UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
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https://doi.org/10.25923/xday-dk39

May 5, 2021

Refer to NMFS No: WCRO-2020-02609

Capt. Mathew J. Martinson
U.S. Environmental Protection Agency
Region 10
1200 Sixth Avenue, Suite 155
Seattle, Washington 98101-3188

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for National Pollution Discharge Elimination System Municipal Stormwater Permits (IDS028061 and IDS028258), Lewiston, Idaho

Dear Capt. Martinson:

Thank you for your letter of August 11, 2020, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for two National Pollution Discharge Elimination System (NPDES) Municipal Stormwater Permits (IDS028061 and IDS028258) in Lewiston, Idaho. This consultation was conducted in accordance with the 2019 revised regulations that implement section 7 of the ESA (50 CFR 402, 84 FR 45016).

In this Biological Opinion (Opinion), NMFS concludes that the action, as proposed, is not likely to jeopardize the continued existence of Snake River spring/summer Chinook salmon, Snake River fall Chinook salmon, Snake River sockeye salmon, or Snake River Basin steelhead. NMFS also determined the action will not destroy or adversely modify designated critical habitat for Snake River spring/summer Chinook salmon, Snake River fall Chinook salmon, Snake River sockeye salmon, or Snake River Basin steelhead. The rationale for our conclusions is provided in the attached opinion.

NMFS also reviewed the likely effects of the proposed action on essential fish habitat (EFH), pursuant to section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1855(b)), and concluded that the action would adversely affect the EFH of Pacific Coast salmon. Therefore, we have included the results of that review in Section 3 of this document. If the response is inconsistent with the EFH Conservation Recommendations, the U.S. Environmental Protection Agency (EPA) must explain why the recommendations will not be followed, including the justification for any disagreements over the effects of the action and the recommendations.

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many Conservation Recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, in your statutory reply to the EFH portion of this consultation, NMFS asks that you clearly identify the number of Conservation Recommendations accepted.

Please contact David Arthaud, Moscow, Idaho at (562) 676-2165 or david.arthaud@noaa.gov if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

Michael P. Tehan
Assistant Regional Administrator
Interior Columbia Basin Office

Enclosure

cc: File
Christina Hacker, USFWS
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Mike Erickson, USACE
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Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response

National Pollution Discharge Elimination System Municipal Stormwater Permits (IDS028061 and IDS028258), Lewiston, Idaho

NMFS Consultation Number: 2020-02609

Action Agency: U.S. Environmental Protection Agency

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Snake River steelhead (*Oncorhynchus mykiss*)	Threatened	Yes	No	Yes	No
Snake River spring/summer Chinook salmon (*Oncorhynchus tshawytscha)*	Threatened	Yes	No	Yes	No
Snake River fall Chinook salmon (*Oncorhynchus tshawytscha)*	Threatened	Yes	No	Yes	No
Snake River sockeye salmon (*Oncorhynchus nerka)*	Endangered	Yes	No	Yes	No

Fishery Management Plan That Identifies EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	Yes	Yes

Consultation Conducted By: National Marine Fisheries Service, West Coast Region

Issued By:
Michael P. Tehan
Assistant Regional Administrator
for Interior Columbia Basin Office

Date: May 5, 2021

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ACRONYMS

Acronyms	Definition
ACMs	Alternative Control Measures
BE	Biological Evaluation
BMP	Best Management Practices
BOR	Bureau of Reclamation
CFR	Code of Federal Regulations
COE	U.S. Army Corps of Engineers
COM	Commercial
CR	Columbia River
CR	Chromium
CU	Copper
CWA	Clean Water Act
DOC	Dissolved Organic Carbon
DPS	Distinct Population Segment
DQA	Data Quality Act
EFH	Essential Fish Habitat
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily Significant Units
FR	Federal Register
HDR	High Density Residential
HG	Mercury
ICTRT	Interior Columbia Technical Recovery Team
IDEQ	Idaho Department of Environmental Quality
IDFG	Idaho Department of Fish and Game
IND	Industrial
ITD2	Idaho Transportation Department District #2
ITS	Incidental Take Statement
LCSC	Lewis-Clark State College
LDGP	Lower Granite Dam Project
LDR	low density residential
LGD	Lower Granite Dam
LGDP	Lower Granite Dam Pool
LGR	Lower Granite Reservoir
LLPs	Lewiston Levee Ponds and Pumping Stations
MeHg	Methylmercury
MP	Microplastics
MPG	Major Population Group
MS4s	Municipal Separate Storm Sewer Systems
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NI	Nickel
NMFS	National Marine Fisheries Service
NPDES	National Pollution Discharge Elimination System
NWFSC	Northwest Fisheries Science Center
O&M	Operation and Maintenance
ODFW	Oregon Department of Fish nd Wildlife
OMB	Office of Management and Budget
OPEN	Open Space

Opinion	Biological Opinion
O_3	Ozone
PAHs	Polycyclic Aromatic Hydrocarbons
PBDE	Polybrominated Diphenyl Ethers
PBFs	Physical or Biological Features
PBTs	Persistent Bioaccumulating Toxicants
PCB	Polychlorinated Biphenyls
PCDD/Fs	Polychlorinated Dibenzo-P-Dioxins and Furans
PCE	Primary Constituent Element
PEL	Probable Effects Level
POPs	Persistent Organochlorine Pollutants
RM	River Mile
RPA	Reasonable Prudent Alternative
RPM	Reasonable and Prudent Measures
SQCs	Sediment Quality Guidelines
SRB	Snake River Basin
SWMP	Stormwater Management Plan
TECs	Threshold Effect Concentrations
Ti	Titanium
TiO2	Titanium Dioxide
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
UA	Urbanized Area
USGCRP	The U.S. Global Change Research Program
VPM	Vegetation Management Plan
VSP	Viable Salmonid Population
WDFW	Washington Department of Fish and Wildlife
WQS	Water Quality Standards
ZN	Zinc

1. INTRODUCTION

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3, below.

1.1. Background

National Marine Fisheries Service (NMFS) prepared the Biological Opinion (Opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402, as amended.

We also completed an essential fish habitat (EFH) consultation on the proposed action, in accordance with section 305(b)(2) of the Magnuson–Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et seq.) and implementing regulations at 50 CFR 600.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available within two weeks at the NOAA Library Institutional Repository (https://repository.library.noaa.gov/welcome). A complete record of this consultation is on file at the Snake River Office, Boise, Idaho.

1.2. Consultation History

In 2018, the U.S. Environmental Protection Agency (EPA) notified NMFS that two National Pollutant Discharge Elimination System (NPDES) permits would soon be issued for the Lewiston, Idaho multi-sector stormwater discharges under the Clean Water Act (CWA) and that ESA consultation would likely be requested. The permits are for stormwater discharges from municipal separate storm sewer systems (MS4s) owned and/or operated by the City of Lewiston and Lewis-Clark State College (City/LCSC; NPDES Permit No. IDS028061) and by the Idaho Transportation Department District #2 (ITD2; NPDES Permit No. IDS028258) in the Lewiston, Idaho, Urbanized Area (UA). The stormwater sewer systems being permitted discharge into the Snake River, Clearwater River, Lewiston Levee Ponds and Pumping Stations (LLPs), and tributaries Lindsay Creek and Tammany Creek.

In July 2020, EPA reconfirmed species lists for the Lewiston area with NMFS. Waters surrounding the area include threatened Snake River spring/summer Chinook salmon, Snake River fall Chinook salmon, Snake River Basin steelhead, and endangered Snake River sockeye salmon. The Snake River is designated critical habitat for Snake River spring/summer Chinook salmon, Snake River fall Chinook salmon, Snake River sockeye salmon, and Snake River Basin steelhead. The Clearwater River is designated critical habitat for Snake River fall Chinook salmon and Snake River Basin steelhead; and the lower one-half mile of Tammany Creek is designated critical habitat for Snake River Basin steelhead. Essential fish habitat (EFH) occurs in the Snake and Clearwater Rivers for Chinook salmon and coho salmon.

NMFS received a biological evaluation (BE) and request for ESA consultation from EPA on August 11, 2020. The parties met online to discuss the BE on September 17, 2020 and NMFS initiated consultation on September 24, 2020 when we received all requested information. On December 17, 2020, NMFS requested a 90-day extension, which EPA agreed to on December 18, 2020. NMFS provided sectional drafts of the proposed action and terms and conditions to EPA on March 8, 2021, which were discussed on March 15, 2021. On April 7, 2021, NMFS provided drafts of the proposed action and terms and conditions sections of the draft opinion to the Nez Perce Tribe and Shoshone-Bannock Tribes; no comments were received.

1.3. Proposed Federal Action

Under the ESA, "action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02). Under MSA, Federal action means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal agency (50 CFR 600.910).

EPA has proposed to issue two NPDES permits, with reserved amendment after completion of ESA consultation, for multiple discharges of stormwater from small urban areas in Lewiston, Idaho. The permittees are the City of Lewiston/Lewis-Clark State College (City/LCSC) and the Idaho Transportation Department #2 (ITD2). Each permittee owns and/or operates a MS4, which is a publicly owned conveyance or system of conveyances used for collecting and conveying storm water that discharges to waters of the United States (40 CFR § 122.26). Such systems may include roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains.

Section 301 of the CWA [33 U.S.C. § 1311(a)] provides that the point source discharge of pollutants to surface waters of the United States is unlawful except in accordance with, among other things, an NPDES permit. Receiving waters for the MS4 discharges to be covered by EPA's subject permit actions are waters of the United States and include all surface waters receiving stormwater discharges from the MS4s. In 1999, EPA issued the "Phase II" stormwater regulations to expand the types of stormwater discharges that must comply with NPDES permits to include discharges from "small MS4s." Based on their geographic locations in the Lewiston, Idaho UA, the MS4s owned and/or operated by the permittees are considered small MS4s and discharges must be controlled in compliance with an appropriate NPDES permit. Section 401 of the CWA, 33 U.S.C. § 1341, requires that certification be obtained from the appropriate State or Tribal agency, certifying that the permitted discharge complies with the State's water quality standards as well as "other appropriate requirements of State law." Both permits are in Idaho and the State may include conditions in 401 certifications to ensure its water quality standards are met. If these conditions are more stringent than the conditions in the permit, then those conditions must be included in the permit.

The subject NPDES permits (EPA 2020a, 2020b) are issued for five-year terms, and are subsequently reissued consistent with regulations, discharge characteristics, and/or receiving water status, including applicable water quality standards [33 U.S.C. § 1342, and implemented by regulations set forth in Title 40 of the Code of Federal Regulations (CFR) Parts 122, 123 and 124]. EPA Region 10 is the NPDES permitting authority for regulated stormwater discharges in the Idaho until July 1, 2021 when the Idaho Department of Environmental Quality (IDEQ) will become the permitting authority.

All NPDES permits for small MS4 discharges must require, at a minimum, that the operator develop, implement, and enforce a comprehensive stormwater management plan (SWMP) designed to reduce the discharge of pollutants from the MS4 to the maximum extent practicable, to protect water quality, and to satisfy the appropriate water quality requirements of the CWA (40 CFR § 122.34). Terms and conditions of small MS4 permits may include narrative, numeric, or other types of requirements (e.g., implementation of specific tasks or best management practices (BMPs), BMP design requirements, performance requirements, adaptive management requirements, schedules for implementation and maintenance, and frequency of actions [40 CFR § 122.34(a)]. Small MS4 permits must contain prescriptive requirements detailing the explicit expectations for each of the six "minimum control measures" described in 40 CFR § 122.34(b), namely public education; public involvement; illicit discharge detection and elimination; construction site runoff control; post construction stormwater runoff control; and pollution prevention/good housekeeping for municipal operations. 40 CFR § 122.34(c) requires water quality-based requirements for NPDES-regulated storm water discharges in addition to or that modify the SWMP control measures where needed to protect water quality or that are based on an EPA-approved water quality cleanup plan called a Total Maximum Daily Load (TMDL). NPDES permits for small MS4 discharges must include terms and conditions to evaluate compliance with permit provisions, including achievement of measurable requirements established as permit requirements [40 CFR § 122.34(d)].

1.3.1. Activity Descriptions

The proposed NPDES permits authorize the City/LCSC and ITD2 (permittees) for MS4 discharges to the Snake River, Clearwater River, Lewiston Levee Ponds and Pumping Stations (LLPs), and tributaries Lindsay Creek and Tammany Creek. Lewiston City's MS4 serves approximately 9.7 square miles with an estimated 115,000 feet of storm sewer (pipe) in place throughout the City. The LCSC MS4 is interconnected with the City's MS4 within a portion of this same area. Surface drainage in much of the UA is conveyed through privately owned natural drainage ways and streams that may be intermixed with other discharges. Thus, the stormwater system in the UA relies on both buried stormwater pipes and surface drainage in ditches and natural channels.

The City describes their MS4 as three distinct areas (North Lewiston; Downtown/Normal Hill; and the Orchards; EPA 2018a). The UA generally drains to the Snake River on the west, Tammany Creek on the south, Lindsay Creek on the east, and the Clearwater River on the north. Most of the known MS4 drains convey runoff to the U.S. Army Corps of Engineers' (COE) Lewiston levee drainage system, which then discharges into the Clearwater River within the pool of Lower Granite Reservoir (LGR; Figure 1). The COE believes they lack discretion to change operations and maintenance of levees and drainage systems, specifically regarding transferring Lewiston UA and other stormwater discharges to the Snake and Clearwater Rivers and for the reuse of stormwater to irrigate lands behind levees. Any monitoring or treatment of these stormwater discharges would need to occur before they enter the COE's levee drainage system.

Stormwater from the eastern portion of the UA discharges into Lindsay Creek along much of its length. The stream is dammed to form a settling pond, which is then discharged through a 0.14-mile tunnel into the Clearwater River at RM 2.2. Stormwater from the western portion of the UA is discharged directly into the Snake River. Along the southern portion of the UA, stormwater is discharged into the Tammany Creek watershed along much of its length and conveyed by Tammany Creek into the Snake River at RM 144.

Through a cooperative agreement between the city and ITD2, the City operates and maintains State of Idaho highway routes within City limits, which includes storm sewer and culvert maintenance for U.S. Highway 12 and its Frontage Road, U.S. 95 and State Highway 128 in the Downtown and North Lewiston areas. ITD2 conducts snow removal, culvert maintenance, and maintenance of unimproved roadsides on U.S. 95 and State Highway 128 only.

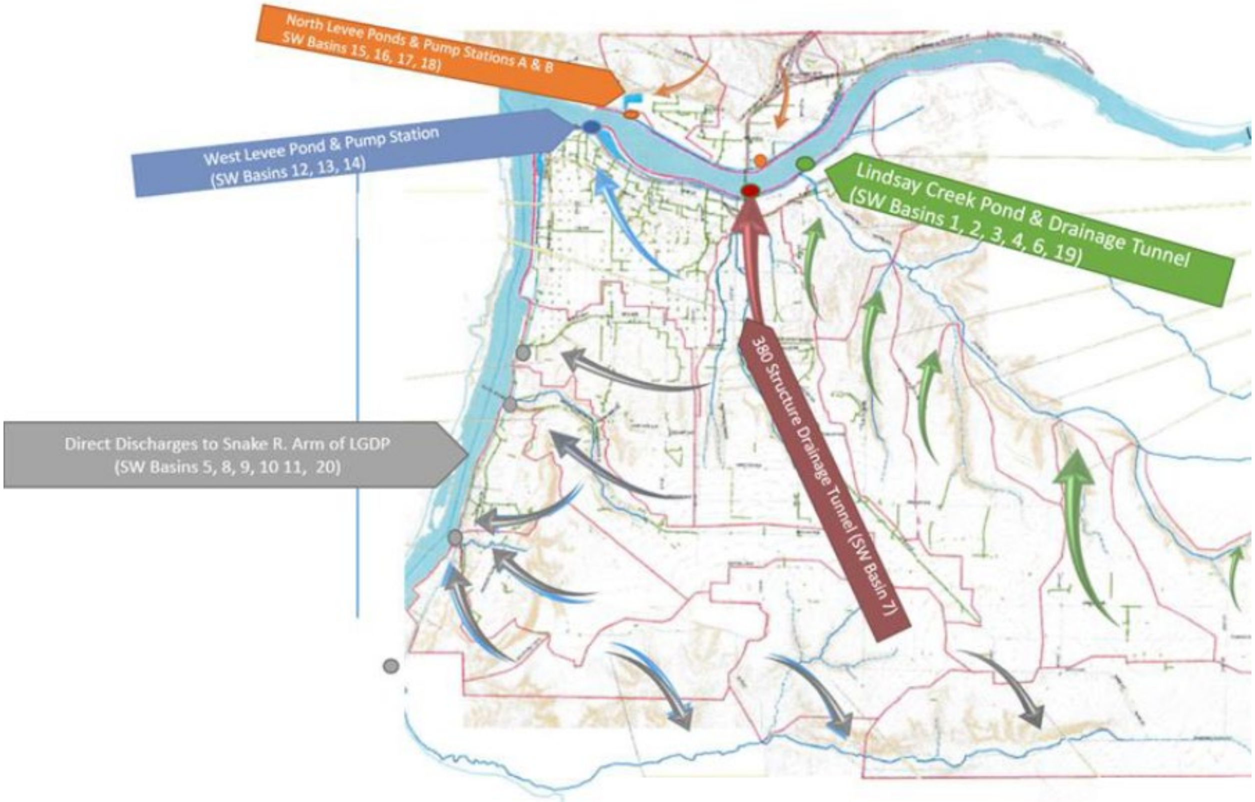


Figure 1. Lewiston urban area stormwater sewer conveyances, common discharge points (shaded circles), and receiving waters. Tags enumerate basins within the UA that are known to drain to specific outfalls. Receiving waters are the Snake River (west), Clearwater River (north), Lindsay Creek (east), and Tammany Creek (south). These reaches of the Snake River and lower Clearwater River are in the backwaters of the Lower Granite Dam Project (LDGP).

1.3.2. Permit Requirements and Schedules

The Permits establish conditions, prohibitions, and management practices designed to reduce the discharge of pollutants from the MS4s to the maximum extent practicable, to protect water quality, and to comply with appropriate CWA requirements. When finalized, the permits require the permittees to implement comprehensive SWMPs. EPA has defined the SWMP control measures and evaluation requirements that the permittees must implement. These provisions are summarized below.

