snake River dams would benefit these species, and the river 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 to not restrict 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 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 fish and wildlife species that cannot relocate to alternative sites (such as the 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 would likely lead to the reestablishment of natural hydrologic processes (e.g., deposition and sediment transport). This return to natural hydrology would in turn promote island habitat and side channel subhabitat formation, which support various life history stages of aquatic species.

MO4

MO4 Summary of Rivers Landscape Findings

- Structural and operational measures of MO4 are likely to benefit evaluation species and other mainstem migratory, migratory corridor, and localized or non-migratory species, but likely not to the extent of the MO3 benefits.
- Operating at the Minimum Operating Pool would maximize the abundance and size of transition areas throughout mainstem subhabitats within the study area and would improve upstream and downstream migration for migratory evaluation species like Pacific lamprey, white sturgeon, and other migratory fishes.
- MO4 includes an operational measure that proposes the highest spill percentage among all alternatives. This may have particularly negative impacts on water quality standards critical for white sturgeon growth and survival.

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) would result in higher winter flows out of Libby Dam, which translate to higher flows in the Kootenai River during that time. While this measure may provide more downstream water delivery flexibility, it may not represent the historic environmental conditions in this reach.

Operational measures of MO4 proposed (Spill to 125 percent TDG) in the Lower Columbia and Lower Snake rivers would result in the highest TDG levels among 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 of MO4 that provide minimum flows out of McNary Dam (McNary Flow Target) and establish reservoir levels at Minimum Operating Pool (MOP) (Drawdown to MOP) may decrease the overall temperature profile below McNary Dam. This results from peak flows 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) subhabitat in the Lower Columbia River.

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). The MO4 would also 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 primarily benefit migratory corridor species like anadromous salmonids, 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) as part of MO4 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. This would, increase the complexity of the river landscape and support mainstem migratory fishes (e.g., white sturgeon), migratory corridor species (e.g., Pacific lamprey), and non-migratory species (e.g., Western pearlshell mussel).

The measure to maintain 220 kcfs (6,230 m^3s^{-1}) flows (an increase in downstream flow) 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 kcfs (4,644 m3s1) (ranging from 111 kcfs to 220 kcfs [3,143 to 6,230 m^3s^{-1}]). 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) would likely yield benefits for aquatic species like 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 would likely benefit Pacific lamprey. These include expanding or improving lamprey passage structures at Bonneville, 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). This would increase the complexity of the rivers landscape and support of migratory corridor species (e.g., Pacific lamprey).

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 river landscape.

LAKES AND RESERVOIRS

NAA

NAA Summary of Lakes and Reservoir Landscape Findings

- Structural and operational measures proposed under the NAA would continue to negatively affect 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.

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. The 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 dams and associated reservoirs have greatly influenced the river 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 dams can significantly change the water quantity in the reservoirs located in the Basin (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 in place prior to dam construction (USFWS 1999, p. M4-1). There are potential negative cascading effects due to frequent changes in water levels in these lakes and reservoirs from system operations. Under the NAA, these effects include the loss of 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 would 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. Similarly, islands are 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, invasive species. Increased predation and spread of non-native species could result in negative impacts on 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 fish and wildlife resources.

NAA Impacts on Key Sites

Continuing operations of the CRSO Federal projects under the NAA will sustain current trends and impacts on the hydrology and ecology of the study area. The operations that drive those trends and the ecological consequences for key sites identified in the Basin are discussed here.

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 salmon by operating the forebay within the Minimum Irrigation Pool (MIP) range (from 262.5 ft to 264.0 ft [80.0 m to 80.5 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, increased barren lands and shoreline as well as islands would be exposed in comparison to winter months.

Safety precautions prohibit sudden changes in the flow from the John Day Reservoir under current operating conditions (NAA). 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 ft [61 cm]) causes lake and reservoir habitats to either 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 these 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, 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 important habitats. Conversely, maintaining a fairly stable pool elevation during important foraging, breeding, and spawning periods would minimize the impacts to both aquatic and terrestrial species.

Mid-Columbia River: Lake Roosevelt

The current operational draft rate limit for Lake Roosevelt is 1.5 ft (0.5 m) per 24 hrs. This minimizes potential bank sloughing and erosion caused by rapid reservoir drawdown. Additionally, the co-lead agencies currently manage Grand Coulee Dam, Libby Dam, Hungry Horse Dam, and Dworshak Dam to provide flow augmentation to benefit 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 would continue under the NAA.

To provide summer flow augmentation, 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 projects. This benefit would also be realized under the NAA. 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 the negative impacts on important 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 reproduction), followed by a descending hydrograph from mid-summer to mid-fall. Flow augmentation drafts would allow many of the key sites along the Columbia River to experience 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 ESA-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 m) for recreational activities through Labor Day. Starting October 1, the project begins drafting to target an elevation within a 0.5 ft (15 cm) of 2,051 ft (625 m) by mid-November, prior to kokanee spawning.

Operations at Libby Dam include the release of flows to benefit ESA-listed Kootenai River white sturgeon. Sturgeon flow augmentation is typically initiated during mid- to late May and extends into mid-June. Augmentation may 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 would continue under the NAA.

Libby Dam is drafted in the summer to benefit resident fishes in the Kootenai River and salmonids 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 both species, and are prioritized over summer refill for recreation. Libby Dam is operated 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. Grand Coulee Dam is operated 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 would 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 salmon and steelhead. In the spring, Dworshak Dam releases between approximately 4 kcfs and 6 kcfs (113 m^3s^{-1} to 170 m^3s^{-1}) 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 Clearwater and the Lower Snake rivers. These lower temperatures and higher water velocities benefit many lakes and reservoir habitats and evaluation species (e.g., Pacific lamprey and native freshwater mussels) by creating conditions close to those historically used by these species.

NAA Impacts on Evaluation Species and Other Guilds and Communities

Clark's Grebe and Western Grebe

Wildlife species affected by rapid fluctuations in reservoir water surface elevation include Western and Clark's grebes. The 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 would continue to threaten grebe growth and survival on all but adequately protected waters.

Dunlin

Dunlin can benefit from 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 would likely result in maintaining the current abundance of migratory habitat that is seasonally available to dunlin.

Floaters

Rapid drawdowns of storage reservoirs can be problematic for a suite of wildlife species, but especially freshwater mussels like floaters. Dry periods and reservoir drawdowns usually expose these resources and, while a few individuals may make it 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 resources are also more susceptible to predation by foraging birds and mammals. Under the NAA, operations would continue to result in negative impacts on freshwater mussels and floaters, in particular.

Colonial Nesting Waterbirds

The co-lead agencies' conduct current operations and water management 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 would effectively limit colonial nesting waterbird colonies in the Lower Columbia River and could negatively impact population abundance in the future.

MO1

MO1 Summary of Lakes and Reservoir Landscape Findings

- Structural and operational measures proposed under MO1 would continue to negatively affect the current hydrograph; the most significant change in comparison to the NAA would 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.

MO1 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

MO1 would further alter the current hydrograph in some areas of the Basin, leading to the accelerated loss of habitat complexity, species diversity, and ecosystem function. MO1 includes two operational measures (Increased Forebay Range Flexibility, Predator Disruption Operations) that would change water quantity and water surface elevation of the John Day Reservoir. For instance, the Increased Forebay Range Flexibility measure would increase the reservoir elevation range and operational flexibility at John Day Dam between April and August. Under this measure, the co-lead agencies would increase water surface elevation 2 ft (61 cm) above MIP between June 1 and August 31. Additionally, the implementation of the Predator Disruption Operations measure would 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 ft (61 cm) increase in reservoir elevation.

The implementation of several other structural measures under MO1 would improve passage rates of Pacific lamprey at John Day Dam. Improving the passage rates of Pacific lamprey ensures the sustainability of this species in the Basin, thereby helping to maintain the native species diversity in this system.

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 would increase the frequency of fluctuations in water levels and an increase in water surface elevation by 0.5 ft (15 cm) in the summer months. In addition, implementation of the Predator Disruption Operations measure at John Day Dam would raise the pool elevation in the John Day Reservoir in April and May by approximately 1 ft (30 cm). This operational would also lead to an increase in water surface elevation, thereby reducing the abundance of barren lands, shorelines, and low-lying areas for evaluation species to use in and around the John Day Reservoir during the spring and summer months.

Under MO1, Umatilla NWR will experience a major 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).

<u>Mid-Columbia River: Lake Roosevelt</u>

Collectively under MO1, the implementation of various operational measures, including the Update System FRM Calculation and Planned Draft Rate at Grand Coulee, would influence water quantity and water surface elevation, particularly in Lake Roosevelt. These measures would reduce water levels in Lake Roosevelt longer into the spring months compared to current

conditions. The Winter FRM Space operational measure in MO1 would also result in a water quantity reduction in Lake Roosevelt during the winter months compared to the NAA.

Under MO1, the implementation of some measures would increase the exposure time of the barren zone around the perimeter of Lake Roosevelt as well as around islands in the winter and spring months. This could result in habitat shifts from wetland or riparian habitats to those that are more tolerant of dryer conditions.

Upper Basin: Lake Pend Oreille and Lake Koocanusa

Under MO1, no structural changes would be implemented at Albeni Falls Dam. Similarly, no changes would be made to Albeni Falls operations in most water years. The co-lead agencies' H&H modeling output shows water surface elevation in most water years consistent with the NAA, except for a few river reaches that would not impact Lake Pend Oreille. The differences in monthly water surface elevation (less than 6 inches [15 cm]) during most water years and months are within the expected range of natural variability.

Only one operational measure in MO1 (Winter System FRM Space) applies and is likely to impact Albeni Falls Dam. This measure would 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 would remain the same in Lake Pend Oreille, with the exception of lower water levels in the winter months as a result of this measure.

Under MO1, three operational measures would be implemented at Libby Dam including: Modified Draft at Libby, December Libby Target Elevation, and Sliding Scale at Libby. Implementing the Modified Draft at Libby measure would base Lake Koocanusa's refill initiation on the local forecast versus forecasts at The Dalles Dam, as specified in the NAA. This would modify operations at Libby Dam to provide additional flexibility for the co-lead agencies to respond to local conditions in the Upper Basin. This measure also would 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 would 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 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 would increase operational flexibility at Libby Dam by using local water supply forecasts to manage operations to support local fish and wildlife resources, rather than using The Dalles Dam, as specified in the NAA. This measure establishes a new September target elevation 5 ft (1.5 m) higher, resulting in water level increases from 1 ft to 2 ft (30 cm to 61 cm), on average, in Lake Koocanusa between June and September. Under MO1, during the spring, water levels in Lake Koocanusa would drop and, during the

summer, fall, and winter months, water levels would increase from water levels in current conditions.