Limitations on Permit Coverage. Discharges that cause or contribute to an excursion above the Idaho or Washington Water Quality Standards (WQS) are subject to notification and corrective action requirements. Discharge of snow and snowmelt to surface waters or the MS4 is prohibited, unless consistent with specified pollution prevention and operational practices. Discharges of otherwise regulated stormwater are allowed into the MS4, provided those discharges are authorized via alternative NPDES permit(s). Non-stormwater discharges from MS4s are prohibited, except under specified conditions.

These limitations are important because shared receiving waters are impaired in one or both States, other discharges requiring NPDES permits may purposely or accidentally increase receiving water pollution beyond established limits by using stormwater infrastructure, and stockpiles of winter-plowed snow can overwhelm or compromise otherwise adequate stormwater drainage.

Permittee Responsibilities. The permittee/MS4 operator is responsible for permit compliance related to their MS4. The City and LCSC choose to share responsibilities as co-permittees and will share in operating and maintaining existing infrastructure, constructing future conveyances, and implementing permit requirements. The City, LCSC and ITD2 may work with outside parties to comply with one or more permit requirements. Each permittee must maintain adequate legal authority, to the extent allowed under Idaho law, to implement the SWMP control measures in its jurisdiction. Each permittee must maintain a written SWMP document that summarizes how the permittee implements the SWMP in its jurisdiction. Each SWMP must collect and report summary information about its SWMP implementation activities; provide adequate financial support to comply with the permit; and impose their SWMP in newly annexed areas within one year of annexation. Pursuant to IDEQ's CWA section 401certification, the permittees must consider practices identified in the most recent version of the IDEQ's Catalog of Stormwater Best Management Practices. Water quality improvements from pollutant reduction activities and implementation of permit requirements will not be complete at the time of permit issuance but are required to be completed during the initial permit term. Permit reissuance thereafter will include summary information of SWMP implementation activities.

Alternative Control Measure Requests. A permittee may request that EPA and IDEQ consider one or more Alternative Control Measures (ACMs) by submitting the documents, plans, or programs equivalent to a comparable permit provision with supporting documentation. EPA and IDEQ will review whether the request is equivalent, and if so, EPA may modify the permit to reflect the ACM(s), pursuant to public notice and comment as required by 40 CFR §§ 122.62 and 124. The City/LCSC must submit a description and implementation of two Pollutant Reduction

Activities and a Monitoring/Assessment plan that address impairment pollutants (sediment, *E. coli*, nitrite plus nitrate as nitrogen; and total phosphorus) in MS4 discharges to Lindsay and Tammany Creeks; as well as temperature in MS4 discharges to the Snake River.

Education, Outreach and Public Involvement. Each permittee must conduct an Education, Outreach and Public Involvement program, through activities targeted to specific audiences, and assessment of the intended results. The permittees must also educate appropriate audiences regarding construction erosion control and permanent runoff control requirements in their jurisdiction. Permittees must maintain a publicly accessible website containing the permittee's SWMP and all Annual Reports.

Illicit Discharge Detection and Elimination. Each permittee must conduct an illicit discharge management program using methods to detect, identify sources, and remove identified non-stormwater discharges from the MS4. The purpose is to eliminate unauthorized and illegal pollutant discharges into and from the MS4. This program must include:

- MS4 map and outfall inventory;
- A regulatory mechanism such as ordinance to effectively prohibit most non-stormwater discharges into the MS4;
- A complaint reporting and response program;
- MS4 outfall screening during dry weather;
- Specific follow-up actions within certain timeframes;
- Spill response and prevention activities including notification requirements;
- Public education on proper disposal of used oil and toxic materials; and
- Training for responsible permittee staff.

Construction Site Stormwater Runoff Control. The permittees must use a regulatory mechanism, such as an ordinance, to:

- Require erosion controls, sediment controls, and materials management techniques to be employed and maintained at projects from initial clearing through final stabilization; for construction activities disturbing one or more acres of land.
- Review and approve preconstruction site plans to ensure appropriate controls are used at sites disturbing one acre or more.
- Conduct construction site inspections for sites disturbing one acre or more, prioritized by disturbance size and potential water quality impact.
- Using available enforcement response, permittees must enforce these requirements at sites disturbing one or more acres.
- Permittees must ensure responsible staff are sufficiently trained to conduct these tasks.

Post Construction Stormwater Management for New Development and Redevelopment. The permittees must use a regulatory mechanism, such as an ordinance, to:

- Require installation and long-term maintenance of permanent stormwater controls at new development and redevelopment (new development at already developed sites) project sites, sufficient to retain onsite runoff volume produced from a 24-hour, 95th percentile storm event, and/or provide a level of pollutant removal greater than the level of pollutant removal expected by the use of onsite retention of runoff volume produced from a 24 hour, 95th percentile storm event.

- Permittees may submit a treatment equivalent expression of such requirements as an ACM, per permit part 2.6.
- Specify appropriate permanent controls for sites disturbing one acre of land or more.
- Review and approve preconstruction permanent control plans for sites disturbing one acre or more.
- Conduct prioritized inspections and enforce requirements for permanent stormwater controls to verify "as built" condition and ensure long term operation and maintenance (O&M); this includes use of O&M agreements for controls on private property and tracking the condition of permanent controls in its jurisdiction; and
- Training for responsible staff.

Pollution Prevention/Good Housekeeping for Municipal Operations. The permittees must properly operate and maintain its MS4 and related facilities, using prudent good housekeeping and pollution prevention measures to protect water quality and reduce the discharge of pollutants through the MS4. To accomplish this, the permit requires:

- Inspection and cleaning of catch basins and inlets.
- O&M procedures for streets, roads, highways and parking lots.
- Inventory and management of street/road maintenance materials.
- Street/road/highway/parking lot sweeping and assessment of existing activities.
- O&M Procedures for other municipal activities.
- Requirements for pesticide, herbicide, and fertilizer applications.
- Stormwater pollution prevention plans for permittee-owned facilities.
- Litter control, and
- Training for responsible staff.

Special Conditions for MS4 Discharges into Impaired Waters. The City/LCSC MS4 discharges to Lindsay Creek and the City/LCSC and ITD2 MS4s discharge to Tammany Creek, where IDEQ has established applicable TMDL waste load allocations for each stream. The City/LCSC and ITD2 MS4s discharge to receiving waters considered impaired by IDEQ that do not yet have applicable TMDLs (Snake River and the levee drainage system, which flows into the Clearwater River). Permit part 4 requires the City/LCSC and ITD2 to:

- Implement at least one pollutant reduction activity designed to reduce *E. coli*, nitrogen, phosphorus, and sediment loadings from the MS4 into Tammany Creek.
- Implement at least one pollutant reduction activity designed to reduce *E. coli*, nutrients, and sediment loadings from the MS4 into the South Fork Lindsay Creek.

- Submit a Monitoring/Assessment Plan that is designed to quantify, at a minimum, pollutant loadings from the City/LCSC MS4 into Lindsay Creek, the City/LCSC MS4s into Tammany Creek, and assess temperature contributions from the City/LCSC MS4s into the Snake River.

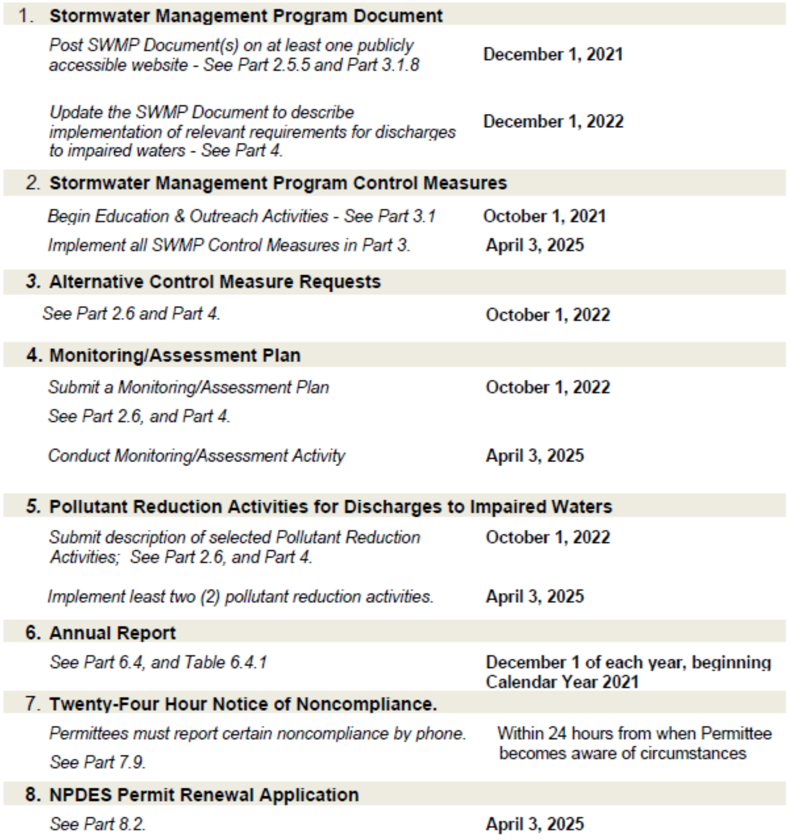
Required Response to Excursions of Idaho Water Quality Standards. If the permittees, EPA and/or IDEQ determine that the MS4 discharge causes or contributes to an excursion of Idaho WQS, the permittees must notify EPA and IDEQ, and may be required to submit an adaptive management response report within 60 days thereafter to identify how the permittees will mitigate or eliminate the MS4 discharge. Upon EPA/IDEQ approval, permittees must immediately begin implementing the adaptive management practices and annually report on progress to date. EPA and IDEQ may modify the permit pursuant to NPDES regulation where additional permit conditions are warranted.

Monitoring, Recordkeeping, and Reporting. The permittees must evaluate their permit compliance at least annually, using the provided reporting format. Permittees conducting monitoring/assessment activities per the required Monitoring/Assessment Plan must submit their data. The permittee must retain all related records for at least five years and submit such only when requested by EPA or IDEQ.

Standard NPDES Permit Conditions. In addition to the standard conditions related to general compliance responsibilities pursuant to 40 CFR Part 122, Permit Part 8.1 contains a detailed list of documentation that each permittee must submit with their Permit Renewal Application.

Permit Schedules. Each permit (EPA 2020a, 2020b) provides a schedule for completing, implementing, monitoring, and reporting permit requirements that were reviewed previously in this section (Tables 1 and 2). These schedules are important to the development and maintenance of the BMPs, and five-year term reissuance of the permits. Permit BMPs include short- and long-term activities, for example, managing buffers of vegetation and trees. These schedules are also important for program monitoring because locations of some stormwater conveyances, their entry points, and outfalls are not known. Similarly, the types, sources, and cumulative loads of contaminants entrained and discharged by stormwater sewers are not known.

Table 1. Permit Schedule of the City/LCSC MS4 Proposed Permit. (IDS028061; EPA; 2020a)



1. Stormwater Management Program Document	
Post SWMP Document(s) on at least one publicly accessible website - See Part 2.5.5 and Part 3.1.8	**December 1, 2021**
Update the SWMP Document to describe implementation of relevant requirements for discharges to impaired waters - See Part 4.	**December 1, 2022**
2. Stormwater Management Program Control Measures	
Begin Education & Outreach Activities - See Part 3.1	**October 1, 2021**
Implement all SWMP Control Measures in Part 3.	**April 3, 2025**
3. Alternative Control Measure Requests	
See Part 2.6 and Part 4.	**October 1, 2022**
4. Monitoring/Assessment Plan	
Submit a Monitoring/Assessment Plan *See Part 2.6, and Part 4.*	**October 1, 2022**
Conduct Monitoring/Assessment Activity	**April 3, 2025**
5. Pollutant Reduction Activities for Discharges to Impaired Waters	
Submit description of selected Pollutant Reduction Activities; See Part 2.6, and Part 4.	**October 1, 2022**
Implement least two (2) pollutant reduction activities.	**April 3, 2025**
6. Annual Report	
See Part 6.4, and Table 6.4.1	**December 1 of each year, beginning Calendar Year 2021**
7. Twenty-Four Hour Notice of Noncompliance.	
Permittees must report certain noncompliance by phone. *See Part 7.9.*	Within 24 hours from when Permittee becomes aware of circumstances
8. NPDES Permit Renewal Application	
See Part 8.2.	**April 3, 2025**

The City/LCSC permit requires at least two pollutant reduction measures, or equivalent alternatives, be implemented (one for Tammany Creek and one for Lindsay Creek) by April 3, 2025 before the end of the five-year permit term (Table 1). There are several stormwater discharges to those waters and several more stormwater discharges into the Snake and Clearwater Rivers (Figure 1), so the permits are designed to effectively develop and maintain BMPs and infrastructure through time. Neither proposed permit requires reduction measures for temperature in Idaho and Washington or for the eight other impairment pollutants which are included in Washington's 303(d) list for this same reach of the Snake River. The proposed ITD2 permit does not require reduction measures for any impairment pollutants (permit part 4) or monitoring (permit part 6.2; Table 2).

Table 2. Schedule of the ITD2 MS4 proposed permit (IDS028258) EPA (2020b)

1. Stormwater Management Program Document	
Post SWMP Document(s) on at least one publicly accessible website - See Part 2.5.3 and Part 3.1.8	**December 1, 2021**
2. Stormwater Management Program Control Measures	
Begin Education & Outreach Activities - See Part 3.1	**October 1, 2021**
Implement all SWMP Control Measures in Part 3.	**April 3, 2025**
3. Alternative Control Measure Requests	
See Part 2.6 and Part 4.	**October 1, 2022**
4. Monitoring/Assessment Plan [Reserved]	
5. Pollutant Reduction Activities for Discharges to Impaired Waters [Reserved]	
6. Annual Report	
See Part 6.4, and Table 6.4.2	**December 1 of each year, beginning Calendar Year 2021**
7. Twenty-Four Hour Notice of Noncompliance.	
Permittees must report certain noncompliance by phone. *See Part 7.9.*	Within 24 hours from when Permittee becomes aware of circumstances
8. NPDES Permit Renewal Application	
See Part 8.2.	**April 3, 2025**

2. ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, each Federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provide an opinion stating how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

2.1. Analytical Approach

This opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "jeopardize the continued existence of" a listed species, which is "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

This opinion relies on the definition of "destruction or adverse modification" which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species" (50 CFR 402.02).
The designation(s) of critical habitat for (species) use(s) the term primary constituent element (PCE) or essential features. The 2016 critical habitat regulations (50 CFR 424.12) replaced this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a ''destruction or adverse modification'' analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

The 2019 regulations define effects of the action using the term "consequences" (50 CFR 402.02). As explained in the preamble to the regulations (84 FR 44977), that definition does not change the scope of our analysis and in this opinion we use the terms "effects" and "consequences" interchangeably.

We use the following approach to determine whether a proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Evaluate the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Evaluate the environmental baseline of the species and critical habitat.
- Evaluate the effects of the proposed action on species and their habitat using an exposure-response approach.
- Evaluate cumulative effects.
- In the integration and synthesis, add the effects of the action and cumulative effects to the environmental baseline, and, in light of the status of the species and critical habitat, analyze whether the proposed action is likely to: (1) Directly or indirectly reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species; or (2) directly or indirectly result in an alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species.
- If necessary, suggest a RPA to the proposed action.

2.2. Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that would be adversely affected by the proposed action (Table 3). The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds that make up the designated area, and discusses the function of the PBFs that are essential for the conservation of the species.

Table 3. Listing status, status of critical habitat designations and protective regulations, and relevant Federal Register decision notices for ESA-listed species considered in this opinion.

Species	Listing Status	Critical Habitat	Protective Regulations
Chinook salmon *(Oncorhynchus tshawytscha)*			
Snake River spring/summer-run	T 6/28/05; 70 FR 37160	10/25/99; 64 FR 57399	6/28/05; 70 FR 37160
Snake River fall-run	T 6/28/05; 70 FR 37160	12/28/93; 58 FR 68543	6/28/05; 70 FR 37160
Sockeye salmon *(O. nerka)*			
Snake River	E 6/28/05; 70 FR 37160	12/28/93; 58 FR 68543	ESA section 9 applies
Steelhead (*O. mykiss*)			
Snake River Basin	T 1/05/06; 71 FR 834	9/02/05; 70 FR 52630	6/28/05; 70 FR 37160

Note: Listing status ‘T’ means listed as threatened under the ESA; ‘E’ means listed as endangered.

2.2.1. Status of the Species

This section describes the present condition of the Snake River spring/summer Chinook salmon, Snake River fall Chinook salmon, and Snake River sockeye salmon evolutionarily significant units (ESUs), and the Snake River basin steelhead distinct population segment (DPS). NMFS expresses the status of a salmonid ESU or DPS in terms of likelihood of persistence over 100 years (or risk of extinction over 100 years). NMFS uses McElhany et al.’s (2000) description of a viable salmonid population (VSP) that defines “viable” as less than a five percent risk of extinction within 100 years and “highly viable” as less than a one percent risk of extinction within 100 years. A third category, “maintained,” represents a less than 25 percent risk within 100 years (moderate risk of extinction). To be considered viable, an ESU or DPS should have multiple viable populations so that a single catastrophic event is less likely to cause the ESU/DPS to become extinct and so the ESU/DPS may function as a meta-population that can sustain population-level extinction and recolonization processes (ICTRT 2007). The risk level of the ESU/DPS is built up from the aggregate risk levels of the individual populations and major population groups (MPGs) that make up the ESU/DPS.

Attributes associated with a VSP are: (1) abundance (number of adult spawners in natural production areas); (2) productivity (adult progeny per parent); (3) spatial structure; and (4) diversity. A VSP needs sufficient levels of these four population attributes in order to safeguard the genetic diversity of the listed ESU or DPS; enhance its capacity to adapt to various environmental conditions; and allow it to become self-sustaining in the natural environment (ICTRT 2007). These viability attributes are influenced by survival, behavior, and experiences throughout the entire salmonid life cycle, characteristics that are influenced in turn by habitat and other environmental and anthropogenic conditions. The present risk faced by the ESU/DPS informs NMFS’ determination of whether additional risk will appreciably reduce the likelihood that the ESU/DPS will survive or recover in the wild.

The following sections summarize the status and available information on the species and designated critical habitats considered in this opinion based on the detailed information provided by the *ESA Recovery Plan for Snake River Spring/Summer Chinook Salmon & Snake River Basin*

Steelhead (NMFS 2017a), *ESA Recovery Plan for Snake River Fall Chinook Salmon* (NMFS 2017b), *ESA Recovery Plan for Snake River Sockeye Salmon* (NMFS 2015), *Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest* (NWFSC 2015), and *2016 five-year review: Summary and evaluation of Snake River sockeye salmon, Snake River spring-summer Chinook, Snake River fall-run Chinook, Snake River Basin steelhead* (NMFS 2016)]. Additional information (e.g., abundance estimates) has become available since the latest status review (NMFS 2016) and its technical support document (NWFSC 2015). This latest information represents the best scientific and commercial data available and is also summarized in the following sections.