Lower Snake River: Dworshak Reservoir

Under MO1, two operational measures (Winter System FRM Space and Modified Dworshak Summer Draft) would impact water quantity at and around Dworshak Reservoir. The Winter System FRM Space measure would increase the space, and therefore lower the water surface elevation, in Dworshak Reservoir from December through March. The Modified Dworshak Summer Draft measure would result in decreased water surface elevation in the early summer months. However, in August and early September, the draft rate would also decrease, resulting in water surface elevation increasing by as much as 10 ft (3 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 would reduce the quantity of water in Dworshak Reservoir during the early summer months, but augment it later in the summer.

MO1 Impacts on Evaluation Species and Other Guilds and Communities

Floaters

Operational measures associated with MO1 would likely subject floaters and Western pearlshell to more frequent water surface elevation fluctuations, 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 would improve passage rates of 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 months, which could lead a transition from wetland and riparian subhabitats to those more tolerant of dryer conditions. Thus, species like floaters could be negatively impacted (Nedeau et al. 2009, p. 21).

Colonial Nesting Waterbirds

The implementation of structural and operational measures associated with MO1 would result in higher and more variable reservoir elevations in the Lower Columbia River. The Predator Disruption Operations measure in MO1 would raise and maintain John Day Reservoir water surface elevations between 263.5 ft (80 m) and 265 ft (81 m) during the months of April and May to disrupt Caspian terns from successfully nesting at the Blalock Islands complex. The increased water surface elevation caused by the Predator Disruption Operations measure would 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 measure in MO1 would increase the operating elevation range from June 1 to August 31 to MIP by 2 ft (61 cm), from 262.5 ft to 264.5 ft (80 m to 81 m). Caspian terns have historically had 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 that inundated nesting areas during the incubation period (BRNW 2013, p. 23; BRNW 2014, p. 27). Inundation would be greater as a result of the Increased Forebay Range Flexibility measure during the typical incubation season compared to what occurred in recent years.

Water surface elevations at and below the 263.5 ft (80 m) reservoir level would likely provide nesting habitat for approximately 6,000 waterbirds. However, a rise in water surface elevation will inundate nests. There is a high likelihood colonial waterbirds would attempt to nest at the Blalock Island complex if the reservoir elevations drop below 263.5 ft (80 m), as they have a history of habitat use there. The greatest negative effects would occur if birds initiate nesting and subsequently reservoir elevations are increased.

The potential impacts of raising or maintaining John Day Reservoir water surface elevations between 263.5 ft and 265.0 ft (80 m and 81 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 (i.e., 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 sites in, or outside of, the Basin at active or historic sites and Corps-created or -enhanced sites. Although habitat was created and enhanced outside the Basin to mitigate impacts from management plans, the numbers of nesting Caspian terns have not increased at these sites over the past couple of years, even though additional nesting habitat is available (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 drivers like food availability, disturbance, and predation.

The impacts of the MO1 measures at John Day Reservoir on Caspian terns should be viewed from a Pacific Flyway population perspective, considering the cumulative effects of management plans and actions across the flyway that affect the population. These impacts, along with all previous and likely future impacts, will likely further reduce the Caspian tern regional breeding population

The increased water surface elevation caused by the Predator Disruption Operations measure would 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. This could lead to a reduction in quantity and quality of foraging areas available to other migratory birds, such as dunlin (Warnock and Gill 1996). Conversely, under MO1, operational measures in the Mid-Columbia River would reduce reservoir levels and increase the exposure time of barren lands and shoreline surrounding Lake Roosevelt, as well as surrounding island habitat in the winter and spring.

MO2

MO2 Summary of Lakes and Reservoir Landscape Findings

- Structural and operational measures proposed under MO2 would result in deeper drafts for hydropower, which would lead to overall temporary decreases in water surface elevation and the potential for the most frequent fluctuations in water surface elevation in both mainstem and storage reservoirs.

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 would increase the amount of water moving through turbines, but would 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. Ramping rates for safety would 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 would increase the water quantity in, and elevation of, the John Day Reservoir. This measure would 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 would increase survival of juvenile Pacific lamprey and improve upstream passage conditions for adult Pacific lamprey, especially at John Day Dam.

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 would 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 would increase the likelihood of frequent fluctuations in water levels, thereby negatively impacting subhabitats and evaluation species in the John Day Reservoir.

Similar to MO1, under MO2, Umatilla NWR will experience a major loss in diversity of island habitat, 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, like MO1, no structural measures would 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 would 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 would 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 would result in changes in draft rates to provide operational flexibility for hydropower production. The Ramping Rates for Safety measure, in particular, would enable dam operators to change flow operations within a 24-hour period to meet changes in energy demands; functionally, this measure would enable the co-lead agencies to change water surface elevation at a faster rate.

The implementation of several operational measures associated with MO2 would influence water quantity and water surface elevation in Lake Roosevelt. The Planned Draft Rate and Winter System FRM Space measures would create lower water levels in Lake Roosevelt area that are expected to persist longer into the spring months in comparison to current conditions. Under MO2, the implementation of these measures would 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 would be implemented at Albeni Falls Dam. However, three operational measures (Winter System FRM Space, Slightly Deeper Draft for Hydropower, and Ramping Rates for Safety) would be implemented at Albeni Falls Dam and would impact Lake Pend Oreille. These measures would 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 would increase substantially in comparison to current conditions.

Under MO2, water quantity and disturbance as a result of recreational activities would largely remain the same in Lake Pend Oreille, with the exception of water surface elevation, which would decrease during the winter months. Changing ramping rates and draft conditions at Albeni Falls Dam would 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 would 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 would result in changes in draft rates from current conditions. The Ramping Rates for Safety measure would allow 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 would 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, would lead to a significant increase in the frequency of fluctuations in water levels in Lake Koocanusa.

The implementation of the Sliding Scale at Libby operational measure would 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, as specified in the NAA. This measure would also establish a new September target elevation 5 ft (1.5 m) higher, resulting in an increase in water surface levels from 1 ft to 2 ft (30 cm to 61 cm), on average, in Lake Koocanusa between June and September. Under MO2, the implementation of the Modified Draft at Libby and December Libby Target Elevation operational measures would result in similar effects to those of MO1.

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

<u>Lower Snake River: Dworshak Reservoir</u>

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 would be drafted deeper that under current conditions. Under MO2, pool elevations would decrease by approximately 2.5 ft to 3 ft (76 cm to 91 cm) during the winter, spring, and summer months.

MO2 Impacts on Evaluation Species and Other Guilds and Communities

Clark's and Western Grebes

MO2 would increase the abundance of barren lands around Lake Roosevelt, which would lead to transformations in associated plant and animal communities. Changes in water surface elevation on Lake Pend Oreille would alter the availability of vegetation and suitable nesting habitat for Clark's and Western 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 would expose nests to increased risk of predation and additional disturbance (i.e., by boat traffic and recreation) (LaPorte et al. 2013). Measures in MO2 that increase the frequency of water surface level fluctuations in Lake Koocanusa would 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 also has the potential to reduce the quantity, quality, and distribution of barren land habitat in the John Day Reservoir, likely impacting the amount of foraging areas available to migrating birds such as dunlin (Warnock and Gill 1996).

Floaters

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

Colonial Nesting Waterbirds

In the John Day Reservoir, measures under MO2 would likely decrease the availability of prey 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 access to prey resources is greater. MO2 includes measures that increase the range of reservoir elevations in the John Day Reservoir. The impacts of these measures would be similar to the impacts of the Predator Disruption Operations and Increased Forebay Range Flexibility measures on Caspian terns discussed as part of MO1.

MO3

MO3 Summary of Lakes and Reservoir Landscape Findings

- Structural and operational measures proposed under MO3 would, over time, restore portions of the Lower Snake River to near-natural aquatic conditions, thereby providing benefits to various habitats and aquatic evaluation species that inhabit these waters; however, these benefits would not be observed in storage reservoirs throughout the study area.
- As a result of some structural and operational measures, apart from the four dam breaching measures, other natural lake and reservoir habitats in the Basin and their inhabitants may be more negatively impacted than in current conditions.

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, although beneficial to almost all ecological and physical processes and habitats identified in this report (and analyzed as part of other landscapes in the "Impacts on Fish and Wildlife Resources" section and this appendix) 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 hydropower production and, collectively, would change draft rates and increase water surface elevation of the storage reservoirs in the Lower and Mid-Columbia River. Proposed operational measures that change draft rates from those in current conditions would also change the quantity of barren land and island habitat, leading to potentially positive (e.g., for dunlin) and negative (e.g., for freshwater mussels) impacts on fish and wildlife resources in the study area.

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

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 would reduce the Minimum Irrigation Pool +1.5 ft (46 cm) restriction. This would likely raise the pool elevation in the John Day Reservoir during the entire year. This measure would increase the amount of water in the John Day Reservoir and, thus, reduce the abundance of barren land and island habitat at these key sites. The implementation of this measure, in comparison to other alternatives, would allow for the greatest change in water levels (hourly and daily) 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 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 operational measures under MO3 would influence water quantity and water surface elevation in Lake Roosevelt. The Planned Draft Rate operational measure would create lower water levels in Lake Roosevelt that persist longer into the spring months in comparison to current conditions.

Changes proposed by 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 would be implemented at Albeni Falls Dam. Output from the co-lead agencies' H&H modeling show water surface elevation in most water years would remain consistent with the NAA, except for a few river reaches that would not impact Lake Pend Oreille.

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

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

Lower Snake River: Dworshak Reservoir

Under MO3, pool elevations at Dworshak Reservoir would decrease by approximately 2.5 ft to 3 ft (76 cm to 91 cm) during the winter, spring, and summer seasons in comparison to current conditions.

MO3 Impacts on Evaluation Species and Other Guilds and Communities

Floaters

Higher storage reservoir water surface elevation during spring and summer months would likely benefit freshwater mussels such as floaters and the Western pearlshell mussel (Nedeau et al. 2009, p. 21). Maintaining a higher water surface elevation would likely result in less migratory

foraging habitat for dunlin, however. Regardless, western pearlshell, floaters, and other native freshwater mussels will likely be subject to rapid fluctuations in water surface levels, which can 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 on Caspian terns discussed as part of MO1.

MO4

MO4 Summary of Lakes and Reservoir Landscape Findings

- Structural and operational measures proposed under MO4 would lead to lower pool water surface elevation in storage reservoirs in the Lower Columbia River during the spring and summer months.

MO4 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

Under MO4, reservoir water surface elevation throughout the Lower Columbia River would 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 enhance survival of migratory fishes. The implementation of the Drawdown to MOP operational measure, for instance, would likely have short-term negative impacts on natural lake and reservoir habitats, but long-term positive impacts for these habitats as a result of decreased pool water surface elevation in the John Day Reservoir between April and July (in all years) and between March and August in dry years.

MO4 Impacts on Key Sites

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

Under MO4, the water surface elevation in the John Day Reservoir would 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 would be exposed during spring and summer under MO4. As a result, open water could transition to mudflats or barren lands (Warnock 1996).

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

Mid-Columbia River: Lake Roosevelt

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

Upper Basin: Lake Pend Oreille and Lake Koocanusa

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

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

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

Similar to other MOs, MO4 includes the implementation of the Sliding Scale at Libby operational measure, which would increase operational flexibility at Libby Dam through the use of local water supply forecasts rather than The Dalles Dam forecasts as in current practices.

Lower Snake River: Dworshak Reservoir

Only one operational measure (Winter System FRM Space) would influence water quantity in the Dworshak Reservoir under MO4. This measure would lower the water surface elevation in the Dworshak Reservoir from December through March to provide space for winter precipitation run-off events.

MO4 Impacts on Evaluation Species and Other Species

MO4 proposes to operate the John Day Dam at MOP rather than MIP. Operating the John Day Dam at MOP would provide the most natural conditions for key sites, which would benefit evaluation species at these sites (USFWS 2019f).

Potential impacts on Clark's and Western grebes would be the same as those under MO1. Structural and operational measures that increase the abundance of barren land in and around Lake Roosevelt would affect plant and wildlife communities both positively and negatively. MO4 includes modifications that would reduce water surface elevation and expose certain 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 invertebrates (Nedeau et al. 2009, p. 21).

RIPARIAN

NAA

NAA Summary of Riparian Landscape Findings

- With the continued lack of functional flows throughout most of the study area, native riparian-obligate species will continue to decline and be replaced by later-successional communities and, eventually, uplands landscapes, thereby decreasing habitat complexity and species diversity throughout the region.
- The suppression of cottonwood and willow regeneration has led to a significant loss in structural complexity of riparian forests. As old relict stands of cottonwoods reach the end of their lifespan without new generations to take their place, river corridors may lose this keystone riparian species that supports a disproportionate quantity and diversity of wildlife.

NAA Impacts on Indicators of Ecological and Physical Processes and Subhabitats

<u>Pre-Dam Hydrograph and Natural Flood Regime</u>

A pre-dam hydrograph in the Basin 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, have similar patterns and nearly the exact same timing (Mahoney and Rood 1998, p. 636).

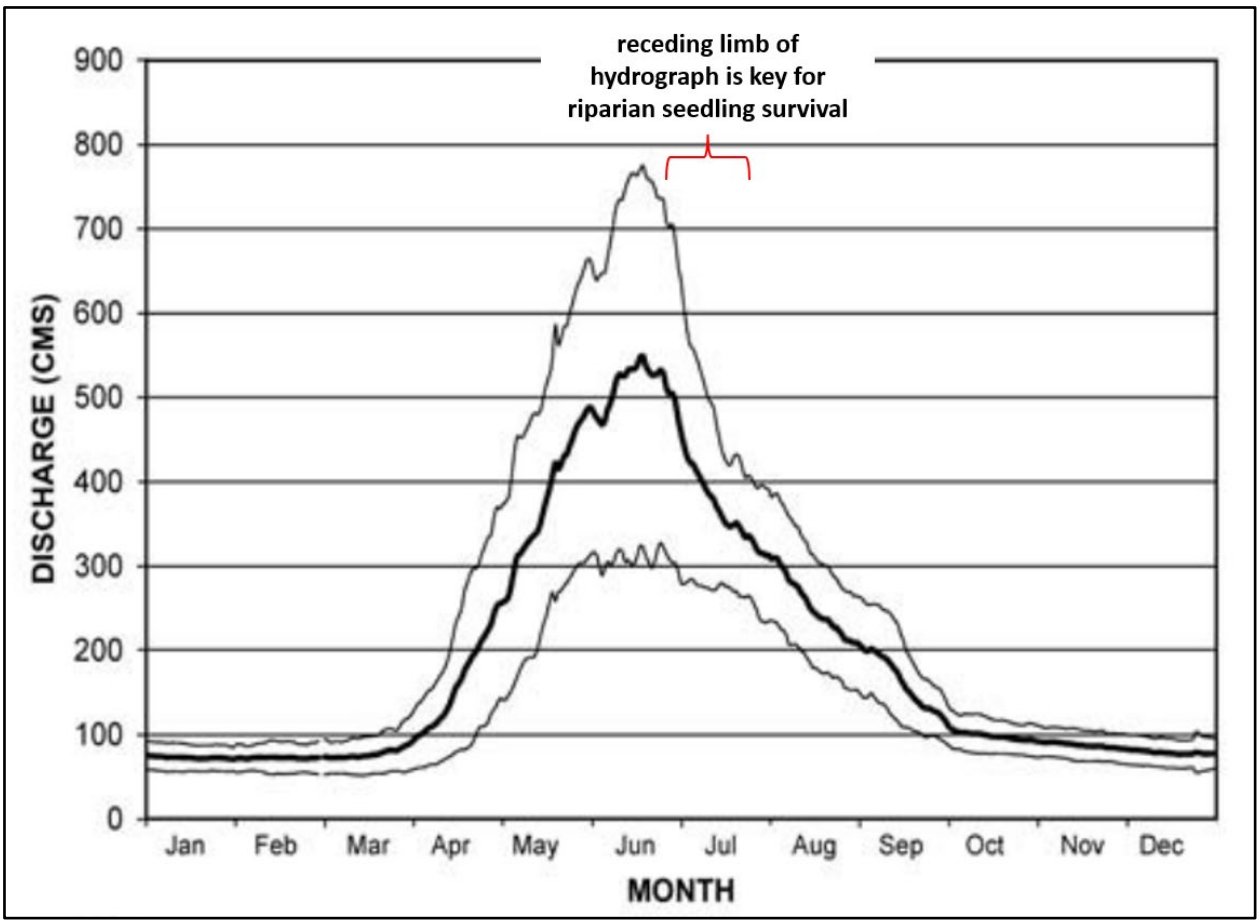

Figure G3. A typical hydrograph of the Upper Snake River (±1 standard deviation) during the pre-dam period of record, from 1911 to 1956
Source: Adapted from Hauer and Lorang 2004, p. 31

Native Riparian Vegetation

The pre-dam hydrograph governs nearly every aspect of the riparian ecosystem, including streambed morphology, sediment and nutrient cycling and deposition, and it helps fulfill essential life-history requirements for riparian vegetation and wildlife (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 keystone plant species with the pre-dam hydrograph, disruption from river regulation can greatly impede the 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 germination of these species (Mahoney and Rood 1998, pp. 634-635). Peak flow events may also occur at different times on a regulated river, perhaps several weeks earlier or later than normal, which also inhibits cottonwood and willow regeneration and benefits invasive 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 would 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 diversity that accompanies 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 of riparian habitat 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 in the study area (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 (Braatne et al. 2007a, p. 247; Dykaar and Wigington 200, p. 92) (Figure G4). This reduction in the riparian

community would 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 extremely 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 through the loss of river function (Fierke and Kauffman 2005, p. 160). Decreases in habitat complexity and function reduce 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 even small tracts of riparian habitat, as these remnant riparian corridors function as important migratory and dispersal routes for many species of wildlife (Hauer et al. 2016, p. 9). There are cascading impacts of an altered hydrograph and the lack of normal flood regimes, starting with the loss of native riparian vegetation and the alteration of

structure and species composition of shorelines, which can 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).

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 site limits the regeneration of new cottonwood-willow habitat. Thus, while more riparian habitat survives here than at other 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 relatively 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 removing 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 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 sites in the Pacific Northwest where sightings of vagrant yellow-billed cuckoos have been observed in recent years, though there are no known populations or breeding occurring throughout this part of the species' former range (eBird Basic Dataset, Version: EBD_relMar-2019). Although this 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 most other sites in the Basin where cottonwoods remain, the large relict patches of cottonwood at this 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 (Dobson 2009, p. 16; Kelly and Dobson 2001, p. 1). Overall, riparian habitat at this site has declined from historical conditions, but it could increase slightly even under the NAA in overall health in the future due to restoration efforts (Christy and Putera 1993, p. 27; Kelly and Dobson 2001, p. 1).

Umatilla NWR is located approximately 8 RM to 15 RM (13 Rkm to 24 Rkm) downstream from the McNary Federal project, and was established for the protection of migratory birds. While this

refuge is managed mostly for waterfowl, it is also critical in supporting other bird species including neotropical migrants, as well as other riparian-dependent plants and wildlife. Because this site is protected as a NWR, its undeveloped shorelines have great potential to maintain 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 that do not occur in much of the rest of this region, including both sediment deposition and erosion (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 site will likely continue without change to current management practices, it functions as an important oasis of habitat connectivity and 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 in Lake Roosevelt 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 mostly 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 would 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 would

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 impacts only one tributary (South Fork Flathead) of the three that flow into the main stem Flathead River (North, Middle, and South Fork of the Flathead River), impacts of Hungry Horse Dam on the mainstem Flathead River are somewhat diluted now and would 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 would 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 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 at this site. In addition, there is an artificial inflow pattern here, where the river enters the reservoir, which mimics a natural delta (USFWS 2019b). These factors increase the ecological value of the area. However, as in most other areas of the Basin, riparian habitat is in decline in complexity, quantity, and quality due to the loss of a functional flow regime and the subsequent spread of invasive species, and this trend would 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 would 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. The quantification of this trend has not yet been published, but it has been observed by multiple experts in the field (Burke et al. 2009, p. S235; USFWS 2019b). This trend would continue under NAA conditions.

Despite new recruitment of cottonwood and willow with the newly adopted functional flow regime, abnormally high winter water surface elevation cause 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 CRSO dams were installed, and this trend would continue under the NAA. Unlike in other parts of the Basin, there has also been a very recent increase in cottonwood and willow recruitment on the Kootenai River due to functional flows.

<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 present 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 would continue under NAA conditions.

The narrow riparian strip along the Tucannon River provides some of the only riparian or large woody vegetation 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 would be limited under the NAA.

Big Flat Recreation Area is a Habitat Management Unit (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% 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 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 (USACOE 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 would 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 site is currently managed with irrigation for riparian plants, and experimental removal of invasive Russian olive (Valente et al. 2019, pp. 1-18). For this analysis, the Service assumes all current management practices at this site would continue under all the alternatives.

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 (1 m) (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 would continue under NAA conditions.

<u>Cottonwood and Willow</u>

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 (400 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; USACOE 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 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 would continue under the NAA.

Viceroy Butterfly

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 expert-validated 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, the Service assumes that viceroys could be present anywhere in the study area east of the Cascade Range 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., their flight period). Loss of host plant and moist soils historically produced through annual flooding is likely threatening viceroy butterfly populations, and this trend would 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 the major cause of decline for the largest proportion of landbirds in western North America (DeSante and George 1994, p. 177). This decline would continue under the NAA. To identify whether the yellow warbler and other focal riparian birds were likely breeding at certain locations or sites in the recent past, the Service filtered eBird observations by location (within 3 miles [5 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		

MO1

MO1 Summary of Riparian Landscape Findings

- While riparian habitat at most of the sites analyzed would not undergo significant change under MO1 in comparison to the NAA, there would be 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 project area, negative impacts on these areas would be disproportionately felt, and should be avoided to the extent possible.