2.2.1.1. Snake River Spring/Summer Chinook Salmon

The Snake River spring/summer Chinook salmon ESU was listed as threatened on April 22, 1992 (57 FR 14653). This ESU occupies the Snake River basin, which drains portions of southeastern Washington, northeastern Oregon, and north/central Idaho. Large portions of historical habitat were blocked in 1901 by the construction of Swan Falls Dam, on the Snake River, and later by construction of the three-dam Hells Canyon Complex from 1955 to 1967. Dam construction also blocked and/or hindered fish access to historical habitat in the Clearwater River basin as a result of the construction of Lewiston Dam (removed in 1973 but believed to have caused the extirpation of native Chinook salmon in that sub-basin). The loss of this historical habitat substantially reduced the spatial structure of this species. The production of SR spring/summer Chinook salmon was further affected by the development of the eight Federal dams and reservoirs in the main stem lower Columbia/Snake River migration corridor between the late 1930s and early 1970s (NMFS 2017a).

Several factors led to NMFS' conclusion that Snake River spring/summer Chinook salmon were threatened: (1) abundance of naturally produced Snake River spring and summer Chinook runs had dropped to a small fraction of historical levels; (2) short-term projections were for a continued downward trend in abundance; (3) hydroelectric development on the Snake and Columbia Rivers continued to disrupt Chinook runs through altered flow regimes and impacts on estuarine habitats; and (4) habitat degradation existed throughout the region, along with risks associated with the use of outside hatchery stocks in particular areas (Good et al. 2005). On May 26, 2016, in the agency's most recent five-year review for Pacific salmon and steelhead, NMFS concluded that the species should remain listed as threatened (81 FR 33468).

Life history. Snake River spring/summer Chinook salmon are characterized by their return times. Runs classified as spring Chinook salmon are counted at Bonneville Dam beginning in early March and ending the first week of June; summer runs are those Chinook salmon adults that pass Bonneville Dam from June through August. Returning adults will hold in deep main stem and tributary pools until late summer, when they move up into tributary areas and spawn. In general, spring-run type Chinook salmon tend to spawn in higher-elevation reaches of major Snake River tributaries in mid- through late August, and summer-run Chinook salmon tend to spawn lower in Snake River tributaries in late August and September (although the spawning areas of the two runs may overlap).

Spatial structure and diversity. The Snake River ESU includes all naturally spawning populations of spring/summer Chinook in the main stem Snake River (below Hells Canyon Dam) and in the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River sub-basins (57 FR 23458), as well as the progeny of 13 artificial propagation programs (85 FR 81822). The hatchery programs include the McCall Hatchery (South Fork Salmon River), South Fork Salmon River Eggbox, Johnson Creek, Pahsimeroi River, Yankee Fork Salmon River, Panther Creek, Upper Salmon River (Sawtooth Hatchery), Tucannon River, Lostine River, Catherine Creek, Lookingglass Creek, Upper Grande Ronde River, and Imnaha River programs. The historical Snake River ESU likely also included populations in the Clearwater River drainage and extended above the Hells Canyon Dam complex.

Within the Snake River ESU, the Interior Columbia Technical Recovery Team (ICTRT) identified 28 extant and 4 extirpated or functionally extirpated populations of spring/summer-run Chinook salmon, listed in Table 2 (ICTRT 2003; McClure et al. 2005). The ICTRT aggregated these populations into five MPGs: Lower Snake River, Grande Ronde/Imnaha Rivers, South Fork Salmon River, Middle Fork Salmon River, and Upper Salmon River. For each population, Table 4 shows the current risk ratings that the ICTRT assigned to the four parameters of a VSP (spatial structure, diversity, abundance, and productivity).

Spatial structure risk is low to moderate for most populations in this ESU (NWFSC 2015) and is generally not preventing the recovery of the species. Spring/summer Chinook salmon spawners are distributed throughout the ESU albeit at very low numbers. Diversity risk, on the other hand, is somewhat higher, driving the moderate and high combined spatial structure/diversity risks shown in Table 4 for some populations. Several populations have a high proportion of hatchery-origin spawners—particularly in the Grande Ronde, Lower Snake, and South Fork Salmon MPGs—and diversity risk will need to be lowered in multiple populations in order for the ESU to recover (ICTRT 2007; ICTRT 2010; NWFSC 2015).

Abundance and productivity. Historically, the Snake River drainage is thought to have produced more than 1.5 million adult spring/summer Chinook salmon in some years (Matthews and Waples 1991), yet in 1994 and 1995, fewer than 2,000 naturally produced adults returned to the Snake River (ODFW and WDFW 2019). From the mid-1990s and the early 2000s, the population increased dramatically and peaked in 2001 at 45,273 naturally produced adult returns. Since 2001, the numbers have fluctuated between 32,324 (2003) and 4,425 (2017), and the trend for the most recent five years (2016–2020) has been generally downward (ODFW and WDFW 2021). Furthermore, the most recent returns indicate that all populations in the ESU were below replacement for the 2013 brood year (Felts et al. 2019)[1] which reduced abundance across the ESU. Twenty Seven of the 28 extant populations remain at high risk of extinction due to low abundance and or productivity, with one population (Chamberlin Creek) at moderate risk of extinction (NWFSC 2015). All currently extant populations of Snake River spring/summer Chinook salmon will likely have to increase in abundance and productivity in order for the ESU to recover (Table 4).

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[1] The return size is not known until five years after the brood year. Preliminary results for the 2019 redd counts indicate that the 2014 brood year will be below replacement for the vast majority (possibly all) of the populations in the Snake River spring/summer Chinook salmon ESU.

Table 4. Summary of viable salmonid population (VSP) parameter risks and overall current status for each population in the Snake River spring/summer Chinook salmon evolutionarily significant unit (NWFSC 2015).

Major Population Group	**Population**	**VSP Risk Parameter**		**Overall Viability Rating**
		Abundance/ Productivity	**Spatial Structure/ Diversity**	
South Fork Salmon River (Idaho)	Little Salmon River	*Insuf. data*	Low	High Risk
	South Fork Salmon River main stem	High	Moderate	High Risk
	Secesh River	High	Low	High Risk
	East Fork South Fork Salmon River	High	Low	High Risk
Middle Fork Salmon River (Idaho)	Chamberlain Creek	Moderate	Low	Maintained
	Middle Fork Salmon River below Indian Creek	*Insuf. data*	Moderate	High Risk
	Big Creek	High	Moderate	High Risk
	Camas Creek	High	Moderate	High Risk
	Loon Creek	High	Moderate	High Risk
	Middle Fork Salmon River above Indian Creek	High	Moderate	High Risk
	Sulphur Creek	High	Moderate	High Risk
	Bear Valley Creek	High	Low	High Risk
	Marsh Creek	High	Low	High Risk
Upper Salmon River (Idaho)	North Fork Salmon River	*Insuf. data*	Low	High Risk
	Lemhi River	High	High	High Risk
	Salmon River Lower main stem	High	Low	High Risk
	Pahsimeroi River	High	High	High Risk
	East Fork Salmon River	High	High	High Risk
	Yankee Fork Salmon River	High	High	High Risk
	Valley Creek	High	Moderate	High Risk
	Salmon River Upper main stem	High	Low	High Risk
	Panther Creek			***Extirpated***
Lower Snake (Washington)	Tucannon River	High	Moderate	High Risk
	Asotin Creek			***Extirpated***
Grande Ronde and Imnaha Rivers (Oregon/ Washington)	Wenaha River	High	Moderate	High Risk
	Lostine/Wallowa River	High	Moderate	High Risk
	Minam River	High	Moderate	High Risk
	Catherine Creek	High	Moderate	High Risk
	Upper Grande Ronde River	High	High	High Risk
	Imnaha River	High	Moderate	High Risk
	Lookingglass Creek			***Extirpated***
	Big Sheep Creek			***Extirpated***

Snake River Fall-run Chinook Salmon

The Snake River fall Chinook salmon ESU was listed as threatened on April 22, 1992 (57 FR 14653). This ESU occupies the Snake River basin, which drains portions of southeastern Washington, northeastern Oregon, and north/central Idaho. Snake River fall Chinook salmon have substantially declined in abundance from historic levels, primarily due to the loss of primary spawning and rearing areas upstream of the Hells Canyon Dam complex (57 FR 14653). Additional concerns for the species have been the high percentage of hatchery fish returning to natural spawning grounds and the relatively high aggregate harvest impacts by ocean and in-river fisheries (Good et al. 2005). On May 26, 2016, in the agency's most recent five-year status review for Pacific salmon and steelhead, NMFS concluded that the species should remain listed as threatened (81 FR 33468).

Life history. Snake River fall Chinook salmon enter the Columbia River in July and August, and migrate past the lower Snake River main stem dams from August through November. Fish spawning takes place from October through early December in the main stem of the Snake River, primarily between Asotin Creek and Hells Canyon Dam, and in the lower reaches of several of the associated major tributaries including the Tucannon, Grande Ronde, Clearwater, Salmon, and Imnaha Rivers (Connor and Burge 2003; Ford 2011). Spawning has occasionally been observed in the tailrace areas of the four main stem dams (Dauble et al. 1999; Dauble et al. 1995; Dauble et al. 1994; Mueller 2009). Juveniles emerge from the gravels in March and April of the following year.

Snake River fall Chinook sub-yearlings rear and migrate downstream through the Snake and Columbia Rivers from March-August, with a significant number of juveniles overwintering in Snake River reservoirs prior to outmigration the following spring as yearlings (Connor et al. 2005; Hegg et al. 2013). Scale samples from natural-origin adult fall Chinook salmon taken at Lower Granite Dam have indicated that approximately half of the returns overwintered in freshwater (Ford 2011).

Spatial structure and diversity. The Snake River fall Chinook salmon ESU includes one extant population of fish spawning in the main stem of the Snake River and the lower reaches of several of the associated major tributaries including the Tucannon, Grande Ronde, Clearwater, Salmon, and Imnaha Rivers. The ESU also includes four artificial propagation programs: Lyons Ferry Hatchery, Fall Chinook Acclimation Ponds, Nez Perce Tribal Hatchery, and Idaho Power Program (85 FR 81822). Historically, this ESU included one large additional population spawning in the main stem of the Snake River upstream of the Hells Canyon Dam complex, an impassable migration barrier (NWFSC 2015). Four of the five historic major spawning areas in the Lower Snake population currently have natural-origin spawning. Spatial structure risk for the existing ESU is therefore low and is not precluding recovery of the species (NWFSC 2015).

There are several diversity concerns for Snake River fall Chinook salmon, leading to a moderate diversity risk rating for the extant Lower Snake population. One concern is the high proportion of hatchery fish spawning across the major spawning areas within the population (NWFSC 2015; NMFS 2017b). Between 2000 and 2014, the five-year average proportion of hatchery-origin fish has ranged from 38 percent (1990-1994) to 69 percent (2010-2014) (NWFSC 2015). The moderate diversity risk is also driven by changes in major life history patterns; shifts in phenotypic traits; high levels of genetic homogeneity in samples from natural-origin returns; selective pressure imposed by current hydropower operations; and cumulative harvest impacts (NWFSC 2015). Diversity risk will need to be reduced to low in order for this population to be considered highly viable, a requirement for recovery of the species. Low diversity risk would require that one or more major spawning areas produce a significant level of natural-origin spawners with low influence by hatchery-origin spawners (NWFSC 2015).

Abundance and productivity. Historical abundance of Snake River fall Chinook salmon is estimated to have been 416,000 to 650,000 adults (NMFS 2006), but numbers declined drastically over the 20th century, with only 78 natural-origin fish (WDFW and ODFW 2020) and 306 hatchery-origin fish (FPC 2019) passing Lower Granite Dam in 1990. Artificial propagation of fall Chinook salmon occurred from 1901 through 1909 and again from 1955 through 1973, but those efforts ultimately failed and, by the late 1970s, essentially all Snake River fall Chinook salmon were natural-origin. The large-scale hatchery effort that exists today began in 1976, when Congress authorized the Lower Snake River Compensation Plan to compensate for fish and wildlife losses caused by the construction and operation of the four lower Snake River dams. The first hatchery fish from this effort returned in 1981 and hatchery returns have comprised a substantial portion of the run every year since.

After 1990, abundance increased dramatically, and in 2014 the 10-year geometric mean (2005–2014) was 22,196 total adult returns (FPC 2019) and 6,148 natural-origin adult returns (NWFSC 2015). This is well above the minimum abundance of 4,200 natural-origin spawners needed for highly viable status. However, the productivity estimate for the 1990–2009 brood years is 1.5, which is below the 1.7 minimum needed for highly viable status. The best available scientific and commercial data available with respect to the adult abundance of this species indicates a substantial downward trend in the abundance of natural-origin spawners from 2013 to 2019. Five-year geometric means in the numbers of natural-origin spawners through 2019 have ranged from a high of 13,905 in 2015 to a low of 8,501 in 2019 (WDFW and ODFW 2020). Even with this decline, the overall abundance has remained higher than before 2005, and appears to remain above the minimum abundance threshold. NMFS will evaluate the viability risk of these more recent returns in the upcoming five-year status review, expected later in 2021.

Snake River Sockeye Salmon

This ESU includes all anadromous and residual sockeye salmon from the Snake River basin in Idaho, as well as artificially propagated sockeye salmon from the Redfish Lake captive propagation and Snake River sockeye salmon hatchery programs (85 FR 81822). The ESU was first listed as endangered under the ESA in 1991, and the listing was reaffirmed in 2005 (70 FR 37160). Reasons for the decline of this species include high levels of historic harvest, dam construction including hydropower development on the Snake and Columbia Rivers, water diversions and water storage, predation on juvenile salmon in the main stem river migration corridor, and active eradication of sockeye from some lakes in the 1950s and 1960s (56 FR 58619; ICTRT 2003). On May 26, 2016, in the agency's most recent five-year status review for Pacific salmon and steelhead, NMFS concluded that the species should remain listed as endangered (81 FR 33468).

Life history. Snake River sockeye salmon adults enter the Columbia River primarily during June and July, and arrive in the Sawtooth Valley peaking in August. The Sawtooth Valley supports the only remaining run of Snake River sockeye salmon. The adults spawn in lakeshore gravels, primarily in October (Bjornn et al. 1968). Eggs hatch in the spring between 80 and 140 days after spawning. Fry remain in the gravel for three to five weeks, emerge from April through May, and move immediately into the lake. Once there, juveniles feed on plankton for one to three years before they migrate to the ocean, leaving their natal lake in the spring from late April through May (Bjornn et al. 1968). Snake River sockeye salmon usually spend two to three years in the Pacific Ocean and return to Idaho in their fourth or fifth year of life.

Spatial structure and diversity. Within the Snake River ESU, the ICTRT identified historical sockeye salmon production in five Sawtooth Valley lakes, in addition to Warm Lake and the Payette Lakes in Idaho and Wallowa Lake in Oregon (ICTRT 2003). The sockeye runs to Warm

Lake, Payette Lake, and Wallowa Lakes are now extinct, and the ICTRT identified the Sawtooth Valley lakes as a single MPG for this ESU. The MPG consists of the Redfish, Alturas, Stanley, Yellowbelly, and Pettit Lake populations (ICTRT 2007). The only extant population is Redfish Lake, supported by a captive broodstock program. Hatchery fish from the Redfish Lake captive propagation program have also been out planted in Alturas and Pettit Lakes since the mid-1990s in an attempt to reestablish those populations (Ford 2011).

With such a small number of populations in this MPG, increasing the number of populations would substantially reduce the risk faced by the ESU (ICTRT 2007). The Northwest Fisheries Science Center (NWFSC) (2015) reports some evidence of very low levels of early-timed returns in some recent years from out-migrating naturally produced Alturas Lake smolts, but the ESU remains at high risk for spatial structure.

Currently, the Snake River sockeye salmon run is highly dependent on a captive broodstock program operated at the Sawtooth Hatchery and Eagle Hatchery. Although the captive brood program rescued the ESU from extinction, diversity risk remains high without sustainable natural production (Ford 2011; NWFSC 2015).

Abundance and productivity. Prior to the turn of the 20th century (ca. 1880), around 150,000 sockeye salmon ascended the Snake River to the Wallowa, Payette, and Salmon River basins to spawn in natural lakes (Chapman et al. 1990). The Wallowa River sockeye run was considered extinct by 1905, Black Canyon Dam on the Payette River blocked the Payette River run in 1924, and anadromous Warm Lake sockeye in the South Fork Salmon River basin may have been trapped in Warm Lake by a land upheaval in the early 20th century (ICTRT 2003). In the Sawtooth Valley, the IDFG eradicated sockeye from Yellowbelly, Pettit, and Stanley Lakes in favor of other species in the 1950s and 1960s, and irrigation diversions led to the extirpation of sockeye in Alturas Lake in the early 1900s (ICTRT 2003), leaving only the Redfish Lake sockeye. From 1991 to 1998, just 16 wild adult anadromous sockeye salmon returned to Redfish Lake. These 16 wild fish were incorporated into a captive broodstock program that began in 1992 and has since expanded so that the program currently releases hundreds of thousands of juvenile fish each year in the Sawtooth Valley (Ford 2011).

Even with the increase in hatchery production, adult returns to Sawtooth Valley have varied. The highest returns were seen in 2010, 2011, and 2014, ranging from 1,099 to 1,516 during these years (Johnson et al. 2020). The general increases observed in the number of adult returns during 2008-2014 is likely due to a number of factors, including increases in hatchery production and favorable marine conditions. The highest number of adults (1,516) returned in 2014, but numbers have generally declined since that time to a low of 17 in 2019 (Johnson et al. 2020). The total number of returning adults documented in the Sawtooth Valley in 2020 was 152 (Dan Baker, IDFG, email sent to Chad Fealko, NMFS, November 2, 2021 regarding 2020 sockeye returns). The recent general decline is in part due to poor survival and growth in the ocean.

The increased abundance of hatchery reared Snake River sockeye reduces the risk of immediate loss, yet levels of naturally produced sockeye returns remain extremely low (NWFSC 2015). The ICTRT's viability target is at least 1,000 naturally produced spawners per year in each of Redfish and Alturas Lakes and at least 500 in Pettit Lake (ICTRT 2007). Very low numbers of adults survived upstream migration in the Columbia and Snake Rivers in 2015 due to unusually high water temperatures. The implications of this high mortality for the recovery of the species are uncertain and depend on the frequency of similar high water temperatures in future years (NWFSC 2015).