MO1 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

MO1 will further the alteration of the hydrograph and flood regimes in some areas of the Basin, which will lead to the accelerated degradation and loss of native riparian vegetation. The 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.

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) under MO1 are expected to decrease less than 3 inches (8 cm) during the spring and summer months, which is considered within the current range of variability. Thus, there should be no significant impact to riparian habitat at this site under MO1.

The Predator Disruption Operations and Increased Forebay Range Flexibility operational measures under MO1 causing water surface elevation changes at the Sandy River Delta to increase approximately 3 inches (8 cm) during the winter and decrease approximately 5 inches (13 cm) or less during the spring and summer. Under MO1, winter water surface elevation should have little impact 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 during the spring and summer. The drop in water surface elevation would also expose a small amount of riparian shoreline immediately adjacent to the water. This newly exposed shoreline could foster new riparian growth if exposure occurred during the right time of year (spring) and was followed by a gradual recession rate (1 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 invasive plants. Most likely, given the altered hydrograph at this site, and, without proper implementation of the change, there would 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 proposed under MO1 causing the prolonged inundation (of approximately 1.5 vertical ft [46 cm) of riparian shoreline at Umatilla NWR during April through August, which would likely lead to loss of riparian vegetation in the inundation zone. There would be a net loss of riparian habitat in MO1 in comparison to NAA, thereby reducing habitat complexity and ecosystem function at the refuge, and further limiting habitat connectivity and migration corridors available to wildlife 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 under MO1, water surface elevation immediately below the Chief Joseph project is expected to decrease by 1 percent or less. This amount of change is expected to be within the current range of variability. The Okanogan River confluence is located approximately 6 RM (10 Rkm) downstream of Chief Joseph Dam, and, thus, impacts on riparian habitat under MO1 are not expected to differ significantly from those of the NAA.

Water surface elevation in the river reaches upstream of the Grand Coulee Dam would be between 3 ft and 6 ft (1 m and 2 m) lower throughout the winter and into early spring (December through March) due to the following MO1 operational measures: Lake Roosevelt Additional Water Supply, Planned Draft Rate at Grand Coulee, and Winter System FRM Space. However, water surface elevation would likely return to the level maintained currently, 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 would likely be even more diluted at the Little Sheep Confluence due to its greater distance upstream from the Grand Coulee Dam. Thus, under MO1, impacts on riparian habitat at this 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 measures under MO1 would 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, the increase is minimal and not expected to change the quantity and quality of riparian habitat on the South Fork Flathead. Reaches downstream of the confluence with the Flathead River would experience even further diluted impacts. Thus, the impacts of MO1 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 impact on 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 would decrease water surface elevation at the Yaak River Confluence in April and May, and during peak flows in June, but would increase water surface elevation in February and March. Water surface elevation may drop by 1 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. The decrease 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 reduction 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 wildlife (i.e., riparian birds). Changes under MO1 will have negative impacts on riparian habitat at the Yaak River Confluence in comparison to the NAA.

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

The Modified Dworshak Summer Draft operational measure under MO1 would create a slight increase in habitat inundation downstream of Dworshak Dam on the Clearwater River during June and July. This increase in water surface elevation is considered within the current range of variability. The impacts downstream of the Clearwater confluence with the Snake River are expected to be even more diluted, and, thus, impacts on riparian habitat under MO1 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.

MO1 Impacts on Evaluation Species and Other Guilds and Communities

While most of the sites analyzed will not undergo significant changes under MO1 relative to the NAA, the additional loss of riparian habitat at three sites (Sandy River Delta, Umatilla NWR, and Yaak River Confluence) will lead to further loss of species diversity and continued declines in abundance of riparian plants and wildlife at a higher rate than under current conditions.

The Sandy River Delta would likely experience a small net loss of riparian habitat due to the lower (5-inch [15-cm] decrease) summer stage. This loss could potentially be mitigated and possibly result in an increase in riparian habitat if executed in a way that promotes the colonization of the newly exposed riparian shoreline with native riparian species instead of invasive species (Rood, S., pers. comm. 2019). This would require the timing of the initial drawdown to align 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 due to the increase in moist soil that would be available for puddling with the additional exposed riparian shoreline. However, if these requirements are not met, the new shoreline could be colonized by invasive species. There could also be loss of some existing riparian habitat due to the decreased summer stage. All riparian species at this site could be affected if this change is implemented in a way that results in net loss of riparian habitat, with cottonwood and willow most directly impacted if lower summer stage causes drought-stress or mortality with the loss of connection of the trees' root systems to the water table. Any impacts, positive or negative, would likely be relatively minor given that only a small amount of shoreline would likely be affected under MO1. The negative impacts on riparian species at Sandy River Delta under MO1 would be slightly greater than under the NAA, and comparable to those under MO2, MO3, and MO4.

Umatilla NWR would 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 would also be impacted from the loss of exposed riparian shoreline available for puddling. Riparian habitat is already in decline at this site, and MO1 would induce a greater rate of decline than that expected under current conditions. Yellow warbler, Bullock's oriole, willow flycatcher, and viceroy butterfly have all been recently observed during the peak of breeding season at Umatilla NWR, and all of these species and others would be negatively impacted by the additional loss of riparian habitat. Umatilla NWR and surrounding riparian habitat would 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 would 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 would 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.

MO2

MO2 Summary of Riparian Landscape Findings

- Structural and operational measures proposed under MO2 would cause the most widespread and detrimental effects on riparian habitat and species in comparison to any of the other proposed alternatives, including the NAA.

MO2 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

The implementation of structural and operational measures under MO2 will further alter the hydrograph and flood regimes in many areas of the Basin, which will lead to the accelerated degradation and loss of native riparian vegetation. 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; 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.

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) under MO2 are expected to be minimal, and considered within the current range of current variability. There should be no significant change to riparian habitat at this site under MO2 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, the impacts of MO2 to riparian habitat in this segment of the Basin appear to result from an interaction between the entire suite of structural and operational measures of this MO, and specific measures individually cannot account for the resulting change presented by the co-lead agencies' H&H modeling output. The overall impact to water surface elevation downstream of Bonneville Dam is an increase of less than 12 inches (30 cm) in November through January, and a decrease of less than 6 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 reach of river not prone to deep freezing during the winter. Reduction in water levels of about 6 inches (15 cm) during the spring and summer would have impacts on riparian habitat at this site comparable 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 invasive 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, is not expected to have measurable differences from current water surface elevation. Thus, impacts on riparian habitat under MO2 should not differ significantly from those of 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 would increase slightly in December and decrease from February through September. This change is expected to be 6 inches (15 cm) or less and within the current range of variability. Thus, impacts on riparian habitat should not differ significantly under MO2 in comparison to the NAA.

Water surface elevation in the river reaches upstream of the Grand Coulee Dam would shift between 3 ft and 6 feet (1 m and 2 m) lower throughout the winter months due to the Planned Draft Rate at Grand Coulee and Slightly Deeper Draft for Hydropower operational measures under MO2. However, water surface elevation would 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 cause negative impacts on riparian vegetation. Thus, impacts on riparian habitat under MO2 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

<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>

The Ramping Rates for Safety and Slightly Deeper Draft for Hydropower operational measures under MO2 appear to be associated with an increase in water surface elevation by 18 inches (46 cm) on the Flathead River in January and a decrease by 6 inches (15 cm) or less between March and July. These changes would have negative impacts on riparian habitat at the Stillwater River Confluence related to vegetation survival during the spring and summer and throughout the winter months. 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. Substantial increases in water levels during January would severely impact riparian vegetation, causing mortality of newly established seedlings. Proposed modifications associated with MO2 are expected to lead to declines in riparian vegetation quantity and quality at this site, preventing cottonwood and willow recruitment in the riparian zone. Thus, riparian habitat is expected to decline significantly here under MO2 in comparison to the NAA.

The Ramping Rates for Safety and Slightly Deeper Draft for Hydropower operational measures under MO2 appear to be associated with an increase in water surface elevation by 6 inches (15 cm) at the Clark Fork Delta during the winter and a decrease by 6 inches (15 cm) between March and May. Both of these changes could lead to mortality of cottonwood and willows. The increase in winter water levels would 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, impacts of implementing MO2 would cause a greater 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 under MO2 appear to

be associated with 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 would 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 would have detrimental impacts on riparian habitat on the Kootenai River. Higher winter water levels would cause an increase in riparian seedling mortality, and lower water levels throughout the rest of the year (spring freshet and spring and summer) would hinder cottonwood and willow recruitment and threaten the survival of existing plants.

The MO2 impacts 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 is significant because this area supports the highest quantity and quality of riparian habitat remaining in the study area.

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

The Ramping Rates for Safety and Winter System FRM Space operational measures under MO2 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 site would decrease in quantity and quality due to changes under MO2 in comparison to the NAA.

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

All sites under MO2 (and MO3) would be affected 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 is hard to predict the impacts, as smaller-scale fluctuations would be less damaging than relatively larger-scale fluctuations. Frequent stage fluctuations would be especially harmful to riparian vegetation during the short seed dispersal window, if the constantly fluctuating water levels continuously re-suspended seeds and prevented 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 non-native 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 mortality of cottonwood and willow and lead to long-term loss of riparian vegetation. Thus, for impacts on key

sites analyzed under MO2 (and MO3, apart from those sites affected by dam breaching measures), it should be assumed that this operational measure would have negative impacts on riparian habitat.

MO2 Impacts on Evaluation Species and Other Guilds and Communities

The impacts on riparian species at the Sandy River Delta under MO2 would 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 on riparian species at Sandy River Delta under MO2 would be slightly greater than under the NAA, and comparable to those under MO1, MO3, and MO4.

Changes in water surface elevation at the Stillwater River confluence would cause the hydrograph to deviate further from the pre-dam state, and would lead to decreases in recruitment of riparian vegetation, survival of newly established seedlings during the winter, and resiliency of existing riparian vegetation. Impacts on cottonwood and willow would be direct and immediate, and impacts on riparian birds, viceroy butterfly, and other wildlife resources that rely on this vegetation would 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 throughout the Basin during the breeding season, and these species could experience long-term local declines due to loss of habitat used for breeding, feeding, and migrating. Riparian species near the Stillwater River Confluence in the Basin would experience negative impacts under MO2 to a greater degree than those under the NAA, MO1, MO3, or MO4.

Under MO2, impacts on riparian habitat and species at the Clark Fork Delta would be similar, but less severe, to those at the Stillwater Confluence. The change in flow regime would stray further from the pre-dam hydrograph, causing mortality of newly established cottonwood and willow seedlings due to increased winter stage. Existing riparian vegetation also may undergo drought stress due to lower water levels in the early part of the spring and summer, but the return to normal water levels by the time of the spring freshet would likely lessen the severity of impacts on riparian species here than at the Stillwater confluence area. Yellow warblers and other riparian songbirds, viceroy butterfly, and other wildlife that depend on riparian habitat could also be affected, resulting in a reduction in fitness, survival, and productivity, which could lead to regional population declines.

The Kootenai River downstream of Libby Dam, including at the Yaak River Confluence, would undergo changes under MO2 that would have detrimental impacts on riparian species. Large decreases in river stage throughout the spring and summer would modify conditions associated with peak flows that lead to cottonwood and willow establishment, and cause drought stress and mortality of existing cottonwood and willow. Large increases in winter stage would further reduce recruitment by causing displacement of any newly established seedlings. Thus riparian wildlife species would likely undergo significant habitat loss and degradation in this region under MO2, and there would likely be regional population declines of these species. Riparian species at the

Yaak River Confluence would experience greater negative impacts under MO2 than with any of the other alternatives, including the NAA.

Decreases in water surface elevation at key sites like Catholic Creek Confluence during the spring and throughout most of the spring and summer could cause prolonged drought-stress during the spring and summer for cottonwood and willow. Loss of quantity and quality of cottonwood and willow habitat could have minor short- and long-term impacts on the viceroy butterfly and riparian birds that depend on riparian habitat, which is already very limited and degraded in this part of the Basin. Even small losses to riparian habitat in this part of the Basin, where little riparian habitat remains, can threaten remaining habitat connectivity. Habitat diversity and connectivity is especially important for the dispersal of species like the viceroy butterfly, and for neotropical migrants such as yellow warbler, Bullock's oriole, and willow flycatcher that depend on quality migratory corridors to provide shelter and food resources. Negative impacts on riparian species at the Catholic Creek confluence area would be greater than those associated with the NAA or the other MOs.

The Ramping Rates for Safety operational measure under MO2 would likely have negative impacts on riparian species. The long-term loss of riparian vegetation such as cottonwood and willow as a result of the lifting of ramping rate restrictions would cause indirect negative impacts on productivity and survival of the species that require this vegetation, such as viceroy butterfly and riparian bird species. In addition, increased rate and frequency of stage fluctuations would likely disrupt the life cycles of aquatic emergent insects and other invertebrates, leading to population declines or even extirpation (Kennedy et al. 2016, p. 561). Disrupting the timing or success of insect hatches could also have significant negative implications for 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, and high quality resources are needed for raising young. Therefore, the lifting of ramping rate restrictions is likely to have negative consequences for riparian species for all sites under MO2 and MO3.

MO3

MO3 Summary of Riparian Landscape Findings

- If steps are taken to prevent the spread of 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 would 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, MO3 would bring the most ecological benefits to riparian habitat of all the other proposed Ms.

MO3 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

MO3 would further the alteration of the hydrograph and flood regimes in some areas of the Basin, which would lead to the accelerated degradation and loss of native riparian vegetation. However, in the Lower Snake River, the hydrograph would become more like the pre-dam hydrograph, and riparian shorelines would improve with a return to historical shorelines more suitable for riparian growth, which could lead to the long-term increase in quantity and quality of riparian vegetation. The increase in quantity and quality of native riparian vegetation in the Snake River portion of the Basin would improve the structure and vegetative species composition of riparian shorelines, leading to increased habitat complexity, ecosystem function, and connectivity in the Basin. 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).

MO3 Impacts on Key Sites

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

Water surface elevation under MO3 is expected to change less than 3 inches (8 cm) downstream of RM 105 (Rkm 169), and this change is within the current range of variability. Impacts on riparian habitat at Julia Butler Hansen NWR, under MO3, will not differ significantly from those of the NAA.

The Ramping Rates for Safety and John Day Full Pool operational measures under MO3 appear to be associated with an increase in water surface elevation downstream of Bonneville Dam by less than 6 inches (15 cm) in November and December and a decrease by 6 inches (15 cm) in January and April through September. The Sandy River Delta would likely experience a loss in riparian habitat 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 under MO3 appears to increase water surface elevation from 6 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 on riparian habitat at Umatilla NWR are expected to be similar, but less severe than those of MO1 (18 inches [46 cm] inundation in MO1). Under MO3, one impact may be an increased rate of decline of riparian habitat quantity and quality at Umatilla NWR, compared to the NAA.

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 under MO3 (and MO1), which diverts additional water from the river to support agricultural irrigation needs during the spring and summer, water surface elevation immediately below the dam is only expected to decrease by 1 percent or less, progressively waning downstream of the dam. This minimal amount of change is expected to be within the current range of variability. The Okanogan River confluence is located approximately 6 RM (10 Rkm) downstream of Chief Joseph Dam, and, thus, impacts on riparian habitat under MO3 are not expected to differ significantly from those of the NAA.

MO3 diverts additional water from the mainstem for agriculture, and capturing this extra water would result in an increase in water levels immediately upstream of Grand Coulee Dam by approximately 6 inches (15 cm) during the winter. Withdrawing this water would lead to a decrease in water levels by less than 12 inches (30 cm) in the early spring. Water surface elevation would return to those consistent with the NAA by May. Impacts on 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 implemented under MO3 likely to impact Lake Roosevelt are only expected to have impacts 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 on riparian habitat under MO3 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 would impact this site. The co-lead agencies claim that resulting variation in water surface elevation on the South Fork Flathead are within the current range of variability, and that variation in water surface elevation would be even more diluted 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 on this area under MO3 are not expected to differ significantly from those of the NAA.

The Hungry Horse Additional Water Supply operational measure under MO3 is expected to have negligible impacts on Lake Pend Oreille, resulting in a lower 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 on 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 under MO3 increase water surface elevations on the Kootenai River from 6 inches to 24 inches (15 cm to 61 cm) in November and December and decrease in water surface elevations from 6 inches to 36 inches (15 cm to 91 cm) during the rest of the year. The implementation of MO3 would lead to increased mortality of cottonwood and willow during the winter due to rising water levels plucking ice-encased seedlings from the ground, as well as mortality of plants no longer able to access the water table. Under MO3, the loss of riparian vegetation at the Yaak River Confluence would be greater 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 would 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 on riparian habitat under MO3 are not expected to differ significantly from those under the NAA.

The dam breaching structural and operational measures under MO3 (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 would newly expose shoreline of the former floodplain for new riparian vegetation to colonize. Initially, however, there may be some net loss of riparian vegetation at the mouth of the tributary. As with other sites on the Snake River, there is the potential for the establishment of non-native plants, especially without proper management during and immediately following dam breaching. Adoption of functional flows at Dworshak Dam would 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, 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 have significant impacts on 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 would 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 at this site.

Additional monitoring and management actions would 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 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 site in comparison to the NAA.

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

MO3 Impacts on Evaluation Species and Other Guilds and Communities

Under MO3, the impacts on species at the Sandy River Delta would 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 on riparian species at Sandy River Delta would be slightly greater than those under the NAA, and comparable to those under MO1, MO2, and MO4.

Under MO3, impacts on riparian species at Umatilla NWR are expected to be similar 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 yellow warbler, Bullock's oriole, willow flycatcher, and viceroy, all of which have been observed at this site during the breeding season. 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 decrease habitat complexity, ecosystem function, and connectivity. The Lower Columbia River, east of the Cascades, is characterized by little remaining riparian habitat, most of which is degraded, and, thus, even a minor loss in riparian habitat can lead to disproportionate impacts on wildlife resources. Under MO3, negative impacts on 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 sites downstream of Libby Dam on the Kootenai River (e.g., Yaak River Confluence) during the early summer would lead to reduced establishment of new cottonwood and willow seedlings, and increased winter stage would cause mortality in newly established seedlings. In addition, a decrease 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 would 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 (such as the yellow warbler, Bullock's oriole, and willow flycatcher), which use cottonwood and willow habitat for feeding, nesting, raising young, and to sustain long migrations. Drops from current summer water levels could be beneficial if they occur in a way that mimics the natural flow regime and creates additional riparian shoreline suitable for the establishment of riparian vegetation. 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 includes large increases to water levels in winter stage, the implementation of spring stage recession would be unlikely to benefit riparian species, as increased winter stage would lead to a net decrease in riparian vegetation. Direct impacts on cottonwood and willow would have indirect impacts on riparian species such as riparian songbirds. Under MO3, impacts on riparian species in the area of the Yaak River Confluence would be slightly more negative than those of MO2 and slightly more positive than those under MO1.

Under MO3, at Lower Snake River sites like the Tucannon River Confluence and Big Flat Recreation Area, dam breaching could cause some immediate loss of existing riparian vegetation. However, most of the riparian vegetation in the Tucannon River would likely survive due to its connection with the water table. At the Big Flat Recreation Area, riparian vegetation irrigated by the Corps would also likely survive. Over time, dam breaching would also 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 sites could be colonized with native riparian vegetation, if managed properly, thereby further increasing the quantity and potential quality of riparian habitat compared to the NAA.

The initial loss of existing riparian vegetation at the Tucannon River Confluence and Big Flat Recreational Area sites would reduce available nesting sites, decrease the quantity of host plant substrate, and limit food resources for riparian species in the short-term. There may also be short-term decreases in survival and productivity of riparian species at these sites, which could negatively impact local populations. However, in addition to MO3, 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 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 under MO3 would likely have negative impacts, as previously described, to all riparian species that inhabit various sites throughout the study area apart from those sites affected by the four structural and operational dam breaching measures.

MO4

MO4 Summary of Riparian Landscape Findings

- Structural and operational measures proposed under MO4 would lead to losses 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 measures would benefit the riparian landscape and species inhabitants.
- In comparison to the other MOs, the implementation of 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.

MO4 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

The structural and operational measures proposed under MO4 would accelerate the degradation and loss of native riparian vegetation in most areas of the Basin. The greatest changes to the hydrograph would 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 resulting from MO4 would shift the current hydrograph closer to the pre-dam hydrograph and, thus, could result in some positive impacts on riparian habitat.

MO4 Impacts on Key Sites

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

Under MO4, changes to water surface elevation downstream of RM 105 (Rkm 169) are expected to be within the current range of variability. Thus, impacts on 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 decrease in water surface elevation at the Sandy River Delta from 2 inches to 7 inches (5 cm to 18 cm) during the spring and summer, resulting in similar impacts on riparian habitat to what would occur under MO1, MO2, and MO3. Water surface elevation would also increase from 2 inches to 4 inches (5 cm to 10 cm) during the winter, but this change should not impact riparian habitat

significantly. As with MO1, MO2, and MO3, decreases in water surface elevation during the spring and summer could result in drought stress or mortality of riparian vegetation. However, newly exposed shoreline could be colonized by native riparian species, provided the initial transition to the lower water level was 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 loss resulting from MO1, MO2, and MO3.