The species remains at high risk across all four-risk parameters (spatial structure, diversity, abundance, and productivity). Although the captive brood program has been highly successful in producing hatchery *O. nerka*, substantial increases in survival rates across all life history stages must occur in order to reestablish sustainable natural production (NWFSC 2015). In particular, juvenile and adult losses during travel through the Salmon, Snake, and Columbia River migration corridor continue to present a significant threat to species recovery (NMFS 2015).

Snake River Basin Steelhead

The Snake River basin (SRB) steelhead was listed as a threatened ESU on August 18, 1997 (62 FR 43937), with a revised listing as a DPS on January 5, 2006 (71 FR 834). This DPS occupies the Snake River basin, which drains portions of southeastern Washington, northeastern Oregon, and north/central Idaho. Reasons for the decline of this species include substantial modification of the seaward migration corridor by hydroelectric power development on the main stem Snake and Columbia Rivers, loss of habitat above the Hells Canyon Dam complex on the main stem Snake River, and widespread habitat degradation and reduced stream flows throughout the Snake River basin (Good et al. 2005). Another major concern for the species is the threat to genetic integrity from past and present hatchery practices, and the high proportion of hatchery fish in the aggregate run of SRB steelhead over Lower Granite Dam (Good et al. 2005; Ford 2011). On May 26, 2016, in the agency's most recent five-year status review for Pacific salmon and steelhead, NMFS concluded that the species should remain listed as threatened (81 FR 33468).

Life history. Adult SRB steelhead enter the Columbia River from late June to October to begin their migration inland. After holding over the winter in larger rivers in the Snake River basin, steelhead disperse into smaller tributaries to spawn from March through May. Earlier dispersal occurs at lower elevations and later dispersal occurs at higher elevations. Juveniles emerge from the gravels in 4 to 8 weeks, and move into shallow, low-velocity areas in side channels and along channel margins to escape high velocities and predators (Everest and Chapman 1972). Juvenile steelhead then progressively move toward deeper water as they grow in size (Bjornn and Reiser 1991). Juveniles typically reside in fresh water for 1 to 3 years, although this species displays a wide diversity of life histories. Smolts migrate downstream during spring runoff, which occurs from March to mid-June depending on elevation, and typically spend 1 to 2 years in the ocean.

Spatial structure and diversity. This species includes all naturally spawning steelhead populations below natural and manmade impassable barriers in streams in the Snake River basin of southeast Washington, northeast Oregon, and Idaho, as well as the progeny of six artificial propagation programs (85 FR 81822). The artificial propagation programs include the Dworshak National Fish Hatchery, Salmon River B-run, South Fork Clearwater B-run, East Fork Salmon River Natural, Tucannon River, and the Little Sheep Creek/Imnaha River programs. The Snake River basin steelhead listing does not include resident forms of *O. mykiss* (rainbow trout) co-occurring with steelhead.

The ICTRT identified 24 extant populations within this DPS, organized into five MPGs (ICTRT 2003). The ICTRT also identified a number of potential historical populations associated with watersheds above the Hells Canyon Dam complex on the main stem Snake River, a barrier to anadromous migration. The five MPGs with extant populations are the Clearwater River, Salmon River, Grande Ronde River, Imnaha River, and Lower Snake River. In the Clearwater River, Dworshak Dam blocked the historic North Fork population from accessing spawning and rearing habitat. Current steelhead distribution extends throughout the DPS, such that spatial structure risk is generally low. For each population in the DPS, Table 5 shows the current risk ratings for the parameters of a VSP (spatial structure, diversity, abundance, and productivity).

The SRB steelhead DPS exhibit a diversity of life-history strategies, including variations in fresh water and ocean residence times. Traditionally, fisheries managers have classified SRB steelhead into two groups, A-run and B-run, based on ocean age at return, adult size at return, and migration timing. A-run steelhead predominantly spend one year in the ocean; B-run steelhead are larger with most individuals returning after two years in the ocean. New information shows that most Snake River populations support a mixture of the two run types, with the highest percentage of B-run fish in the upper Clearwater River and the South Fork Salmon River; moderate percentages of B-run fish in the Middle Fork Salmon River; and very low percentages of B-run fish in the Upper Salmon River, Grande Ronde River, and Lower Snake River (NWFSC 2015). Maintaining life history diversity is important for the recovery of the species.

Diversity risk for populations in the DPS is either moderate or low. Large numbers of hatchery steelhead are released in the Snake River, and the relative proportion of hatchery adults in natural spawning areas near major hatchery release sites remains uncertain. The high proportion of hatchery fish on natural spawning grounds and the uncertainty regarding these estimates (NWFSC 2015) thus, drives moderate diversity risks for some populations. Reductions in hatchery-related diversity risks would increase the likelihood of these populations reaching viable status.

Table 5. Summary of viable salmonid population (VSP) parameter risks and overall current status for each population in the Snake River Basin steelhead distinct population segment (NWFSC 2015). Risk ratings with "?" are based on limited or provisional data series.

Major Population Group	**Population**	**VSP Risk Parameter**		**Overall Viability Rating**
		Abundance/ Productivity	**Spatial Structure/ Diversity**	
Lower Snake River	Tucannon River	High?	Moderate	High Risk?
	Asotin Creek	Moderate?	Moderate	Maintained?
Grande Ronde River	Lower Grande Ronde	N/A	Moderate	Maintained?
	Joseph Creek	Very Low	Low	**Highly Viable**
	Wallowa River	N/A	Low	Maintained?
	Upper Grande Ronde	Low	Moderate	**Viable**
Imnaha River	Imnaha River	Moderate?	Moderate	Maintained?
Clearwater River (Idaho)	Lower Mainstem Clearwater River*	Moderate?	Low	Maintained?
	South Fork Clearwater River	High?	Moderate	High Risk?
	Lolo Creek	High?	Moderate	High Risk?
	Selway River	Moderate?	Low	Maintained?
	Lochsa River	Moderate?	Low	Maintained?
	North Fork Clearwater River			*Extirpated*
Salmon River (Idaho)	Little Salmon River	Moderate?	Moderate	Maintained?
	South Fork Salmon River	Moderate?	Low	Maintained?
	Secesh River	Moderate?	Low	Maintained?
	Chamberlain Creek	Moderate?	Low	Maintained?
	Lower Middle Fork Salmon River	Moderate?	Low	Maintained?
	Upper Middle Fork Salmon River	Moderate?	Low	Maintained?
	Panther Creek	Moderate?	High	High Risk?
	North Fork Salmon River	Moderate?	Moderate	Maintained?
	Lemhi River	Moderate?	Moderate	Maintained?
	Pahsimeroi River	Moderate?	Moderate	Maintained?
	East Fork Salmon River	Moderate?	Moderate	Maintained?
	Upper Mainstem Salmon River	Moderate?	Moderate	Maintained?
Hells Canyon	Hells Canyon Tributaries			*Extirpated*

*Current abundance/productivity estimates for the Lower Clearwater Mainstem population exceed minimum thresholds for viability, but the population is assigned moderate risk for abundance/productivity due to the high uncertainty associated with the estimate.

Abundance and productivity. Historical estimates of steelhead production for the entire Snake River basin are not available, but the basin is believed to have supported more than half the total steelhead production from the Columbia River basin (Good et al. 2005). The Clearwater River drainage alone may have historically produced 40,000 to 60,000 adults (Ecovista et al. 2003), and historical harvest data suggests that steelhead production in the Salmon River was likely higher than in the Clearwater (Hauck 1953). In contrast, at the time of listing in 1997, the five-year geomean abundance for natural-origin steelhead passing Lower Granite Dam, which includes all but one population in the DPS, was 11,462 adults (Ford 2011). Abundance began to increase in the early 2000s, with the single year count and the five-year geomean both peaking in 2015 at 45,789 and 34,179, respectively (ODFW and WDFW 2021). Since 2015, the numbers have declined steadily with only 9,634 natural-origin adult returns counted for the 2020-run year (ODFW and WDFW 2021).

Population-specific abundance estimates exist for some but not all populations. Of the populations for which we have data, three (Joseph Creek, Upper Grande Ronde, and Lower Clearwater) were meeting minimum abundance/productivity thresholds based on information included in the 2015 status review; however, since that time, abundance has substantially decreased. Only the five-year (2014-2018) geometric mean of natural-origin spawners of 1,786 for the Upper Grande Ronde population appears to remain above the minimum abundance threshold established by the ICTRT (Williams 2020). The status of many of the individual populations remains uncertain, and four out of the five MPGs are not meeting viability objectives (NWFSC 2015). In order for the species to recover, more populations will need to reach viable status through increases in abundance and productivity.

Status of Critical Habitat

In evaluating the condition of designated critical habitat, NMFS examines the condition and trends of PBFs, which are essential to the conservation of the ESA-listed species because they support one or more life stages of the species. Proper function of these PBFs is necessary to support successful adult and juvenile migration, adult holding, spawning, incubation, rearing, and the growth and development of juvenile fish. Modification of PBFs may affect freshwater spawning, rearing or migration in the action area. Generally speaking, sites required to support one or more life stages of the ESA-listed species (i.e., sites for spawning, rearing, migration, and foraging) contain PBFs essential to the conservation of the listed species (e.g., spawning gravels, water quality and quantity, side channels, or food) (Table 6).

Table 6. Types of sites, essential physical and biological features (PBFs), and the species life stage each PBF supports.

Site	Essential Physical and Biological Features	Species Life Stage
Snake River Basin steelhead[a]		
Freshwater spawning	Water quality, water quantity, and substrate	Spawning, incubation, and larval development
Freshwater rearing	Water quantity and floodplain connectivity to form and maintain physical habitat conditions	Juvenile growth and mobility
	Water quality and forage[b]	Juvenile development
	Natural cover[c]	Juvenile mobility and survival
Freshwater migration	Free of artificial obstructions, water quality and quantity, and natural cover[c]	Juvenile and adult mobility and survival
Snake River spring/summer Chinook salmon, fall Chinook, and sockeye salmon		
Spawning and juvenile rearing	Spawning gravel, water quality and quantity, cover/shelter (Chinook only), food, riparian vegetation, space (Chinook only), water temperature and access (sockeye only)	Juvenile and adult
Migration	Substrate, water quality and quantity, water temperature, water velocity, cover/shelter, food[d], riparian vegetation, space, safe passage	Juvenile and adult

[a] Additional PBFs pertaining to estuarine, nearshore, and offshore marine areas have also been described for Snake River Basin steelhead. These PBFs will not be affected by the proposed action and have therefore not been described in this opinion.

[b] Forage includes aquatic invertebrate and fish species that support growth and maturation.

[c] Natural cover includes shade, large wood, log jams, beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.

[d] Food applies to juvenile migration only.

Table 7 describes the geographical extent within the Snake River of critical habitat for each of the four ESA-listed salmon and steelhead species. Critical habitat includes the stream channel and water column with the lateral extent defined by the ordinary high-water line, or the bankfull elevation where the ordinary high-water line is not defined. In addition, critical habitat for the three salmon species includes the adjacent riparian zone, which is defined as the area within 300 feet of the line of high water of a stream channel or from the shoreline of standing body of water (58 FR 68543). The riparian zone is critical because it provides shade, streambank stability, organic matter input, and regulation of sediment, nutrients, and chemicals.

Table 7. Geographical extent of designated critical habitat within the Snake River for ESA-listed salmon and steelhead.

Evolutionarily Significant Unit (ESU)/ Distinct Population Segment (DPS)	Designation	Geographical Extent of Critical Habitat
Snake River sockeye salmon	58 FR 68543; December 28, 1993	Snake and Salmon Rivers; Alturas Lake Creek; Valley Creek, Stanley Lake, Redfish Lake, Yellowbelly Lake, Pettit Lake, Alturas Lake; all inlet/outlet creeks to those lakes.
Snake River spring/summer Chinook salmon	58 FR 68543; December 28, 1993 64 FR 57399; October 25, 1999	All Snake River reaches upstream to Hells Canyon Dam; all river reaches presently or historically accessible to Snake River spring/summer Chinook salmon within the Salmon River basin; and all river reaches presently or historically accessible to Snake River spring/summer Chinook salmon within the Hells Canyon, Imnaha, Lower Grande Ronde, Upper Grande Ronde, Lower Snake–Asotin, Lower Snake–Tucannon, and Wallowa sub-basins.
Snake River fall Chinook salmon	58 FR 68543; December 28, 1993	Snake River to Hells Canyon Dam; Palouse River from its confluence with the Snake River upstream to Palouse Falls; Clearwater River from its confluence with the Snake River upstream to Lolo Creek; North Fork Clearwater River from its confluence with the Clearwater River upstream to Dworshak Dam; and all other river reaches presently or historically accessible within the Lower Clearwater, Hells Canyon, Imnaha, Lower Grande Ronde, Lower Salmon, Lower Snake, Lower Snake–Asotin, Lower North Fork Clearwater, Palouse, and Lower Snake–Tucannon sub-basins.
Snake River Basin steelhead	70 FR 52630; September 2, 2005	Specific stream reaches are designated within the Lower Snake, Salmon, and Clearwater River basins. Table 21 in the Federal Register details habitat areas within the DPS's geographical range that are excluded from critical habitat designation.

Spawning and rearing habitat quality in tributary streams in the Snake River varies from excellent in wilderness and roadless areas to poor in areas subject to intensive human land uses (NMFS 2015; NMFS 2017a). Critical habitat throughout much of the Interior Columbia, (which includes the Snake River and the Middle Columbia River) has been degraded by intensive agriculture, alteration of stream morphology (i.e., channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, livestock grazing, dredging, road construction and maintenance, logging, mining, and urbanization. Reduced summer stream flows, impaired water quality, and reduction of habitat complexity are common problems for critical habitat in non-wilderness areas. Human land use practices throughout the basin have caused streams to become straighter, wider, and shallower, thereby reducing rearing habitat and increasing water temperature fluctuations.

In many stream reaches designated as critical habitat in the Snake River basin, stream flows are substantially reduced by water diversions (NMFS 2015; NMFS 2017a). Withdrawal of water, particularly during low-flow periods that commonly overlap with agricultural withdrawals, often increases summer stream temperatures, blocks fish migration, strands fish, and alters sediment transport (Spence et al. 1996). Reduced tributary streamflow has been identified as a major limiting factor for Snake River spring/summer Chinook and Snake River basin steelhead in particular (NMFS 2017a).

Many stream reaches designated as critical habitat for these species are listed on the Clean Water Act 303(d) list for impaired water quality, such as elevated water temperature (IDEQ 2020). Many areas that were historically suitable rearing and spawning habitat are now unsuitable due to high summer stream temperatures, such as some stream reaches in the Upper Grande Ronde. Removal of riparian vegetation, alteration of natural stream morphology, and withdrawal of water for agricultural or municipal use all contribute to elevated stream temperatures. Water quality in spawning and rearing areas in the Snake River has also been impaired by high levels of sedimentation and by heavy metal contamination from mine waste (e.g., IDEQ and USEPA 2003; IDEQ 2001).

The construction and operation of water storage and hydropower projects in the Columbia River basin, including the eight run-of-river dams on the main stem lower Snake and lower Columbia Rivers, have altered biological and physical attributes of the main stem migration corridor. Hydro-system development modified natural flow regimes, resulting in warmer late summer and fall water temperature. Changes in fish communities led to increased rates of piscivorous predation on juvenile salmon and steelhead. Reservoirs and project tailraces have created opportunities for avian predators to successfully forage for smolts, and the dams themselves have created migration delays for both adult and juvenile salmonids. Physical features of dams, such as turbines, have delayed migration for both adults and juveniles. Turbines and juvenile bypass systems have also killed some out-migrating fish. However, some of these conditions have improved. The Bureau of Reclamation and U.S. Army Corps of Engineers have implemented measures in previous Columbia River System hydropower consultations to improve conditions in the juvenile and adult migration corridor including 24-hour volitional spill, surface passage routes, upgrades to juvenile bypass systems, and predator management measures. These measures are ongoing and their benefits with respect to improved functioning of the migration corridor PBFs will continue into the future.

Climate Change Implications for ESA-listed Species and their Critical Habitat

One factor affecting the rangewide status of Snake River salmon and steelhead, and aquatic habitat at large, is climate change. The U.S. Global Change Research Program (USGCRP) reports average warming in the Pacific Northwest of about 1.3ºF from 1895 to 2011, and projects an increase in average annual temperature of 3.3ºF to 9.7ºF by 2070 to 2099 (compared to the period 1970 to 1999), depending largely on total global emissions of heat-trapping gases (predictions based on a variety of emission scenarios including B1, RCP4.5, A1B, A2, A1FI, and RCP8.5 scenarios). The increases are projected to be largest in summer (Melillo et al. 2014, USGCRP 2018). The five warmest years in the 1880 to 2019 record have all occurred since 2015, while 9 of the 10 warmest years have occurred since 2005 (Lindsey and Dahlman 2020).

Several studies have revealed that climate change has the potential to affect ecosystems in nearly all tributaries throughout the Snake River (Battin et al. 2007; Independent Scientific Advisory Board; ISAB 2007). While the intensity of effects will vary by region (ISAB 2007), climate change is generally expected to alter aquatic habitat (water yield, peak flows, and stream temperature). As climate change alters the structure and distribution of rainfall, snowpack, and glaciations, each factor will in turn alter riverine hydrographs. Given the increasing certainty that climate change is occurring and is accelerating (Battin et al. 2007), NMFS anticipates salmonid habitats will be affected. Climate and hydrology models project significant reductions in both total snow pack and low-elevation snow pack in the Pacific Northwest over the next 50 years (Mote and Salathé 2009). These changes will shrink the extent of the snowmelt-dominated habitat available to salmon and may restrict our ability to conserve diverse salmon life histories.

In the Pacific Northwest, most models project warmer air temperatures, increases in winter precipitation, and decreases in summer precipitation. Average temperatures in the Pacific Northwest are predicted to increase by 0.1 to 0.6°C (0.2°F to 1.0°F) per decade (Mote and Salathé 2009). Warmer air temperatures will lead to more precipitation falling as rain rather than snow. As the snowpack diminishes, seasonal hydrology will shift to more frequent and severe early large storms, changing stream flow timing, which may limit salmon survival (Mantua et al. 2009). The largest driver of climate-induced decline in salmon populations is projected to be the impact of increased winter peak flows, which scour the streambed and destroy salmon eggs (Battin et al. 2007).