The Drawdown to MOP operational measure also appears to be associated with decreasing water surface elevation on river reaches between McNary Dam and Bonneville Dam. This decrease would occur between April and July in most years and between March and August in dry years. Drops in water surface elevation would begin at 6 to 18 inches above McNary Dam, and they would increase in magnitude (2.3 to 4 feet) with distance downstream to Bonneville Dam. Under MO4, the water surface elevation at Umatilla NWR would decrease by approximately 1 to 2 feet, which could lead to significant loss of riparian habitat. As with the Sandy River Delta site above, newly exposed shoreline could be colonized by native riparian species if the initial transition to the lower water level was managed with appropriate timing and a subsequent gradual recession rate, resulting in an increase in riparian habitat. However, without proper management of the stage decrease there would 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 associated with MO4, the change in water elevation downstream of Chief Joseph Dam is expected to be within the current range of variability. Therefore, the impacts on riparian habitat at the Okanogan River confluence, resulting from MO4, are not expected to differ significantly from those of the NAA.

The Winter FRM Space and McNary Flow Target operational measures decrease in 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 (0.6 m to 2.4 m) in the spring and summer. The amount of stage decrease would attenuate with upstream distance from Grand Coulee Dam, resulting in a decrease in water surface elevation from only 3 ft to 4 ft (91 cm to 122 cm) in the winter and from 1 ft to 2 ft (30 cm to 61 cm) in the spring and summer in the upstream reaches near the Canadian border. A decrease in water surface elevation in the winter should be largely inconsequential for riparian habitat quantity and quality, but a decrease in water surface elevation during the spring and summer would result in the loss of riparian vegetation. If the timing of the initial drop in the water level was scheduled appropriately, and 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 decrease in water surface elevation between February and July, and would not support the colonization of riparian species and, rather, would likely cater more toward invasive species establishment. Thus, under MO4, it is expected

that there would be a greater loss of riparian habitat from the Threemile Creek to Six Mile Creek confluences in comparison to the NAA.

Under MO4, the Winter FRM Space and McNary Flow Target operational measures appear to be associated with a decrease in water surface elevation at the Little Sheep Creek confluence from 3 ft to 4 ft (91 cm to 122 cm) in the winter and from 1 ft to 2 ft (30 cm to 61 cm) in the spring and summer. The nature and mechanism of the impacts on riparian habitat would be similar to those described for Threemile Creek to Sixmile Creek confluences, but less severe. The Service expects there would be a greater loss of riparian habitat at this site in comparison to 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

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 be within the current range of variability, and changes downstream of the confluence of the South Fork and mainstem Flathead River are expected to be further diluted. The Stillwater River confluence is located approximately 20 RM (32 Rkm) downstream from the South Fork and mainstem Flathead River confluence, and therefore 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 (78 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 returned to the normal summer surface elevation in other years. Although, in most years, the impacts of MO4 on native riparian habitat would not differ significantly from those of the NAA, there would 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 inch [15 cm] drop in spring water levels)

The Modified Draft at Libby and December Libby Target Elevation operational measures under MO4 appear to be associated with a decrease 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 through the spring peak flows in June and through July. Under MO4, the Lower Stage for Riparian operational measure would 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 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 peak flows 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 decrease drought stress of 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 also increase overwintering survival of newly established seedlings that would be under threat of rising winter water levels in current conditions. Riparian habitat at this site is expected to increase in quantity and quality as a result of proposed modifications under MO4 in comparison to those of the NAA.

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

No changes in operations at Dworshak Dam would occur under MO4. Impacts of the Drawdown to MOP operational measure at Lower Granite Dam would decrease water surface elevation by approximately 12 inches (30 cm) in March and increase water surface elevation by approximately 4 inches (10 cm) in spring and summer. However, impacts on the Lower Granite Dam pool would be reduced upstream of the Catholic Creek confluence, and the summary hydrograph for the Catholic Creek confluence is nearly identical to that of the NAA. Thus, under MO4, impacts on riparian habitat at this 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 decrease in water surface elevation by approximately 12 inches (30 cm) in March, as well as an increase of approximately 4 inches (10 cm) through June, in reaches above Ice Harbor Dam including the Tucannon River Confluence. A decrease in water levels in March may lead to drought stress of 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 on 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 would 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 HMU 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 site would likely remain unaffected. Overall, under MO4, the quantity and quality of riparian vegetation at this site is not expected to differ significantly from that of the NAA.

MO4 Impacts on Evaluation Species and Other Guilds and Communities

Under MO4, the impacts on species at the Sandy River Delta site would 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, negative impacts on riparian species at the Sandy River Delta site would be slightly greater than those under the NAA, and comparable to those of MO1, MO2, and MO3.

Under MO4, water surface elevation at Umatilla NWR would decrease throughout most of the spring and summer, dropping between approximately 1 ft and 2 ft (30 cm and 61 cm) in April through July in most years and March through August in dry years. The drop in water surface elevation during June would further reduce spring peak flows, inhibiting recruitment of new cottonwood and willow, and lower water levels throughout the spring and summer could result in drought stress and mortality of existing cottonwood and willow. The net loss of riparian vegetation at this site would lead to indirect impacts on riparian species such as the yellow warbler, Bullock's oriole, willow flycatcher, and viceroy butterfly. A reduction in the quantity and quality of riparian habitat could lead to reduced productivity and survival of these species at this site and others. Riparian habitat is limited in quantity and quality in this subbasin, and, thus, even minor losses can have disproportionate effects on fish and wildlife resources.

Under MO4, water surface elevation at both Threemile to Sixmile Creek confluences and Little Sheep Creek confluence would decrease in the winter and throughout the spring and summer. Cottonwood and willow vegetation unable to maintain contact with the lower water table during the spring and summer would undergo drought stress and mortality, and there would be a net loss of riparian vegetation quantity and quality, which would impact local riparian animal populations that would suffer from loss of habitat. Due to the altered hydrographs at these sites and the new shoreline to be exposed under MO4, there would likely be an increased risk of the spread and establishment of non-native species. However, appropriate flow management could negate these negative impacts and even result in benefits to riparian habitat. Without appropriate flow management, however, negative impacts on riparian species upstream of Grand Coulee Dam would be greater 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 would 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 would result in greater negative impacts on 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 (70 cm) during the spring and summer would result in drought stress and subsequent mortality of cottonwood and willow. Under MO4, adverse impacts on riparian habitat at the Clark Fork Delta exceed those of the NAA, MO1, and MO3, and they are comparable to those of MO2.

Riparian songbirds such as yellow warbler, Bullock's oriole, and willow flycatcher and other riparian species would suffer indirectly from long-term loss of cottonwood and willow all of these aforementioned sites. During dry years, wildlife resources may also suffer directly due to desiccation of habitat. 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 feed breeding riparian birds, among other species, and help form the base of the riparian food web.

Riparian vegetation at the Yaak River Confluence would likely benefit from the impacts of MO4 for several reasons. First, winter water levels would be more consistent in general, and they would be managed to not exceed levels of the previous peak flow. Second, peak flows would be slightly higher in June, followed by a carefully managed stage recession rate that would promote the recruitment of native riparian vegetation. Third, slightly higher water levels in July would reduce drought stress for riparian vegetation during hot and dry summer periods. These factors would likely cause a modest increase in quantity and quality of riparian vegetation immediately adjacent to the shoreline, even though riparian vegetation situated deeper into the riparian corridor would 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 would likely gain some ecological benefits.

WETLANDS

NAA

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.

NAA Impacts on Indicators of Ecological and Physical Processes and Subhabitats

<u>Habitat Complexity and Ecosystem Function</u>

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 important for evaluation species and other species. 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

low, and the implementation of structural and operational measures under the NAA would likely lead to further losses in plant and wildlife species diversity.

Pre-Dam Hydrograph and Natural Flood Regime

The wetlands landscape and subhabitats may be 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).

NAA Impacts on Key Sites

Key Island Sites

For the purposes of the FWCAR, the Service analyzed impacts of the NAA and all other MOs on key island sites in the four subbasins. These islands, and others 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 represents the baseline ecological conditions under the current configuration of the CRSO and its operations. 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 island 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.

Key River Delta Sites

For the purposes of the FWCAR, the Service analyzed impacts of the NAA and all other MOs on key river delta sites in the four subbasins. These river deltas, and others 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 would continue under the NAA.

For example, continued fluctuations in water surface elevation under the NAA would likely 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 (USFWS 2019c).

At the 15,000-ac (61-km^2) McNary NWR, water entrained from the CRSO has created a network of high-carbohydrate food-providing farm fields and wetland subhabitats throughout the refuge. 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 has transitioned to an active management area to replicate natural hydrologic regimes through moist-soil wetland impoundments (Healy, F., in litt. 2019). Over 75,000 ac (304 km^2) of riverine 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).

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, Western painted turtle, Woodhouse's toad, and Western toad. 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 continue to utilize nesting areas in the uplands landscape from April to June. Reptiles and amphibians, including turtles, toads, and salamanders, will also continue to utilize 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 in the study area will affect population expansion and productivity of these species by continuing to reduce 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, 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). Species populations may vary in abundance as changes in patterns of water surface elevation may impact individuals' ability to grow and reproduce seasonally (during late summer and early fall).

MO1

MO1 Summary of Wetlands Landscape Findings

- Structural and operational measures associated with MO1 will result in low to moderate impacts on wetland habitat and subhabitats, especially throughout the Lower Columbia River subbasin and the Kootenai River.

- The implementation of some measures under MO1 would 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.

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 more frequently and for a greater duration of time than in current conditions. These impacts would be especially evident in backwaters, which may become disconnected from the mainstem (e.g., Kootenai River). Disconnected wetlands expose species inhabitants to a higher level of desiccation, which results in less complex habitat and reduced species abundance (USFWS 2019c).

Changes in water surface elevation resulting from MO1 would also negatively impact wetland vegetation quantity and quality in comparison to NAA conditions. Higher water levels in the summer (June through September) would increase inundation at adjacent wetland habitats upstream of dams, resulting in potential loss of existing emergent vegetation or a transition in plant community structure and status (to one that is more tolerant of patterns of regular inundation). However, under MO1, the implementation of operational changes in outflows downstream of Federal projects would reduce water levels during the spring by several inches, thereby preventing regrowth of existing native vegetation and resulting in the desiccation of wetland habitats.

MO1 Impacts on Key Sites

<u>Key Island Sites</u>

Lower Columbia River: Reed Island and 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 on island sites in the Lower Columbia River would be evident at Reed Island, and Steigerwald Lake NWR and 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 diminished impacts in the Mid-Columbia River at identified island sites. The Hanford Reach, in particular, would be exposed to the impacts 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 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 critical wetland vegetation and cover that supports species' breeding and rearing areas. These impacts may also be evident, but diminished, upstream at the Wells Wildlife Area.

Upper Basin: Everett Island and Kootenai NWR

Under MO1, the impacts of some operational measures would likely be diminished during some water years at key island sites like 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 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 a decrease in water surface elevation of 5 inches (13 cm) in November. Overall, changes in water surface elevation related to MO1 could result in a faster rate of decrease in wetland quality at Everett Island and other sites in comparison to the NAA.

In comparison to the NAA and other MOs, the implementation of the Modified Draft at Libby and December Libby Target Elevation operational measures in MO1would have the greatest impacts on the wetlands landscape in the Upper Basin at the Kootenai NWR. Under MO1, the water surface elevation would be lower in December and higher in February and March at the Kootenai NWR. 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 temperatures warm, proposed operational measures would 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 would also likely experience slightly more inundation, however, the impacts of erosion during this time would be buffered and would not differ from those of the NAA.

<u>Key River Delta Sites</u>

In most years, the implementation of MO1 would be expected to result in no major impacts on key river delta sites in the study area. For example, in the Pack River Delta near Lake Pend Oreille in the Upper Basin, there would be a slight rise 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 would 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 would likely experience similar impacts on those of the NAA. However, in the case that McNary NWR and the affiliated 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).

MO1 Impacts on Evaluation Species and Other Species

A decrease in water levels during the spring and summer in the Lower Columbia River could reduce the quantity and quality of wetland habitats, especially at NWR sites including Reed Island, Steigerwald NWR, and Sauvie Island Wildlife Area, where Service managers maintain wetlands landscape for species such as Western painted turtles.

As a result of changes in water levels proposed under MO1, species that live in and use wetland habitat and subhabitat in the study area and in the Mid-Columbia River may experience negative impacts. For example, mallard would have less open water to forage, and potential desiccation of some wetland habitats could lead to loss of breeding and rearing areas for amphibians (e.g., Woodhouse's toad) that inhabit the Hanford Reach and Wells Wildlife Area. 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 would be minor. Overall, the implementation of structural and operational measures associated with MO1 would lead to immeasurable impacts on the survival, growth, and reproduction of wetland species in the Mid-Columbia River in comparison to the NAA.

In the Upper Basin, mallard would likely benefit initially from high water surface elevation for feeding. 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 would 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 would limit seasonal access to forage resources and reduce available besting 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 diminish below the confluence of the Clearwater River. Mallards would 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, would likely lead to an increase in 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.

MO2

MO2 Summary of Wetlands Landscape Findings

- A general pattern of higher winter flows followed by lower spring and summer flows at various island and river delta key sites in the study area may lead to conversion of wetland habitats and displacement of evaluation species.
- Proposed operations of the CRSO Federal project reservoirs MOP would result in widespread negative impacts on the wetlands landscape and evaluation species.

MO2 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

In general, 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 (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 would likely lead to low to moderate changes in wetland habitat complexity and ecosystem function throughout the Lower Columbia River in comparison to the NAA.

The implementation operational measures associated with MO2 (e.g., Planned Draft Rate at Grand Coulee) would likely result in deeper drafts for power generation, which would lower water surface elevation from 3 ft to 6 ft (1 m to 2 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 be negligible impacts on wetland habitats and subhabitats during the spring and summer. Deeper drafts could affect the pre-dam hydrograph and natural flood regimes 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 would 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 during 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 would draft Dworshak Reservoir for power generation, and pool elevation would decrease from approximately 2.5 ft to 3 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 further downstream on the Snake River and Palouse River deltas.

MO2 Impacts on Key Sites

<u>Key Island Sites</u>

Lower Columbia River: Reed Island and 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 the wetlands landscape on island sites to various negative impacts. On average, water levels immediately downstream of Bonneville Dam at Reed Island, Steigerwald Lake NWR, and Sauvie Island Wildlife Area would 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 would result in noticeable impacts on the wetlands landscape at island sites in the Mid-Columbia River. However, the Winter System FRM Space operational measure could influence 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) would likely lead to a faster rate of decrease in quality of the wetlands landscape quality in the Hanford Reach, whereas the potential impacts of these changes would likely be less impactful at the Wells Wildlife Area.

Upper Basin: Everett Island and Kootenai NWR

Proposed structural and operational measures in association with MO2 would impact wetland habitats in a variety of ways. For instance, the implementation of MO2 would cause notable changes in outflow from Libby Dam in almost every season; however, changes to wetland habitats and species inhabitants would likely be most evident during the winter, as a result of the December Libby Target Elevation operational measure.

Higher water levels in the Kootenai River and at Kootenai NWR during the winter 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 would 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 would also experience moderate impacts, including a reduction in abundance and distribution wildlife resources that live and use the wetlands landscape. Lastly, in comparison to the NAA, changes in ramping rates under MO2 would likely alter patterns of seed dispersal, germination and establishment, and the long-term viability of wetland vegetation at these island sites.

Lower Snake River: Silcott Island

The implementation of other operational measures in association with MO2, with impacts on wetland habitats 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 MO2 would likely result in a decrease of hydrologic connectivity related to wetland habitats, leading to desiccation and a transition in plant community structure and status.

<u>Key River Delta Sites</u>

Lower Columbia River: Sandy River Delta

Under MO2, average water levels immediately downstream of Bonneville Dam would be less than 1 ft (30 m) 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) would experience minor negative impacts due to fluctuating water levels, with these impacts under MO2 becoming progressively muted downstream, near the Columbia River Estuary.

Mid-Columbia River: Lower Crab Creek and McNary NWR

Wetlands at the Lower Crab Creek and other key sites in the Mid-Columbia River would also, similar to what would occur in current conditions, likely remain intact under MO2. McNary NWR, for instance, would not experience negative impacts as a result of changes in water levels or flow conditions.

Upper Basin: Pack River Delta

In the Upper Basin, various habitats most likely to be affected by fluctuating water levels under MO2 would be mudflats and barren zones, emergent and forested wetlands, scrub-shrub wetlands, and submerged aquatic beds. Implementing MO2, in comparison to the NAA, would increase exposure of these habitats to erosion from boat wakes, wind, and waves. Under MO2, these impacts would impact 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 hydropower production would be most likely to have the greatest adverse impacts on the wetlands landscape in the Lower Snake River. Alternatively, wetland habitats that characterize the Snake River Delta will remain intact, as changes in water surface elevation would be less significant downstream towards the confluence of the Snake River.

MO2 Impacts on Evaluation Species and Other Species

Under MO2, in the Lower Columbia River, a 1-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 and Steigerwald Lake NWR and 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 would be less than 0.5 ft (15 cm) in comparison to that under the NAA. These changes would 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 as a result of the implementation of MO2 may be 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 successfully rear their young (USFWS 2019c).

In the Upper Basin, proposed changes in ramping rates and draft conditions at Albeni Falls Dam would change water surface elevation on Lake Pend Oreille and the Pend Oreille River, downstream of the dam. While proposed operational measures at Libby Dam would 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). While mallard foraging opportunities might be more readily available as a result of higher winter flows, 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, would 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 would experience noticeable 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 on other species at the Snake River and Palouse River deltas would be minor.

In the study area, proposed changes to operations of the CRSO Federal project reservoirs above MOP would 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).

MO3

MO3 Summary of Uplands 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 on ecological and physical processes that support the structure and function of the wetlands landscape.
- Under MO3, discrete wetland habitats and subhabitats could become desiccated, resulting in negative impacts on some evaluation species. However, if wetland restoration activities in addition toMO3 are implemented and monitored long-term, then wetland habitat quality may increase.

MO3 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

Under MO3, changes in water levels and patterns of inundation and seasonal drying have the potential to drown out wetland vegetation, but this impact may not be noticeable in the Lower Columbia and Mid-Columbia river subbasins. The two structural and two operational dam breaching measures associated with MO3, if implemented, would restore a portion of the Lower Snake River to a free-flowing state and, thus, over time, more closely resemble 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 deposition of sediment 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, breaching the earthen portions of the four Lower Snake River dams would likely reduce habitat complexity and ecosystem function in the short-term.

The implementation of structural and operational measures under MO3 would change the composition, quantity, and quality of wetland vegetation in the study area, especially in the Lower Snake River. Reservoir drawdown would likely threaten existing wetland habitats, now perched higher in the tributaries, with extended periods of drying. Non-native vegetation could spread and establish in drawdown zones if active habitat restoration does not occur.

MO3 Impacts on Key Sites

Key Island Sites

Lower Columbia River: Reed Island and Steigerwald Lake NWR and Sauvie Island Wildlife Area

Structural measures associated with MO3, if implemented, would be unlikely to noticeably affect wetland habitats negatively throughout the Lower Columbia River. Key sites might experience the impacts of minor changes in water surface elevation under MO3, similar to those described in the other MOs. These changes would be most evident in the Columbia River Gorge, downstream of Bonneville Dam.

Lower water levels in the Lower Columbia River in the spring and summer would limit the quantity and quality of wetland vegetation at managed wetlands (e.g., Reed Island and Steigerwald Lake NWR and 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 under MO3.

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 on wetland habitats in the Mid-Columbia River. These changes would result in operations similar to those under the NAA rather than those under MO1 or MO4, and they would likely lead to a decrease by 1 ft (30 cm) in water surface elevation from April to October. 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.

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 would likely influence the wetlands landscape throughout the Upper Basin.

Outflows near Everett Island and Kootenai NWR would likely increase by 10 to 35 percent in early winter (November and December) and decrease by 5 to 40 percent during the rest of the year. As

a result, water surface elevation on the Pend Oreille and Kootenai rivers would be 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 would likely inundate river banks at Everett Island and Kootenai NWR and redistribute seeds from existing wetland habitats and subhabitats. Higher water levels in the winter would also lead to increasing bank sloughing and erosion, which would potentially degrade water quality. Lower spring flows would likely reduce the moisture content of wetland soils, thereby reducing the suitability of shorelines in the spring and summer for 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 island sites. Under MO3, water surface elevation would drop from approximately 95 ft to 110 ft (29 m to 34 m) exposing approximately 13,800 ac (56 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 wetlands landscape would decrease significantly in quality, and the availability of other landscapes would increase in comparison to those conditions under the NAA. Beyond MO3, wetland vegetation could be reestablished as a result of focused restoration efforts and long-term monitoring.

However, the Service projects that wetland subhabitat 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 would impact long-term wetland habitat quantity, quality, and distribution throughout the 140-mile (64-km) section of river.

Where wetlands already occur in the NAA, these habitats could transition to uplands habitats. 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.

<u>Key River Delta Sites</u>

Lower Columbia River: Sandy River Delta

Under MO3, wetland habitat will likely be maintained at the Sandy River Delta in the Lower Columbia River, providing high quality habitat for the benefit of local plants and wildlife. 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, would produce negligible impacts in downstream flows through the Mid-Columbia River. Wetland habitats at Lower Crab Creek, for instance, would likely remain intact.

The four structural and operational dam breaching measures associated with MO3, however, would result in an extreme amount of sedimentation at McNary NWR. Native soils that existed prior to the dam and flooding will experience further sediment deposition. In the short-term, many of the submerged aquatic vegetation beds that occur at this key site will be lost or degraded due to the sedimentation or conversion to more riverine (i.e., lotic) subhabitats. 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, 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 would reduce flows on the Flathead, Clark Fork, and Pend Oreille rivers by 90 kcfs (2,549 m^3s^{-1}) in the winter and spring; however, this measure would have negligible impacts on water surface elevation in Lake Pend Oreille and river reaches downstream of the Albeni Falls Dam. Despite these changes, the Hungry Horse Additional Water Supply measure would not influence the quantity, quality, and distribution of wetland vegetation adjacent to the reservoir or river landscapes

Lower Snake River: Snake River Delta and Palouse River Delta

In the Lower Snake River, in the short-term, wetland habitats would decrease in quantity and quality at river delta sites due to changes in water surface elevation resulting from reservoir drawdown. However, in the long-term, structural and operational measures associated with dam breaching would create additional areas for wetland reestablishment.