Higher water temperatures and lower spawning flows, together with increased magnitude of winter peak flows are all likely to increase salmon mortality. The ISAB (2007) found that higher ambient air temperatures will likely cause water temperatures to rise. Salmon and steelhead require cold water for spawning and incubation. As climate change progresses and stream temperatures warm, thermal refugia will be essential to persistence of many salmonid populations. Thermal refugia are important for providing salmon and steelhead with patches of suitable habitat while allowing them to undertake migrations through or to make foraging forays into areas with greater than optimal temperatures. To avoid waters above summer maximum temperatures, juvenile rearing may be increasingly found only in the confluence of colder tributaries or other areas of cold-water refugia (Mantua et al. 2009).

Climate change is expected to make recovery targets for salmon and steelhead populations more difficult to achieve. Climate change is expected to alter critical habitat by generally increasing temperature and peak flows and decreasing base flows. Although changes will not be spatially homogenous, effects of climate change are expected to decrease the capacity of critical habitat to support successful spawning, rearing, and migration. Habitat actions can address the adverse impacts of climate change on salmon. Examples include restoring connections to historical floodplains and freshwater and estuarine habitats to provide fish refugia and areas to store excess floodwaters, protecting and restoring riparian vegetation to ameliorate stream temperature increases, and purchasing or applying easements to lands that provide important cold water or refuge habitat (Battin et al. 2007; ISAB 2007).

2.3. Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02).

For purposes of this consultation, the action area extends from the farthest upstream City/LCSC and ITD2 stormwater discharges that may affect the Clearwater River from RM 4 downstream to its confluence with the Snake River and from the farthest upstream City/LCSC and ITD2 stormwater discharges that may affect the Snake River at RM 144 near the Tammany Creek confluence. The action area includes two small tributary streams: Lindsay Creek, in which stormwater discharges may affect fish and the amount of food near its confluence with the Clearwater River at RM 2.2 and Tammany Creek, in which stormwater discharges may affect fish and the amount of food in its lower one-half mile and confluence with the Snake River at RM 144. The action area extends downstream in the Snake River to Lower Granite Dam (LGD) at RM 103, which is the waterbody (Lower Granite Reservoir; LGR) where sediment-bound loads from the proposed action are expected to settle and traceable effects to resident biota are expected to occur.

Within the action area, the Snake River is used by rearing and migrating juveniles and migrating and staging adults of threatened Snake River spring/summer Chinook salmon, Snake River Fall Chinook salmon, Snake River Basin steelhead, and endangered Snake River sockeye salmon. The lower Clearwater River is used by rearing and migrating juveniles and migrating and staging adults of Snake River fall Chinook salmon and Snake River Basin steelhead. Lower Tammany Creek may be used by spawning and rearing Snake River Basin steelhead. Within the action area the Snake River is designated critical habitat for Snake River spring/summer Chinook salmon, Snake River fall Chinook salmon, Snake River sockeye salmon, and Snake River Basin steelhead; the Clearwater River is designated critical habitat for Snake River fall Chinook salmon and Snake River Basin steelhead; and the lower one-half mile of Tammany Creek is designated critical habitat for Snake River Basin steelhead.

2.4. Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultations, and the impact of State or private actions, which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

Urban development alters the natural infiltration of vegetation and soil and generates or collects many diverse pollutants that accumulate on impervious surfaces and compacted and poor soils. Precipitation runs off these surfaces and is quickly drained through a system of conveyances into streams, rivers, and lakes. The hydrologic effects of these alterations and climate change increase erosion and streambank scouring, downstream sedimentation and flooding, and channel simplifications, which can affect aquatic life (Jorgensen et al. 2013; Jonsson et al. 2017). Contaminants become entrained in stormwater from a variety of sources in the urban landscape and are typically discharged to surface waters in mixtures. Urban stormwater is commonly a major contributing factor to water quality impairments (EPA 2020).

Roads generate a broad range and large loads of pollutants that accumulate and runoff impervious surfaces into stormwater drains and into streams, rivers, and lakes. Vehicle wear and emissions are primary sources of tire tread particles, metallic particles (particularly copper and chromium); persistent bio-accumulating toxicants (PBTs) from upholstery, plastic, and carpet; and polycyclic aromatic hydrocarbons (PAHs), nickel, and zinc from exhaust and leakage.

The current types, concentrations, and loads of pollutants draining from the Lewiston UA and associated roadways are not well monitored. Stormwater contaminants from monitored UAs and proximate receiving waters in the region and elsewhere (EPA 2020) indicate pollutants entering the Lewiston UA stormwater conveyances are likely to include: common-use herbicides and pesticides, nutrients (nitrogen, phosphorus), silt and sediment, chlorides, metals, petroleum hydrocarbons, livestock fecal matter (bacteria), pharmaceuticals, surfactants (detergents, cleaners, pesticide adjuvants), along with several PBTs and their metabolites (Table 8). These common and legacy pollutants are often present regardless of land use within a drainage. Other parameters such as temperature, pH, hardness, and conductivity may also be pollutants or indicators that other pollutants are negatively impacting receiving waters.

Table 8. Common urban area pollutants expected in Lewiston stormwater.

Pollutant Class	Examples	Urban Sources
PBTs (persistent bio-accumulating toxicants)	POPs (persistent organochlorine pollutants) PCBs (polychlorinated biphenyls) PBDEs (polybrominated diphenyl ethers) PFCs (poly- and per-fluorinated compounds) Pharmaceuticals (estrogen, antidepressant)	Eroding soil, solids, development, redevelopment, vehicles, emissions, industrial, consumer products
Petroleum hydrocarbons	PAHs (polycyclic aromatic hydrocarbons), microplastics	Roads (vehicles, tires), Industrial, consumer products
Metals	Mercury, copper, chromium, nickel, titanium, zinc	Roads, electronics, pesticides, paint, waste treatment
Common use pesticides, surfactants	Herbicides (glyphosate, diquat), insecticides, fungicides, adjuvants, surfactants (detergents, soaps)	Roads, railways, lawns, levees, golf courses, parks
Nutrients and Sediment	Nitrogen, phosphorus fertilizers Fine-grained inorganic sediment	Fertilizer, soil erosion
Temperature and Dissolved oxygen	Warm water, unvegetated exposed surfaces (soil, water, sediments)	Impervious surfaces, rock, soil (roads, parking lots, railways, roofs,)
Bacteria	*Escherichia coli*	Livestock waste, organic solids

Contaminants in stormwater drains may reach receiving waters in solution or bound to organic or inorganic material. Water currents may transport contaminates that are in solution or suspended far downstream, even to estuaries and the ocean. Contaminants bound to solids typically settle on substrates, where some are buried by sedimentation and sequestered to deep sediments away from most aquatic biota. Wind waves, water currents, and changing water levels erode substrates and resuspend contaminated sediments that are transported farther downstream (Johnson et al. 2005). Sedimentation of contaminated material occurs in habitats with slower currents (wider or deeper sections of channel, reservoir backwaters, coves, and shorelines). In soil, sediments, and water, various metals and changes in oxygen, pH, and temperature can alter toxicity, binding properties, volatility, and degradation patterns and persistence of contaminants (Johnson et al. 2005). Metals especially serve as redox catalysts, chelating or binding other contaminants or eluting them from their bound state. Salmonid prey may accumulate contaminants by direct contact in water and sediments, ventilation in water, or ingestion of contaminated plankton, invertebrates, detritus, and sediment. Salmonids and other fish may be exposed to contaminants in water by dermal contact, respiration, and from ingestion of contaminated prey.

In the Snake River and its tributaries upstream of the action area, the collective effects of agriculture and its irrigation storage reservoirs, hydropower development, mining, forestry, grazing, and urbanization have combined to negatively affect the environmental baseline for water and sediment quality in the action area. Most populations of Snake River salmon ESUs and the SRB steelhead DPS depend upon the Snake River in the action area, and downstream reaches of the lower Snake River and Columbia River, for juvenile rearing and migration and adult migration routes between the Pacific Ocean and spawning areas in Idaho and eastern Oregon.

Contaminants in water and sediments of the action area that are also present throughout the lower Snake River and Columbia River downstream of action area include mercury, copper, and other metals; chlorinated pesticides and their degradates (DDT, DDD, DDE), polychlorinated dibenzo-p-dioxins and furans, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), PAHs, and many others (Hinck et al. 2006; Seiders et al. 2007; Johnson et al. 2006; Johnson et al. 2013a; Alvarez et al. 2014; Counihan et al. 2014; WDOE 2006. Persistent organochlorine pollutants (POPs), some of which were discontinued 15 to 30 years ago, still exceed benchmarks for human health, aquatic life, and fish-eating wildlife in water, bed-sediment, and fish tissue samples in the Snake and Columbia Rivers (Johnson and Norton 2005; Hinck et al. 2006; Seiders et al. 2011; Johnson et al. 2007; Johnson et al. 2013b; Nilsen et al. 2014; Alvarez et al. 2014; WDOE 2021). Arkoosh et al. (2011) found high proportions (42 percent to 94 percent) of juvenile Chinook salmon were exposed to PBT and PAH levels in the action area that could potentially cause adverse effects and that contribute to harmful body burdens and lipid concentrations that continue to be accumulated during rearing and migration in downriver reaches. Thus, Snake River salmonid exposure and bioaccumulation of PBTs occurring in the action area significantly contribute to harmful levels measured in Snake River salmonid juveniles in the Columbia River and estuary (Arkoosh et al. 2011).

Lower Granite Dam (LGD) and reservoir (LGR) is the uppermost of four projects on the lower Snake River, including Little Goose, Lower Monumental, and Ice Harbor dams and reservoirs. All are run-of-the river facilities, with limited storage capacity. The dams were built to support navigation, hydropower generation, irrigation, and recreation. The impoundment of the river converted it into a continuous reservoir system, increasing depths to 100 feet or more, altering and slowing river flows, increasing water temperature and sedimentation of contaminants (Coutant and Whitney 2006). Temperature, dissolved oxygen, and pH are water quality impairment pollutants in the Snake River where it flows into LGR (WDOE 2021) and the action area in Idaho and Washington. Dissolved oxygen levels in the Snake River at the head of the LGR may be quite low from early summer to fall, because dissolved oxygen is primarily reduced by high water temperatures (NMFS 2004; EPA 2020). Dissolved oxygen concentration at the upstream monitoring location on the Snake River ranged from 5.9 mg/L to 14.4 mg/L, with a mean of 8.59 mg/L (EPA 2019, 2020).

Tiffan and Hatten (2012) estimated 44 percent of LGR shoreline is comprised of riprap. Almost the entire shoreline of the Lewiston UA along the Snake and Clearwater Rivers is hardscaped with riprap. The Lewiston levees that extend 7.6 miles mostly along the lower Clearwater River are practically devoid of vegetation or trees (Figure 2; EPA 2020). This lack of vegetation along with the hardscape shoreline and channel modification reduces the function and value of salmonid habitat, resulting in a reduction in prey in the action area, and increased floodplain water temperatures of 7-10ºC over that of the Clearwater River (EPA 2020; COE 2005; Nitoiu and Beltrami 2005; Henning et al. 2006; Jorgensen et al. 2013). To prevent growth of vegetation, levees are treated with highly toxic formulations and mixtures of terrestrial herbicides (Roundup, diquat, and others); this practice of levee management has not undergone ESA section 7 consultation (NMFS 2019; NMFS 2012).

Figure 2**.**Google Earth images of lower Clearwater River riparian and floodplain habitats; (upper) north levee a pump station and (lower) west levee pump station.

The COE changes pool elevations of LGR and/or dredges the lower Clearwater River and confluence area seasonally and every few years as needed to maintain navigation access (NMFS 2014b). Dredge spoils are disposed of in-water within LGR (Bennett et al. 1995; Gottfried et al. 2011; NMFS 2014b), where variable water levels may repeatedly resuspend potentially contaminated sediment and redistribute it farther downriver (Tremblay and Lucotte 1997). Using dredge spoils to create shallow water habitat that was lost from the inundation of LGR, has attracted increased use by juvenile salmonids (Gottfried et al. 2011), although risk from contaminated sediments continues. Hydropower, navigation, industry, urbanization, agriculture, levees, and widespread bank armoring have adversely impacted habitat in the action area. These altered habitats reduce survival and growth of listed salmonids in the action area by contributing to elevated water temperature, increased chemical contamination, and the proliferation of invasive plants, invertebrates, and warm water fish predators and competitors (NMFS 2019; Erhardt et al. 2018; Tiffan et al. 2020; Tiffan et al. 2014; Tiffan et al. 2016; Garland et al. 2002; Li et al. 1984).

Sediment Quality in the Action Area

Sediments of the Snake and Clearwater Rivers in the action area have accumulated chemical contaminants from several sources, including dioxin, metals, pesticides, herbicides, ammonia and nitrogen (NMFS 2004; USFWS 2004; EPA 2020).

Sediment core samples in the action area of LGR and the Snake and Clearwater Rivers contained higher concentrations of metals in fine-grained sediments. Higher velocity currents and turbulence at the confluence typically carry contaminated suspended solids and sediments farther downstream into LGR. The particles then settle in substrate depressions and other areas of slower current (Braun et al. 2012), including those along shallow water and nearshore habitats where juvenile salmonids rear and feed. Highest concentrations of metals contaminating sediments were often at or within a foot of substrate surfaces and readily available to benthic invertebrates. Consistent concentrations in cores extending from substrate surfaces to five feet in depth indicate contaminant loads are continually delivered.

Of the metals tested in the action area copper and chromium most frequently exceeded sediment quality guidelines (SQGs) threshold effect concentrations (TECs[2]) (MacDonald et al. 2000a), primarily within the lower Clearwater River and 1-18 miles downstream of the confluence (Table 9; Braun et al. 2012). Typically, metals concentrations were lower in samples collected from the Snake River upstream from the confluence as compared to those collected from the Clearwater River and downstream in LGR (Braun et al. 2012). Concentrations of metals were greater than TECs in 43 percent of the samples at site 31 (Snake RM 121) and 29 percent of the samples at site 9 (Clearwater RM 0.9; Braun et al. 2012; Table 9). The highest concentration of sediment copper (740 mg/kg DW) was found in the lower Clearwater River (RM 0.9) off its northern shore, which far exceeds the probable effects level (PEL of 197 mg/kg DW; MacDonald et al. 2000a; Buchman 2008). The highest sediment concentrations of zinc (390 mg/kg DW; Table 9) were found at this same location in the lower Clearwater River, which exceeded its PEL of 315 mg/kg DW).

Sediment mercury concentrations exceeded TECs in samples from three sites in the Snake River within the action area, from one mile upstream of the Clearwater confluence to 18 miles downstream of the confluence (Braun et al. 2012). Most mercury concentrations from sediments of the Snake and Clearwater River ranged from 0.01-0.04 mg/kg DW; however, several samples downstream from the confluence had mercury concentrations of 0.1-0.3 mg/kg DW. The highest concentration of sediment mercury (2.32 mg/kg DW) exceeded its PEL of 0.49 mg/kg DW and was found in the action area of the Snake River within the pool of LGR about one mile upstream of the Clearwater confluence (Table 9; Braun et al. 2012).

Hells Canyon Dam is about 100 river miles upstream of the action area and is one of three dams/reservoirs that release substantial concentrations (0.062 ng/L) of methylmercury (MeHg) during late summer and fall and concentrations of unfiltered inorganic divalent Hg during early spring (median 0.9-0.96 ng/L; Baldwin et al. 2020). Significant adverse sub-lethal effects for sensitive aquatic species are observed at 0.03-0.1 µg/L and water quality criteria of 0.012 µg/L provide only limited protection (Eisler 1987; NMFS 2014a). Mercury species are transformed by organic and inorganic processes to MeHg, which quickly bio-accumulates throughout aquatic food webs and biomagnifies through trophic levels. Dissolved MeHg from the Hells Canyon Complex is delivered by the Snake River directly to the action area. Thirty-one percent of smallmouth bass sampled from the Hells Canyon Complex to 60 miles downstream in the Snake River exceeded IDEQ's human health fish tissue criterion for mercury (0.3 mg/kg WW). In the action area, mercury concentrations in resident fish exceed Washington's water quality criteria for human health concentrations (Table 10; WDOE 2021).

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[2] In sediment quality guidelines, threshold effect concentration (TEC) and probable effect level (PEL) are designed to frame responses of aquatic organisms to contaminant challenges (i.e., toxicity test endpoints). Basically, if toxic concentrations in sediment exceed TEC then adverse effects to some endpoints (e.g., diversity, growth, food web contamination) are expected and if sediment concentrations exceed PEL then severe habitat degradation and associated adverse effects are expected (e.g., reduced abundance, lethality, food web contamination).

Dworshak Dam is about 40 river miles upstream of the action area where cold water is released from the hypolimnion of its 600 feet deep reservoir during spring and summer to mitigate warm temperatures in the lower Snake River reservoirs. Cold-water releases from Dworshak Reservoir are commonly large enough to double natural flows of the lower Clearwater River in the action area. Concentrations of MeHg released from Dworshak Reservoir were not found in literature searches, but its large varial zone and thermally stratified depths have potential for MeHg production, even if nutrients and mercury are limited. Water from Dworshak Reservoir has low concentrations of dissolved organic carbon (DOC). Low DOC (9 mg/L; EPA 2019) in the action area increases the toxicity of copper (NMFS 2014a) to juvenile salmonids and their invertebrate prey.

Another metal prevalent in the sediments of LGR was titanium dioxide (TiO_2). The acute effects screening threshold level for TiO_2 is 2,000 ppb in Buchman (2008). Braun et al. (2012) found concentrations of TiO_2 in sediments of the lower Clearwater River ranged from (4,540 to 7,760 mg/kg or ppm), which were distributed in slightly declining concentrations to LGD. Consistent concentrations of TiO_2 from near substrate surfaces to depths of five feet, indicate discharged loads are substantial and continual over long-terms and are readily available to bind with PBTs and metals and enter food webs. Titanium dioxide concentrations in sediments of the Snake River above the confluence were approximately half or less than those of the lower Clearwater River, which indicates local source(s).

Table 9. Locations of exceedances of probable effect levels (PELs), threshold effect concentrations (TECs), and concentration ranges of metals among dry-weight sediment core samples from the Snake and Clearwater Rivers in the action area (MacDonald et al. 2000a; Braun et al. 2012). River miles (RMs) increase from river mouths upstream; the Clearwater River confluence is at RM 139 of the Snake River and RM 0 of the Clearwater River.

Receiving Water	River Mile	Site	Copper (11-740 mg/kg)	Chromium (20-56 mg/kg)	Mercury (0.01-2.3 mg/kg)	Nickel (10-28 mg/kg)	Lead (11-39 mg/kg)	Zinc (45-390 mg/kg)
Snake	141	84	TEC					
Snake	140	81	TEC		PEL			
Clearwater	0.92	9	PEL	TEC		TEC		PEL
Snake	138	60	TEC	TEC	TEC			
Snake	130	38	TEC	TEC		TEC		
Snake	121	31	TEC	TEC	TEC	TEC	TEC	TEC

Sediment concentrations of several metals exceeded harmful effects thresholds, which are expected to reduce and alter benthic invertebrate communities (MacDonald et al. 2000a). Such alteration first reduces abundance and production of sensitive benthic invertebrate, such as filter feeders and other large-bodied energy-rich prey. Fine sediment commonly leads to a preponderance of smaller-bodied guilds of silt/sand burrowing invertebrates that may bioaccumulate contaminants at relatively higher rates. NMFS (2004) summarized the near absence of bivalve mussels in the action area and required monitoring for a bioaccumulation study. EPA (2019) described that attempts to rear bivalves in cages throughout the confluence area failed due to mortality. Although warm temperatures were described as the likely cause, substrate-water fluxes of metals (Amato et al. 2018) or sedimentation were also likely contributors. Nonnative *Neomysis* prawns have invaded the action area and are increasing in relative abundance and in salmonid diets (Tiffan et al. 2014). These small benthic invertebrates are omnivores that may feed heavily on contaminated detritus in offshore and nearshore depositional areas. Vertical nocturnal and seasonal migrations to shallow water may bring deep-water sequestered benthic energy and contaminants to shallow water-feeding salmonids (Tiffan et al. 2017). Ingesting relatively more, smaller prey that are closely associated with contaminated sediments is likely to increase bioaccumulation rates in rearing salmonids (Farag et al. 1998; Bettaso and Goodman 2010).

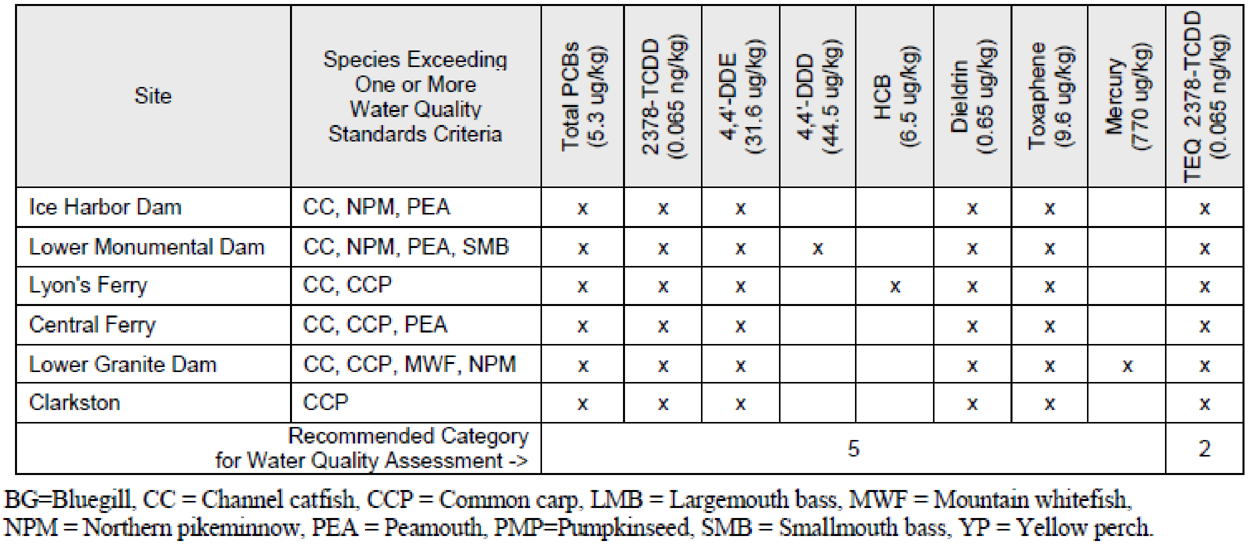
Contaminants in Fish in the Action Area

Seiders et al. (2011) collected fish from six areas of the Snake River within and downstream of the action area. Sixty samples from ten species of fish were tested for mercury, POPs, PCBs, PBDEs, and polychlorinated dibenzo-p-dioxins and furans (PCDD/Fs). No sites in these reaches of the Snake River met the State of Washington's water quality standards fish tissue/human health criteria for fish consumption because of elevated levels of contaminants in one or more species of fish.

Washington lists these reaches and water bodies as water quality impaired under the Federal Clean Water Act (Category 5; 303[d] list; WDOE 2021). Fish monitoring sites in LGR included one near Clarkston (just downstream of the Lewiston UA and confluence with the Clearwater River) and another farther downstream near LGD, which are in the action area. These two sites did not meet Washington water quality criteria for fish tissue/human health criteria for fish consumption based on elevated concentrations of total PCBs, 2378-TCDD, 4,4'-DDE, dieldrin, toxaphene, and mercury in resident fishes (Table 10; Seiders et al. 2011; Seiders and Sandvik 2020). These monitored sites are downstream of the Lewiston UA and receive contaminated stormwater and other discharges from several industrial, navigation, and commercial sites along the lower Clearwater and Snake Rivers in Idaho.

Typically, long-lived, larger-bodied, higher trophic-level piscivores, and strongly benthic fishes have highest concentrations of bioaccumulate and biomagnified contaminants in tissues. These are represented in the Snake River by channel catfish, bass, and northern pikeminnow (Table 10). Also contaminated, however, are mountain whitefish, peamouth, and bluegill, which feed on benthic invertebrates and zooplankton across a range of habitats (substrate, water column, and surface), at similar trophic stages to juvenile salmonids, albeit for only a few more years. Erhardt et al. (2018) estimated salmonids could comprise 30 percent of the annual diets of smallmouth bass in LGR.

Table 10. Monitoring sites, fish species, and 303d listed impairment pollutants in the Snake River in Washington (from Seiders et al. 2011; Seiders and Sandvik 2020; WDOE 2021). Sites Lower Granite Dam (RMs 103-105) and Clarkston (RMs 130-135) are in the action area.



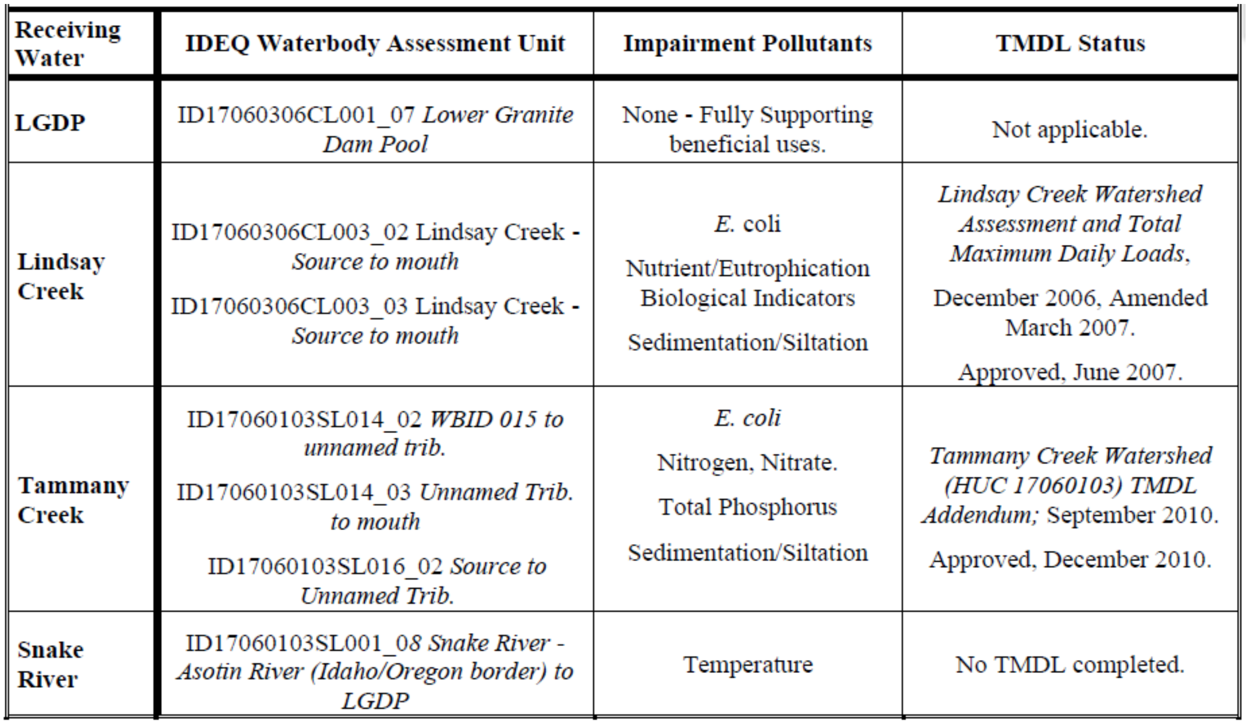
Site	Species Exceeding One or More Water Quality Standards Criteria	Total PCBs (5.3 ug/kg)	2378-TCDD (0.065 ng/kg)	4,4'-DDE (31.6 ug/kg)	4,4'-DDD (44.5 ug/kg)	HCB (6.5 ug/kg)	Dieldrin (0.65 ug/kg)	Toxaphene (9.6 ug/kg)	Mercury (770 ug/kg)	TEQ 2378-TCDD (0.065 ng/kg)
Ice Harbor Dam	CC, NPM, PEA	x	x	x			x	x		x
Lower Monumental Dam	CC, NPM, PEA, SMB	x	x	x	x		x	x		x
Lyon's Ferry	CC, CCP	x	x	x		x	x	x		x
Central Ferry	CC, CCP, PEA	x	x	x			x	x		x
Lower Granite Dam	CC, CCP, MWF, NPM	x	x	x			x	x	x	x
Clarkston	CCP	x	x	x			x	x		x
	Recommended Category for Water Quality Assessment ->	5								2

BG=Bluegill, CC = Channel catfish, CCP = Common carp, LMB = Largemouth bass, MWF = Mountain whitefish, NPM = Northern pikeminnow, PEA = Peamouth, PMP=Pumpkinseed, SMB = Smallmouth bass, YP = Yellow perch.

Idaho Water Quality and Other Dischargers in the Action Area

The state of Idaho includes the Snake River, Lindsay and Tammany Creeks as impaired waters (Table 11; IDEQ 2016), all of which are receiving waters of Lewiston MS4 discharges. The lower Clearwater River within the Lower Granite Dam Pool (LGDP) is listed by IDEQ (2016) as having no impairment pollutants and as fully supporting all beneficial uses.

Table 11. Water quality assessments, impairment pollutants, and TMDL status of receiving waters in and around the Lewiston Urban Area in Idaho. The receiving waterbody LGDP is the lower Clearwater River within the Lower Granite Dam Pool.



Receiving Water	IDEQ Waterbody Assessment Unit	Impairment Pollutants	TMDL Status
LGDP	ID17060306CL001_07 *Lower Granite Dam Pool*	None - Fully Supporting beneficial uses.	Not applicable.
Lindsay Creek	ID17060306CL003_02 Lindsay Creek - *Source to mouth* ID17060306CL003_03 Lindsay Creek - *Source to mouth*	*E.* coli Nutrient/Eutrophication Biological Indicators Sedimentation/Siltation	*Lindsay Creek Watershed Assessment and Total Maximum Daily Loads,* December 2006, Amended March 2007. Approved, June 2007.
Tammany Creek	ID17060103SL014_02 *WBID 015 to unnamed trib.* ID17060103SL014_03 *Unnamed Trib. to mouth* ID17060103SL016_02 *Source to Unnamed Trib.*	*E. coli* Nitrogen, Nitrate. Total Phosphorus Sedimentation/Siltation	*Tammany Creek Watershed (HUC 17060103) TMDL Addendum;* September 2010. Approved, December 2010.
Snake River	ID17060103SL001_08 *Snake River - Asotin River (Idaho/Oregon border) to LGDP*	Temperature	No TMDL completed.

Other wastewater, industrial, and industrial stormwater discharges to the Snake and Clearwater Rivers are permitted by IDEQ or by WDOE in the Snake River action area in and around the Lewiston UA (Table 12). These discharges contribute to impaired water and sediment quality (NMFS 2004; EPA 2019) in the action area but their permits have not undergone ESA consultation and the underlying NPDES permits are not covered by this consultation. These other discharges in the action area may occur in proximity to MS4 discharges, may intermix with MS4 discharges in levee drainage system discharges to the Clearwater River, or intermix in conveyances discharging to the Snake River. Several nonpoint source discharges contribute to water and sediment quality impairments in Tammany and Lindsay Creeks upstream of and within the action area and are not covered by this consultation.

Table 12. Existing industrial, wastewater, and industrial stormwater dischargers near Lewiston, Idaho and Clarkston, Washington that may impact the action area.

Facility	Permit Number	Permit Type	Receiving Water
Idaho			
Lewiston WWTP	ID0022055	POTW	Clearwater River
City of Lewiston Water Treatment Plant	IDG380003	Drinking Water Treatment Plant	Clearwater River
Clearwater Paper Corporation	ID0001163	Industrial	Snake River
Pacific Steel and Recycling	IDR053088	Industrial Stormwater	Clearwater River
Herco, Inc. Asphalt Paving Plant	IDR053215	Industrial Stormwater	Clearwater River
Clearwater Bullets	IDR053238	Industrial Stormwater	Snake River
Clearwater Paper Corporation	IDR053113	Industrial Stormwater	Lost Creek Wetland
Port of Lewiston	IDR053166	Industrial Stormwater	Clearwater River
Port of Lewiston	IDR053167	Industrial Stormwater	Clearwater River
Port of Lewiston	IDR053168	Industrial Stormwater	Clearwater River
Federal Cartridge	IDR053178	Industrial Stormwater	Snake River
Federal Cartridge	IDR053179	Industrial Stormwater	Snake River
Washington			
Appleside Townhomes	WAR307837	Construction Stormwater	Snake River
Asotin County Landfill	ST0005370	Industrial Stormwater	Snake River
Atlas Sand & Rock Evans Road Pit	WAG507004	Sand and Gravel	Snake River
Clarkston City	WAR046502	Municipal Stormwater	Snake River
Clarkston WWTP	WA0021113	POTW	Snake River
Dimke Properties Housing Development	WAR308515	Construction Stormwater	Snake River
Motley Bayman Pit	WAG507157	Sand and Gravel	Snake River
Poe Asphalt Paving Dry Gulch Pit	WAG507137	Sand and Gravel	Snake River
Poe Asphalt Paving Inc. 1900 Plant	WAG500057	Sand and Gravel	Snake River

Exposure and Fish Presence in the Action Area

Most Snake River populations of anadromous salmon and steelhead rear and migrate downstream as juveniles and migrate upstream as adults through the action area. Anadromous fish are not present in Lindsay Creek because a dam and tunnel block its lower reach. Steelhead are expected to spawn during spring and rear year-round in the lower half-mile of Tammany Creek in the action area. Most sub-yearling and yearling spring/summer Chinook salmon are present, rearing and migrating through the action area from March through July (Connor et al. 2001; Tiffan et al. 2014; Erhardt et al. 2018). Some sub-yearling fall Chinook salmon arrive in the action area later in the summer and fall, overwinter, and migrate the following spring (Connor et al. 2005; Hegg et al. 2013). Some yearling sockeye salmon and steelhead migrate downstream during spring and rear several weeks in LGR, while other juvenile steelhead may rear one or two years in the action area. Overall, several life history types of several different species variably use the action area for days to months or years (Tiffan et al. 2018; Tiffan et al.

2012). Most adult salmon migrate through the action area in a few days with some fish staging for longer periods until water temperatures cool during late summer and fall. Adult steelhead typically migrate upstream into LGR during summer and fall and may overwinter there for 6-10 months prior to spring spawning (Keefer et al. 2008).

Movement rates of migrating juvenile salmon are slower in lower velocity and colder water. Yearling smolts may migrate through LGR in a few days or weeks, feeding each day. Natural-reared salmonids are typically smaller than hatchery fish, smaller sub-yearlings and yearlings tend to feed on smaller-bodied invertebrates, which accumulate higher concentrations of metals (Farag et al. 1998; Farag et al. 1999) and smaller fish tend to rear in shallow water shoreline habitats of the action area for longer periods (Tiffan et al. 2018; Tiffan et al. 2012). The growth of juvenile salmonids is largely determined by the availability, consumption rate, and energy content of prey in freshwater systems (Sergeant and Beauchamp 2006; Tiffan et al. 2014; Grunblatt et al. 2019). These fish must feed to build energy reserves required for migration where they are vulnerable to depleted lipids and starvation or exhaustion, and to predation in lower rivers, estuary, and ocean (Muir and Coley 1996; Macneale et al. 2010; Davis et al. 2018; Erhardt et al. 2018).

The major food source of rearing and migrating salmonids within the action area is benthic invertebrates (Bennett et al. 1983; Bennett et al. 1995; Muir and Coley 1996; Tiffan et al. 2014). Dipterans, Coleoptera, amphipods, and prawns adapted to sand and silt substrates are often of smaller size, burrow into sediments and exhibit extensive vertical migrations to deep sediments each day to reduce predation. These invertebrates may also feed more frequently in biofilms and detritus along reservoir substrates where several types of pollutants settle and may accumulate contaminants at greater concentrations than larger-bodied invertebrates (Farag et al. 1998; Farag et al. 1999). Smaller benthic invertebrates comprise large proportions of salmonid diets in LGR (Tiffan et al. 2014; Bennett et al. 1983). Smaller-bodied sub-yearling Chinook salmon and one-year old sockeye salmon and steelhead typically eat smaller invertebrates (Farag et al. 1998) and rear for longer periods in the LGR than older and larger juveniles do. Zooplankton and terrestrial insects are also substantial components of salmonid diets (Muir and Coley 1996; Tiffan et al. 2014).

2.5. Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.17). In our analysis, which describes the effects of the proposed action, we considered 50 CFR 402.17(a) and (b).

Analysis Used to Estimate Effects

Estimates of the types, concentrations, and annual loads of contaminants discharged within the Lewiston UA are limited or unknown. The MS4 stormwater drains are not mapped or monitored. The BE (EPA 2020), characterized likely types and concentrations of contaminants in stormwater discharges within the Lewiston UA, using surrogate contaminant types and end-of-pipe concentrations from large UAs in Puget Sound and from the Lewiston levee reports (Table 13). The focal pollutants (metals and PAHs) were analyzed for acute toxicity risks based on expected water concentrations and mixing rates at individual outfalls only in portions of receiving waters within Idaho. Using these methods EPA (2020) assessed that the subject action is not likely to adversely affect listed salmonids or their critical habitats.