Deep sediment deposits adjacent to the mainstem post-dam breaching would be more suitable for wetland reestablishment than the rocky, shallow soils that current characterize the shorelines.

At the Palouse River Delta, a major drop in water surface elevation would lead to increased sediment accumulation in the mainstem (i.e., Snake River). Over time, as ecological and physical processes begin to be 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).

MO3 Impacts on Evaluation Species and Other Species

Wetland evaluation species that inhabit areas within the Lower Columbia River would experience diminished impacts as a result of MO3. For instance, a decrease in water surface elevation during the spring and summer could reduce the quantity and quality of wetland habitats, especially at key sites like Reed Island and Steigerwald Lake NWR and Sauvie Island Wildlife Area, where managers maintain the wetlands landscape to support many species (e.g., Western pond turtle).

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 inches (8 cm) and, thus, within the current range of variability. Regardless, this minor change could affect wildlife resource (i.e., mallards, Western painted turtles) use of wetland habitats and subhabitats at this river delta site. Under MO3, there may be seasonal occurrences during which this average reduction in water surface elevation is exceeded. These instances, if prolonged, would result in limited feeding and reproduction opportunities for wetland species.

Evaluation species that inhabit wetlands in the Upper Basin would also be exposed to negative impacts resulting from the implementation of MO3. For example, lower spring and summer flows on the Kootenai River could lead to lower water levels in off-channel sloughs and backwaters from May to late June, drying out amphibian (i.e., Western toad) eggs. Lower water surface elevation is likely to be detrimental to the breeding success of birds such as the American bittern, mallard, and sora, depending on when and where they breed during the year. Further, changes to the frequency of wetting and drying cycles in wetland habitats at various sites would affect the availability and quality of wetland plants used for nest construction.

In the short-term, MO3 would negatively affect wetland reptiles and amphibians during and immediately following the implementation of the dam breaching measures and reservoir drawdown. Reptiles are generally more mobile than amphibians and, thus, are less dependent on the accessibility to aquatic landscapes, with the exception of turtles. A permanent reduction in water surface elevation and loss of riparian and wetlands landscape could isolate amphibian populations and lead to the desiccation of eggs. Past studies showed that amphibian eggs exposed to desiccation for approximately one day are no longer viable (McMenamin et al. 2008, p. 16989). Thus, amphibian populations could experience population-level declines following a widespread, generational loss of eggs along some stretches of the river. Over time, however, wetlands evaluation species could increase in abundance as shallow water habitats and wetland subhabitats reestablish. In the long-term, contiguous wetland habitats would improve habitat connectivity to support dispersal of, and movement for, reptiles and amphibians.

Under MO3, in the long-term, the abundance of wetland habitats on island sites in the Lower Snake River would increase and, thus, support more and diverse wildlife resources. For instance, approximately 50 islands in this subbasin, each greater than 5 ac (2 ha), provided support for nesting habitat for Canada geese before they were inundated behind the Lower Snake River dams (Martin et al. 1985, p. D-3). Wintering mallard would likely experience disturbance during dam breaching, causing individuals to potentially relocate. In the short-term, degraded water quality and sediment transport processes would limit aquatic prey resources and foraging success for

waterfowl dependent on aquatic invertebrates and fish 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 would be a transition from submerged aquatic plants (e.g., pondweeds and waterweeds) in slower-moving reservoirs to those 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 would affect the abundance of benthic organisms and could enable the invasion and establishment of non-native species in the resulting drawdown zones (Chen et al. 2016, p. 1; Cushing 1993, p. 27).

MO4

MO4 Summary of Uplands Landscape Findings

- Some structural and operational measures proposed under MO4 could lead to positive impacts on the expansion and sustainability of the wetlands landscape, especially in the Upper Columbia River (e.g., Kootenai River) and Lower Snake River.
- Proposed operations of the CRSO Federal project reservoirs at MOP could hinder efforts to increase wetland habitat complexity and ecosystem function, especially in the Lower Columbia River where significant decreases in water surface elevation are projected to occur below McNary Dam.

MO4 Impacts on Indicators of Ecological and Physical Processes and Subhabitats

The implementation of the Drawdown to MOP operational measure in MO4 would effectively 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, would continue at these Federal projects. Pool elevations would 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 would increase progressively downstream until a potential decrease (between approximately 2.3 ft and 4 ft [70 cm and 122 cm] lower in comparison to the NAA) in the Bonneville Reservoir.

Under MO4, the Columbia River Estuary below Bonneville Dam would experience minor changes in water surface elevation in average years and wet years, similar to those described in MO1. In very dry years (80 to 99 percent AEP) the spring freshet in May and June could increase water surface elevation from 0.5 ft to 1.5 ft (15 cm to 46 cm), in comparison to the NAA. However, in most years, the Service expects changes in water surface elevation, with an increase in winter water levels by approximately from 2 inches to 4 inches (5 cm to 10 cm) and a decrease in water levels during the spring and summer from approximately 2 inches to 7 inches (5 cm to 18 cm), to result in

negative impacts on the wetlands landscape. However, these impacts would be slightly less negative further downstream of Bonneville Dam, toward the Columbia River Estuary.

Changes in water surface elevation would result in negative impacts on 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 alternately 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 would likely be offset in part by the implementation of the Winter Stage for Riparian and McNary Flow Augmentation operational measures. These measures, in particular, would 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 this measure would likely yield long-term benefits to the wetlands landscape throughout the Upper Basin.

The implementation of the Drawdown to MOP operational measure in MO4, if implemented, would lead to major changes in operations at Ice Harbor Dam, Lower Monumental Dam, Little Goose Dam, and Lower Granite Dam such that pool elevation would be drawn down so that it would be, on average, approximately 4 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 would decrease by approximately 1 foot in late March than what is proposed under the NAA, thereby promoting a more pre-dam hydrograph and natural flood regime.

MO4 Impacts on Key Sites

<u>Key Island Sites</u>

Lower Columbia River: Reed Island and Steigerwald Lake NWR and Sauvie Island Wildlife Area

Under MO4, the implementation of the Drawdown to MOP operational measure would 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 would be between approximately 2.3 ft and 4.0 ft (70 cm to 122 cm) 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 wetland vegetation that support evaluation species.

Mid-Columbia River: Hanford Reach and Wells Wildlife Area

While structural and operational measures associated with MO4 may influence operations of Grand Coulee Dam and Chief Joseph Dam, they are not expected to result in measurable differences in outflow or water surface elevation in comparison to the NAA.

Upper Basin: Everett Island and Kootenai NWR

Implementing the McNary Flow Target operational measure, however, would 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 would 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. Under MO4, at Libby Dam, changes in water surface elevation during the spring and summer have the potential to alternately inundate and desiccate narrow bands of emergent vegetation, which could negatively influence evaluation species. Outside of the spring and summer, these changes, and the resulting impacts, would be less severe.

Lower Snake River: Silcott Island

Due to aggressive drafting, the water surface elevation at all key sites the Lower Snake River would decrease by approximately 1 ft (30 cm) in late March in comparison to the NAA. According to the co-lead agencies H&H modeling output, however, wetland habitats and subhabitats would remain wet for longer periods of time, especially during the spring and summer, in comparison to the NAA, MO1, and MO2. As a result, the quantity and quality of nesting 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.

<u>Key River Delta Sites</u>

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, would influence operations of the Grand Coulee Dam and Chief Joseph Dam, they are not expected to result in outflow or changes in water surface elevation that are measurably different from those of the NAA. Consequently, the implementation of related measures would have negligible impacts on 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 would lower water surface elevation at reservoir pools associated with McNary Dam between April and July and, in dry years, between March and August. For example, upstream of McNary Dam, water

surface elevation would decrease from 0.5 ft to 1.5 ft (15 cm to 46 cm) than that in current conditions. As a result of this 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

Wetland habitats and subhabitats at Pack River Delta in the Upper Basin would likely be negatively impacted by the implementation of operational measures associated with MO4. This site has a complex alluvial fan, and it is characterized by adjacent wetland habitats, both connected and disconnected from the mainstem Pack River. Under MO4, in dry years, the Pack River Delta would 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 would 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 wetland habitats and off-channel pools along the shorelines at the Snake River and Palouse River delta sites. Under MO4, the Service projects a faster increase in quality or overall health of the wetlands landscape at the Palouse River Delta in comparison to the NAA, MO1, and MO2.

MO4 Impacts on Evaluation Species and Other Species

Under MO4, the implementation of the Drawdown to MOP operational measure would result in negative impacts on American bittern, mallard, and Western painted turtle. This measure, if implemented, would result in the overall reduction in water surface elevation at Reed Island and Steigerwald Lake NWR and Sauvie Island Wildlife Area, and Sandy River Delta, thereby impacting the survival, growth, and reproduction of wetland evaluation species. These negative impacts will be more pronounced upstream at the McNary NWR.

Evaluation species that inhabit wetland habitats and subhabitats in the Mid-Columbia River would likely retain their current population status.

In the Upper Basin, a decrease in water surface elevation of 2.6 ft (79 cm) during dry years would affect many wetland species, decreasing their ability to 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 would potentially benefit the mallard, sora, and Western toad in the long-term.

American bittern, mallard, and Western toad that inhabit key 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 various evaluation species (USFWS 2019c).

Under MO4, depending on the location in the study area, reductions in water surface elevation in Federal project reservoirs to MOP would likely reduce the abundance of available shallow-water habitat that often supports non-native aquatic predators like Northern pike. However, other wetland subhabitats, where a slight increase in water surface elevation is likely to occur, may promote establishment of non-native piscivorous (i.e., fish-eating) fish.

UPLANDS

NAA

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 evaluation species.
- In the future under the NAA, native grasslands and sagebrush subhabitats will continue to be impacted by other land use management and policy decisions.

NAA Impacts on Indicators of Ecological and Physical Processes and Subhabitats

<u>Grassland and Sagebrush Subhabitats</u>

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.

<u>Natural Bluff Landforms</u>

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 this 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.

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 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 are not expected to change in abundance as a result of continued dam 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.

MO1

MO1 Summary of Uplands Landscape Findings Under MO1

- Structural and operational measures associated with MO1 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.

MO2

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 evaluation species.

MO3

MO3 Summary of Uplands Landscape Findings Under MO3

- Structural and operational measures associated dam breaching as part of MO3 have the potential to impact 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 would be compromised.

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 dams on the Lower Snake River 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 on 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 [5 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 on 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.

MO4

Summary of Uplands Landscape Findings Under MO4

- 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.