In the following effects sections, NMFS' independent primary analysis investigates the types of contaminants expected to be present within the Lewiston UA along with their persistence, toxicity, and fate after discharge in receiving waters. The metals and PAHs analyzed by EPA (Table 13) were expanded to include PBTs, nutrients, tire tread particles, pesticides, sediment, and temperature (Table 8). Potential concentrations of pollutants in water, sediment, and food webs in the action area including LGR were considered in a more basic but similar way to that of NMFS (2004). Acute and chronic effects based on exposures of a wider range of rearing and migrating salmonid life histories were considered. Collective loads from within the entire Lewiston UA and its highways for the five-year durations of the permits were considered in relation to background concentrations in the sediments and fish tissue of resident fish in the action area from available studies. The properties and interactive toxicity of mixtures of contaminants from other local discharges (Table 12) were also considered. Finally, likely effects to juvenile salmonids from research studies, which isolated and/or measured the pathways, occurrence, and potential impacts to juvenile salmonids, and their prey in the action area and similar situations in the western U.S., were reviewed to consider similar effects in the action area.

Effects on Listed Species

Effects to salmonids caused by UA stormwater discharges could occur in five main ways: (1) acute mortality or injury from toxicity; (2) reduced growth, fitness, and survival of fish from chronic ingestion of contaminated prey, including latent effects; (3) altered behavior, avoidance, or reduced fitness from sub-lethal toxicity; (4) reduced fish growth of fish from toxicity that is lethal to prey, which reduces the diversity and abundance of prey availability; or (5) physical alterations to hydrology, channels, and substrates that reduce survival of salmonids and increase avoidance behaviors. These effects pathways are considered collectively similar among salmonid species considered here in terms of outcome (reduced survival) and within their similar life stages but specific differences will be noted where appropriate.

Urban development alters natural infiltration patterns of stormwater, reduces infiltration rates, and rapidly drains the excess surface water. Increased impervious surface area (such as roads, parking lots, driveways, and rooftops) interrupts the natural process of stormwater infiltration to vegetation and soils. These alterations to normative hydrology increase streambank scouring, sedimentation, and channel simplification, which further reduce the buffering and settling of mixtures of contaminants expected to be entrained in stormwater from the Lewiston UA and its highways (Table 8).

Urban stormwater is usually a significant contributing factor to local and larger-scale chronic water and sediment quality impairments. The 10 square mile Lewiston UA and its several miles of riverside highways and bridge crossings generate or collect diverse mixtures of many pollutants from atmospheric deposition, exhaust and vehicle emissions, soil erosion, and human activity that can accumulate on and then wash from hardened surfaces and drain into receiving waters. Once in receiving waters, contaminants may be dissolved or suspended with or as organic or inorganic particles. Many of these may attach, mix, or interact with other compounds and transform into new compounds or degradants with different properties and toxicities. Fates of most contaminants include downstream transport, sedimentation and burial or resuspension, microbial decomposition, or consumption by plankton and aquatic invertebrates. PBTs, PAHs, and metals may bioaccumulate in food webs.

Table 13. Estimated focal pollutant waterborne concentrations (µg/L) from land use sources from other UAs and from discrete samples summarized in Lewiston levee reports, which were analyzed in the BE. Land use types: LDR (low density residential); HDR (high density residential); COM (commercial); IND (industrial); and OPEN (open space).

Focal Pollutant		**LDR**	**HDR**	**COM**	**IND**	**OPEN**
Metals/Metalloids	Aluminum, dissolved	252[c]	252[c]	163[c]	163[c]	697
	Antimony, dissolved	0.40[d]	0.40[d]	0.40[d]	0.40[d]	0.00
	Arsenic, dissolved	2.73	4.41[c]	1.57	3.02[c]	0.61
	Barium, dissolved	42.1[c]	42.1[c]	33.1[c]	33.1[c]	28.5
	Beryllium, dissolved	0.05[c]	0.05[c]	0.05[c]	0.05[c]	0.10
	Cadmium, dissolved	0.10	0.07	0.20	0.24	0.02
	Chromium, dissolved	1.17[d]	1.17[d]	1.17[d]	1.17[d]	0.00
	Cobalt, dissolved	0.60[c]	0.60[c]	0.44[c]	0.44[c]	1.48
	Copper, dissolved	5.75	7.27	11.47	6.86	3.95
	Iron, dissolved	6620[d]	6620[d]	6620[d]	6620[d]	0.00
	Lead, dissolved	1.09	1.17	3.44	1.81	0.48
	Manganese, dissolved	261[c]	261[c]	151[c]	151[c]	337
	Mercury, total	0.08	0.09	0.09	0.06	0.04
	Nickel, dissolved	2.37[c]	2.37[c]	2.28[c]	2.28[c]	2.37
	Selenium, dissolved	2.00[c]	2.00[c]	2.00[c]	2.00[c]	0.50
	Silver, dissolved	0.02[d]	0.02[d]	0.02[d]	0.02[d]	0.00
	Thallium, dissolved	0.03[c]	0.03[c]	0.03[c]	0.03[c]	0.10
	Titanium, dissolved	28.6[d]	28.6[d]	28.6[d]	28.6[d]	0.00
	Vanadium, dissolved	45.4[d]	45.4[d]	45.4[d]	45.4[d]	0.00
	Zinc, dissolved	38.7	96.5	125.8	76.9	10.0
PAHs	1-Methylnaphthalene	0.03[a]	0.03[a]	0.29[a]	0.22[a]	0.01
	2-Methylnaphthalene	0.23	0.31	1.06	0.96	0.01
	Acenaphthene	0.23	0.23	0.56	0.15	0.01
	Acenaphthylene	0.23	0.14	0.56	0.15	0.01
	Anthracene	0.33	0.21	1.01	0.13	0.01
	Benz(a)anthracene	0.26	0.27	1.44	0.43	0.01
	Benzo(a)pyrene	0.44	0.39	1.69	0.49	0.03
	Benzo(b)fluoranthene	0.43	0.28	2.04	0.40	0.01
	Benzo(g,h,i)perylene	0.42	0.34	1.83	0.57	0.01
	Benzo(k)fluoranthene	0.40	0.25	1.40	0.28	0.01
	Chrysene	0.48	0.38	2.11	0.64	0.01
	Dibenzo(a,h)anthracene	0.66	0.50	0.82	0.11	0.02
	Fluoranthene	0.51	0.49	2.95	0.78	0.01
	Fluorene	0.11	0.24	0.54	0.28	0.01
	Indeno(1,2,3-cd)pyrene	0.50	0.42	1.77	0.54	0.02
	Naphthalene	0.40	0.38	1.11	1.09	0.02
	Phenanthrene	0.26	0.31	1.95	0.53	0.01
	Pyrene	0.49	0.45	2.76	0.84	0.02

Source Data: Unless otherwise noted using the nomenclature below, the data reported is the geometric mean across all three datasets.

[a] Western Washington Report + Puget Sound Toxics Report

[b] Lewiston Levee Reports, Western Washington Report, and Puget Sound Toxics Report

[c] Lewiston Levee Reports + Puget Sound Toxics Report

[d] Lewiston Levee Reports

[e] Puget Sound Toxics Report

Persistent Bioaccumulative Toxicants (PBTs)

PBTs are an expansive grouping (WAC 2021) of chemical compounds (and some metals) that may persist several years while maintaining high toxicity, often move readily among air, water, sediment, and food webs, and may bioaccumulate in listed salmonids and other fish from exposure to water, sediments, and from their diet of zooplankton, invertebrates, and other fish. PBTs often bind to sediments and are typically found in diverse mixtures in aquatic environments along with a broad range of pesticides, nutrients, metals, and PAHs (Johnson et al. 2006; Laetz et al. 2009; Baldwin et al. 2009; Johnson et al. 2013a). PBTs include POPs (persistent organochlorine pollutants) as described by Sloan et al. (2010), which include PCB congeners, PBDE congeners, DDT and metabolites, dioxins and furans, other organochlorinated compounds, and pesticides (hexachlorocyclohexanes, hexachlorobenzene, chlordanes, aldrin, dieldrin, mirex, and endosulfan I).

PBTs typically include similar modes of toxicity and are often carcinogens, endocrine and reproductive disrupters, and transgenerational disrupters. PBTs may cause neurological and developmental disorders, oxidative stress, weakened immune systems, and may cause mortality of invertebrates and fish in aquatic ecosystems (Soto et al. 1994; Major et al. 2020; WDOE 2021). PBTs are often found in mixtures together with a broad range of PAHs and metals, to which PBTs readily bind and interact; often-increasing toxicity and mobility. The following PBTs are expected to have these generally similar effects and are likely to be present in the Lewiston MS4 discharges.

POPs. Include organochlorinated pesticides and metabolites (DDT, DDE), toxaphene, dieldrin, other DDT-like compounds, and polychlorinated dibenzo-p-dioxins and furans. Some POPs that were discontinued 15 to 30 years ago continue to be reported at toxic concentrations in fish (Johnson et al. 2013a; Johnson et al. 2013b). DDT, toxaphene, and dieldrin are major agricultural insecticides that were often used on cereal grains and fruit orchards, in mosquito abatement programs, and to kill fish in ponds (Eisler 1970; WDOE 2021). Portions of the Lewiston UA are built on old orchards and wheat fields and the UA is nearly surrounded by streams and rivers. Most POPs are likely to enter stormwater from wind and water erosion or construction disturbance of legacy-contaminated soils. Some POPs are volatile and often deposit in the atmosphere where they are highly mobile and are likely to settle on impervious surfaces in the UA and enter stormwater drainage systems.

Dioxins and furans are most likely to be absorbed to particulate matter when entering stormwater. Common sources are air emissions from regional forest fires and from trash burning and stack emissions from industries in and around the Lewiston UA. Construction activities or erosion of soils may disturb recent or legacy deposits of POPs that become entrained in stormwater runoff and drain into receiving waters and sediments. Concentrations of dioxins and furans from upstream reference sites in the Snake and Clearwater Rivers markedly increase through and downstream of the Lewiston UA (EPA 2019). POPs exceeded Washington's water quality standards for fish tissue/human health in the action area (Seiders et al. 2011; WDOE 2021) and are also distributed downstream in the lower Snake and Columbia Rivers (Johnson and Norton 2005; Hinck et al. 2006; Johnson et al. 2007; Seiders et al. 2011; Arkoosh et al. 2011; Alvarez et al. 2014; WDOE 2021).

Arkoosh et al. (2011) found juvenile spring/summer Chinook salmon accumulated significant body burdens of POPs during migration between hatchery release and through the action area to LGD. Yearling smolts were sampled for POPs and released from hatcheries (Rapid River, Dworshak, and Clearwater) upstream of the action area. Migrants surviving to LGD were sampled for POPs concentrations in lipids and whole bodies. During the week to three-week migration from hatcheries to LGD, typical travel rates were 3-5 times faster in natural rivers upstream of LGR and slowed when migrants enter the action area and pool of LGR. Within relatively short periods (days to weeks) with most time spent rearing and migrating through the action area, lipid concentrations of POPs increased approximately 2-5 times and whole-body concentrations increased 1-3 times. Larger juvenile salmonids that migrate quickly through the action area may accumulate smaller amounts of contaminants while smaller and slower moving juveniles that spend several days to months feeding in the action area are expected to accumulate harmful body burdens prior to migrating farther downstream, where they will increase those concentrations, causing lethal and sub-lethal effects.

Because LGR is the initial dam encountered, in-river and barged fish may be exposed to POPs in the action area. Fish that accrue POPs in the action area may be barged to the lower Columbia River with little increase in contaminant loading. Fish that accrue POPs in the action area and then migrate in-river experience increased body burdens with continued ventilation, growth, and lipid depletion throughout migration. During in-river migration from LGD to the lower Columbia River and estuary, lipid and whole-body concentrations may increase another one to four times. Of the contaminants measured in juveniles in the action area, Arkoosh et al. (2011) concluded that DDTs and related organochlorinated pesticides and PAHs pose the greatest threat to Snake River spring/summer Chinook salmon. Lundin et al. (2019) modeled effects of persistent organic compounds in the lower Willamette and Columbia Rivers that were estimated to result in body burdens that reduced juvenile Chinook salmon survival by 54 percent, which led to a 20 percent reduction in the abundance of adults. Juvenile salmonids that survive to spawn will pass POPs to eggs and larvae, which can be 20-40 times more sensitive to mortality from POPs than older juveniles (Walker and Peterson 1994) can. It is likely that the proposed action will add small contributions to these lethal and sub-lethal effects.

PCBs. PCBs are very persistent, include 209 man-made compounds, and usually occur in complex mixtures. Sources include food packaging, electronic transformers and capacitors, plasticizers, wax and pesticide extenders, lubricants, inks and dyes, and legacy sealants (WDOE 2021) and are likely to occur in stormwater runoff that is discharged into receiving waters. PCB concentrations in resident fish exceed Washington's water quality criteria for human health concentrations in the action area (Table 10; WDOE 2021). We did not locate site specific data for PCB tissue burdens in anadromous salmonids within the action area; however, other studies well describe the mechanisms for uptake and effects.

Meador et al. (2002) provided a framework for analyzing the effects and bioaccumulation of PCBs in salmonids. Meador (2014) estimated that hatchery-reared juvenile Chinook salmon survival was reduced 45 percent during rearing and migration through contaminated rivers and estuaries in Puget Sound. Increased body burdens of mostly PCBs and PAHs in juvenile Chinook salmon were accrued from contaminated water and ingestion of contaminated food. Body burdens increased greatly in relatively short time frames (days-months). Together, these factors increase bioaccumulation rates and adverse effects to juvenile salmonids.

Fall spawning salmon provision large amounts of lipids (yolk) to eggs that support embryos and larvae over winter until first feeding the following spring (Daley et al. 2013). Adults that were contaminated as juveniles in the action area and elsewhere bioaccumulate POPs throughout life and deposit POPs in eggs. Thus, transgenerational adverse effects occur and if food is limited and offspring need to depend longer on depleting lipid reserves, bio-amplification may exceed harmful effects thresholds approximately 5-9 fold (Daley et al. 2012, MacDonald et al. 2000b; Meador et al. 2002; Johnson et al. 2007).

PBDEs. PBDEs are flame retardants added to foam, plastics, and textiles, and are often found in car seats, electronics, building insulation, and older upholstered furniture and mattresses (WDOE 2021; Eisler 1986b). Studies show PBDEs have been spreading from these common items in UAs and roadways and entering stormwater that partitions to biota and sediments in receiving waters (Hites 2004; WDOE 2021; Stone 2006). PBDEs are rapidly increasing in the environment, doubling every 2-5 years (WDOE 2021) and other pollutants (nutrients and other wastewater contents; O'Neill et al. 2020) increase their toxicity. Salmon ingest contaminated terrestrial and aquatic prey in the action area and assimilate some PBDE congeners throughout life (Stone 2006; Arkoosh et al. 2017). Even low concentrations of some PBDEs cause sub-lethal effects in salmonids such as alteration of thyroid hormone levels or thyroid function and neurological disorders (Sloan et al. 2010). Arkoosh et al. (2017) found thyroid hormone concentrations were altered in juvenile Chinook salmon when fed environmentally relevant concentrations of some PBDE congeners for 5-40 days. Most migrating smolts spend more than five days and maybe thirty percent or more may rear for several weeks or months in the action area. This exposure is likely to cause sub-lethal disruption of thyroid hormones that impact critical functions salmonids require for growth, smolting, and migration (Iwata 1995).

Stormwater discharges of PBDEs contribute to the degraded water and sediment quality of Lindsay and Tammany Creeks and make small contributions to the degraded water and sediment quality of the Clearwater and Snake Rivers. Cumulative loads delivered to receiving waters are likely to reduce and contaminate prey, cause acute and chronic sub-lethal toxicity in juvenile salmonids, and increase toxic and absorptive properties of other PBTs and metals in the action area.

Polycyclic aromatic hydrocarbons (PAHs)

Petroleum-based contaminants are usually in the form of two or more condensed aromatic carbon rings, include more than 100 different chemicals, and usually occur as complex mixtures in the environment. Major human-related sources released to the environment are from wood stoves, creosote treated wood, and vehicle emissions, plastics including tire wear particles, improper motor oil disposal, leaks, and asphalt sealants (WDOE 2021). PAHs are lipophilic, persistent, interact synergistically with bio-accumulative and redox-active metals and other contaminants, and may disperse long-distances in water (Gauthier et al. 2014, 2015; Arkoosh et al. 2011; WDOE 2021). Metabolites are commonly more toxic than the parent, some are carcinogenic, neurotoxic, and cause genetic damage. Although biotransformation of PAHs causes oxidative stress with subsequent cellular damage and increased energy is required at the cost of growth, many organisms (including salmon) can eliminate at least the lower density PAHs from their bodies as part of metabolism and excretion (Arkoosh et al. 2011). However, plants and some aquatic organisms, such as mussels and lamprey, have limited ability to metabolize or degrade PAHs, which may bioaccumulate over several years (Tian et al. 2019; Nilsen et al. 2015). PAHs and metabolites are acutely toxic to salmonids and may cause narcosis at low levels of exposure, can in some cases bioaccumulate through food webs (water, groundwater, soil, and plants; Bravo et al. 2011; Zhang et al. 2017), and can also cause chronic sub-lethal effects to aquatic organisms at very low levels (Neff 1985; Varanasi et al. 1985; Meador et al. 1995). PAHs can affect DNA within the nucleus of cells, cause genetic damage, and are classified as carcinogens (Collier et al. 2014).

Arkoosh et al. (2011) sampled juvenile spring/summer Chinook salmon from hatcheries upstream of the action area to the lower Columbia River. They found that bile concentrations of PAHs were sometimes higher at hatcheries and frequently higher at LGD and in fish barged from LGD, indicating highest exposures may be occurring in the action area, and to lesser extent upstream. PAH levels generally declined downstream of LGD, with some indication of repeated exposure. High proportions (42% to 94%) of out-migrating spring Chinook juveniles were exposed to PAH levels that could potentially cause adverse effects (Arkoosh et al. 2011). Exposure to PAHs, metals, and PBT complexes, along with other stressors (i.e., warm temperature) increase the risk of additive and synergistic interactions and potential for sub-lethal adverse effects. Most sub-lethal effects are related to narcosis, oxidative stress, increased energy required to maintain homeostasis, increased depletion of limited energy reserves, reduced growth, reduced immune response, and increased predation (Bravo et al. 2011; Arkoosh et al. 2011; Collier et al. 2014; EPA 2020). Stormwater discharges of PAHs contribute to the degraded water and sediment quality of Lindsay and Tammany Creeks and make small contributions to the degraded water and sediment quality of the Clearwater and Snake Rivers. Pulses and cumulative loads delivered to lower Tammany Creek and the Snake and Clearwater Rivers are likely to reduce and contaminate prey, cause acute and chronic lethal and sub-lethal toxicity in juvenile salmonids, and increase toxic and absorptive properties of PBTs and metals in these portions of the action area.

Microplastics and Transformation Products

Microplastics (MPs) are generally found in higher numbers near UAs along the Snake River, including the action area near Lewiston (Kapp and Yeatman 2018). Campanale et al. (2020) detailed sources of MPs were mostly from electrical and electronics, building and construction, transport, and textiles. Brahney et al. (2021) found that stormwater runoff from roads around UAs in the western U.S. produced 84 percent of MPs compared to the remainder of UAs, which produced only 0.4 percent. Agricultural runoff produced five percent of MPs and 11 percent were legacy MPs from the ocean. City roads produced fewer MPs in stormwater because surrounding buildings and trees reduced wind and dust and because vehicles emit fewer microplastics (tire tread particles) at slow speeds. Highways and roads with higher speed limits and increased exposure produced vastly more MPs, because vehicles produce their own buffeting winds and tire tread wears at much greater rates (Brahney et al. 2021). Ingested MPs can interfere with food capture and digestion, particularly for benthic filter feeders, leading to decreased feeding, oxidative stress, or mortality of sensitive aquatic invertebrates and fish (Kapp and Yeatman 2018). MPs are infused with PBT additives and when released to aquatic environments strongly attract other PBTs, PAHs, and metals (especially copper and zinc). Some MPs sink to sediments and others are buoyed by MPs and are transported long distances downstream, including through and over dams (Rochman et al. 2013; Wang et al. 2018; Campanale et al. 2020), and into the ocean where MPs carry PBTs and several metals over long terms (Rochman et al. 2014). Many MPs eventually enter the hydrologic cycle to be re-deposited throughout the western U.S. (Brahney et al. 2021). Mounting evidence shows MPs bioaccumulate in benthic invertebrates (e.g., amphipods, prawns; Campanale et al. 2020), which are primary food sources for juvenile salmonids in the action area. Some MPs in fish, breakdown into smaller particles that can enter the circulatory system and remain to be transferred to higher trophic predators (Wang et al. 2018). PBTs and other contaminants leach from the MPs and bioaccumulate in tissues (Rochman et al. 2013; Campanale et al. 2020).

One of most common microplastics entering aquatic habitats from proximate roadways and stormwater discharges are tire tread wear particles (Tian et al. 2020; Brahney et al. 2021). The ubiquitous antioxidant 6PPD or [(N-(1, 3-dimethylbutyl)-N'-phenyl-p-phenylenediamine] is used to preserve elasticity of tires. The 6PPD may transform in the presence of ozone (O_3) from automotive and other UA emissions to 6PPD-quinone. The 6PPD-quinone is acutely toxic to juvenile and adult salmonids and is identified by Tian et al. (2020) as the primary cause of urban runoff mortality syndrome described by Scholz et al. (2011). Acute toxicity ending in mortality of juveniles and adult salmonids is caused by relatively low concentrations and short duration exposures (24 hr., LC_{50} = 0.79 µg/L) of 6PPD-quinone. Stormwater discharges of MPs (especially tire tread particles) contribute to the degraded water and sediment quality of lower Tammany Creek and the Clearwater and Snake Rivers. Pulses and cumulative loads of tire tread particles and MPs may cause acute lethal toxicity of adult and juvenile steelhead in lower Tammany Creek and are likely to reduce and contaminate prey, cause chronic sub-lethal toxicity in juvenile salmonids, and increase toxic and absorptive properties of PBTs and metals in the Clearwater and Snake Rivers within the action area.

Metals

Mercury (Hg). Sources of mercury are diverse and include natural emissions and weathering of metallic ores, human activities (mining, emissions from the burning and refining of coal and petroleum fuels, paper mills, cement production), and consumer products (thermostats, automotive switches, fluorescent lights, and dental fillings (WDOE 2021). Air emissions from industrial activities are by far the major source of mercury in most locations (Fitzgerald et al. 1998; Obrist et al. 2018). Mercury is a common stormwater contaminant (Tables 8 and 13; Fleck et al. 2016; EPA 2020). Mercury contaminates aquatic habitats and food webs, including rearing and migrating salmonids in the action area. Mercury concentrations in resident fish exceed Washington's water quality criteria for human health concentrations in the action area (Table 10; WDOE 2021).

All forms of mercury are toxic to fish, invertebrates, other animals, and humans (Eisler 1987; Broussard et al. 2002). Mercury ions produce toxic effects by protein precipitation, enzyme inhibition, and generalized corrosive action (Broussard et al. 2002). Mercury is a mutagen, teratogen, and carcinogen, and causes embryocidal, cytochemical, and histopathological effects (Eisler 1987). Significant adverse sub-lethal effects for sensitive aquatic species are observed at 0.03-0.1 µg/L and water quality criteria of 0.012 µg/L provide only limited protection (Eisler 1987; NMFS 2014a). Mercury species are transformed by organic and inorganic processes to methylmercury (MeHg), which bio-accumulates throughout aquatic food webs and biomagnifies through trophic levels. Bettaso and Goodman (2010) found that lamprey ammocetes, which filter-feed from burrows in contact with sediments and ingest more benthos-dependent prey, bio-accumulated 12-25 times greater concentrations of mercury in their bodies than did mussels, which feed from water columns. In reservoir habitats of the action area, juvenile salmonids ingest large numbers of benthic invertebrates. Smaller fish tend to ingest smaller invertebrates, which may accumulate higher concentrations of metals (Farag et al. 1998). Daily feeding on potentially contaminated invertebrates, long migrations, depleted lipid stores, and bursts of energy to escape predators, increase ventilation and growth. Together, these factors increase bioaccumulation rates and adverse effects to juvenile salmonids. Sediments of the Snake River in the action area contain loads of mercury at concentrations that are likely to reduce and contaminate prey and cause chronic sub-lethal toxicity in juvenile salmonids and increase toxic and absorptive properties of PBTs and other metals. Stormwater discharges of mercury make small contributions to the degraded water and sediment quality of the Snake River in the action area.

Copper (Cu). Many sources of copper occur in UAs and along roadways, including household waste, electrical wire, and pesticides (Tables 8 and 13). Copper is highly toxic to aquatic biota and ESA-listed salmon and steelhead can experience a variety of acute and chronic lethal and sub-lethal effects (NMFS 2014a). Copper bio-accumulates in invertebrates and fish (Feist et al. 2005; Layshock et al. 2021), is redox-active, and interacts with or alters many compounds in mixtures (Gauthier et al. 2015). Copper-PAH mixtures, which synergistically interact are highly toxic through several exacerbating mechanisms: copper weakens cell membranes increasing absorption of PAHs, copper chelates or hastens and preserves the bio-accumulative toxicity of PAHs; and PAHs in turn increase the bio-accumulative and redox properties of Copper (Gauthier et al. 2015). Sub-lethal effects of copper include avoidance at very low concentrations (Hecht et al. 2007) and reduced chemosensory function at slightly higher concentrations, which in turn causes maladaptive behaviors, including inability to avoid copper or to detect chemical alarm signals (McIntyre et al. 2012). Appreciable adverse effects can be expected with increases as small as 0.6 µg/L above background concentrations (NMFS 2014a).

Copper concentrations typically increase during spring-summer high flows when migrating juvenile salmonids are most actively feeding and growing at greatest rates (NMFS 2014a). Copper toxicity increases significantly during conditions of low calcium carbonate ($CaCO_3$), low pH, and low DOC (NMFS 2014a). These conditions are present in the lower Clearwater River and downstream Snake River in the action area. Survival of juvenile salmon and steelhead, particularly during migration, is strongly size and season dependent (Mebane and Arthaud 2010). Small reductions in size and slower growth may slow or delay migration and will result in disproportionately larger reductions in survival during migration and entry into saltwater (Tattam et al. 2013, Thompson and Beauchamp 2014).

The lower Clearwater River sediments near the Levee A pond (RM 0.9; Braun et al. 2012) exceeded the PEL for copper (MacDonald et al. 2000a) by five times. Toxicity of copper is increased in the ambient conditions of low hardness, pH and dissolved oxygen sags, and very low DOC (from the hypolimnion releases of oligotrophic water from Dworshak Reservoir that are used to mitigate warm temperatures in the action area), and in the presence of several other metals and PBTs (Tables 9 and 10). After flowing a mile downstream, the Clearwater River enters the temperature and PBTs water quality impaired Snake River in Washington. Moreover, DOC remains low in LGR, particularly in the Clearwater River plume, which often flows alongside or sub-ducts beneath the Snake River. In these situations, only limited mixing occurs between plumes (Cook et al. 2003, 2006) and elevated concentrations and loads of higher toxicity copper may occur in Snake River for miles downstream. Stormwater discharges make small contributions to copper concentrations in sediment and water of the Clearwater and Snake Rivers that likely cause chronic sub-lethal and lethal toxicity in juvenile salmonids and increase toxic and absorptive properties of PBTs and zinc in the action area.

Chromium (Cr). Sources of chromium include phosphate fertilizers, chrome plating, paper mills, sewage, and solid wastes from the disposal of consumer products and chromium is a common pollutant found in stormwater UAs and along roadways (Eisler 1986a; Tables 8 and 13). While the pure metallic form is absent naturally, it is commonly found in three oxidation states: Cr II, Cr III, and Cr VI (Bakshi and Panigrahi (2018). Chromium is a redox-active metal, causing oxidative stress and oxidative-induced alterations of DNA in fish and other aquatic organisms (Eisler 1986a; Sevcikova et al. 2011). Hook et al. (2006) found that Cr VI caused oxidative stress in rainbow trout. Toxicity and uptake of Cr VI is increased in conditions of pH 7.8 and lower, low DOC, and low hardness (Vanderputte et al. 1981; Eisler 1986a), which exist in the action area. Comprehensive reviews show that chromium is taken up by fish and aquatic organisms through the gastrointestinal tract, respiratory tract, and skin (Eisler 1986a; Farag et al. 2006; Sevcikova et al. 2011; Bakshi and Panigrahi 2018). Chromium was the second most frequent metal to exceed TECs in sediments of the Clearwater River and downstream Snake River and its concentrations are likely to contaminate prey (e.g., amphipods, daphnids) in oligotrophic water released from Dworshak Reservoir. Chromium concentrations in this portion of the action area may cause behavioral avoidance by listed salmonids. Dietary uptake of Cr VI may cause chronic sub-lethal toxicity in juvenile salmonids and is likely to increase the toxic and absorptive properties of PBTs and other metals. Stormwater discharges of chromium make small contributions to the degraded water and sediment quality in the lower Clearwater River and downstream Snake River in the action area.

Zinc (Zn). Major sources of zinc include electroplaters, smelting and ore processors, mine drainage, domestic and industrial sewage, combustion of solid wastes and fossil fuels, road surface runoff (vehicle emissions, motor oils, lubricants, tires, and fuel oils), corrosion of zinc alloys and galvanized surfaces, and erosion of agricultural soils (Eisler 1993). Sediments in the Clearwater River portion of the action area exceeded the zinc PEL of 315 mg/kg (Table 9; MacDonald et al. 2000a). Stormwater discharges of zinc make small contributions to the degraded water and sediment quality in the lower Clearwater River. Several species of zinc are highly mobile in aquatic environments, are often transported many miles downstream, and eventually load to sediments. Zinc interacts with many chemicals and aquatic conditions of reduced pH and dissolved oxygen, low DOC, and elevated temperatures increase zinc toxicity, causing altered patterns of accumulation, metabolism, and toxicity (Eisler 1993; Farag et al. 1998). Many aquatic invertebrates and some fish may be adversely affected from ingesting zinc-contaminated particulates (Farag et al. 1998). In freshwater fish, excess zinc affects the gill epithelium, which leads to internal tissue hypoxia, reduced immunity, and may acutely include osmoregulatory failure, acidosis, and low oxygen tensions in arterial blood (Eisler 1993). Toxicity of zinc mixtures with other metals is mostly additive; however, toxicity of zinc-copper mixtures is more than additive (or synergistic) for freshwater fish and amphipods (Skidmore 1964; de March 1988). Sediments of the Clearwater River and downstream Snake River contain loads of zinc at concentrations that are likely to reduce and contaminate prey and cause chronic sub-lethal toxicity in juvenile salmonids and increase toxic and absorptive properties of PBTs and other metals in the action area.

Titanium (Ti). Consumer products using bulk and nanoparticles of TiO_2 are increasing worldwide and is used in paints, pigments, varnishes, plastics, sewage treatment, and others (Sharma and Agrawal 2005; Nunes et al. 2018). Titanium dioxide is considered to have generally low toxicity and was not reviewed in the BE but is likely present in stormwater in the Lewiston UA (Table 13). Sediments of the lower Clearwater River and Snake River contained large loads of TiO_2 (4,540 to 7,760 mg/kg; Braun et al. 2012). Recent research finds that nanoparticles in freshwater and saltwater continually aggregate into larger micro-particles and bind with high affinity to mixtures of metals and other contaminants (Nunes et al. 2018).

Titanium dioxide nanoparticles physically cling to fish gills, causing some physical injuries (oedema and thickening of lamellae) that may reduce efficiency of gas exchange and significantly decreased the proportion of time rainbow trout spent swimming at high speed (Boyle et al. 2013). When rainbow trout were exposed to high concentrations, titanium oxide caused oxidative stress, disrupted signal transducing in gills and intestine, decreased intracellular calcium, altered homeostasis and resting potential, changed tissue copper and zinc levels, and may decrease enzyme activity in the brain (Federici et al. 2007). TiO_2 nanoparticles physically fill or clog digestive tracts of some aquatic invertebrates causing increased feeding rates and reduced digestion, which increases oxidative stress and may lead to lethality (Das et al. 2013). Stormwater from the Lewiston UA likely makes small contributions of TiO_2 to sediments of the Clearwater River and downstream Snake River, which contain large loads of TiO_2 at concentrations that are likely to kill and contaminate prey (e.g., amphipods), cause chronic sub-lethal toxicity in juvenile and adult salmonids, and increase toxic and absorptive properties of PBTs and other metals in the action area.

Nickel (Ni). Sources of nickel in UAs and highways include metal emissions from tires, petroleum combustion, household waste, and fertilizers (Sharma and Agrawal 2005). Nickel is a redox-active metal (Gauthier et al 2015) that can interact with other metals and PBTs to increase toxicity, oxidative stress, and immune defense depletion in fish and invertebrate prey (Eisler 1985, 1998; Stohs and Bagchi 1995; Sevicikova et al. 2011; Palermo et al. 2015). Nickel exceeded the TEC of 22.7 mg/kg at several locations in the lower Clearwater River and downstream Snake River (Table 9; Braun et al. 2012; MacDonald et al. 2000a). Stormwater discharges of nickel will make small contributions to the degraded water and sediment quality in these portions of the action area. Sediments of the Clearwater River and downstream Snake River contain loads of nickel at concentrations that are likely to reduce and contaminate prey and cause chronic sub-lethal toxicity in juvenile salmonids and increase toxic and absorptive properties of PBTs and other metals in the action area.

Common Pesticides and Nutrients

Pesticides and fertilizers are ubiquitous in UAs and are applied annually on lawns, pastures, orchards, and other interspersed agricultural lands (Table 8; Gilliom et al. 2006; Gilliom 2007). Terrestrial pesticides, adjuvants, and fertilizers can be highly persistent and toxic upon entering aquatic environments, causing acute and chronic effects to salmonids and their invertebrate prey (Scholtz et al. 2012). Glyphosate-based-herbicides (e.g., Roundup) are mostly likely to runoff of roads and railways (Botta et al. 2009), riprap and levees, and other areas of limited and poor soil with intensive vegetation control (Kjaer et al. 2011). Highest concentrations (75-90 µg/L) of glyphosate in streams are commonly from urban storm sewers during storms (Botta et al. 2009) and were concentrated in soil, sediments, and solid matter (Primost et al. 2017), even as water concentrations remained low. Effective vegetation removal by herbicides increases erosion of soil that may contain legacy POPs and mercury (Jonsson et al. 2017). Glyphosate and other contaminants in biofilms of wetlands can be 2-3 orders of magnitude higher than surrounding water and represent concentrated exposures to higher trophic levels (Beecraft and Rooney 2021).

Common terrestrial-use herbicide formulations and adjuvants may include bio-accumulating metals and PAHs, which are added to enhance performance and increase toxicity of active ingredients (Defarge et al. 2018). Additives are often labeled as proprietary “inert” ingredients but consist primarily of petroleum-based oxidized molecules and trace metals (arsenic, chromium, cobalt, lead, nickel, and others), which concentrate in soil, organic solids, sediments, and biofilms. Glyphosate significantly increases the bio-accumulation of mercury in zooplankton (Tsui et al. 2005). Mammals, mussels, amphibians, several insects, and many aquatic invertebrates are sensitive to sub-lethal and lethal toxicity of several pesticides, including glyphosate-based herbicides and their surfactants (Bringolf et al. 2007; Relyea and Diecks 2008; Janssens and Stoks 2017; Motta et al. 2018; Scully-Engelmeyer et al. 2021). Some pesticides are endocrine disruptors and may include transgenerational effects (Kubsad et al. 2019; Major et al. 2020). Stormwater discharges of common-use herbicides and other biocides contribute to the degraded water and sediment quality of Lindsay and Tammany Creeks and the Clearwater and Snake Rivers. Pulses and cumulative loads of common-use herbicides and other biocides are likely to reduce and contaminate prey, cause acute and chronic sub-lethal toxicity in juvenile and adult salmonids, and increase toxic and absorptive properties of PBTs and metals in the action area.

Tammany and Lindsay Creeks include silt sedimentation and nutrients (nitrogen, nitrite, nitrate, phosphorus) as impairment pollutants. Stormwater discharges of nutrients and sediment contribute to these impairments of Lindsay and Tammany Creeks. Anadromous salmonids are not present in Lindsay Creek, but steelhead may spawn, incubate as eggs and larvae, and rear as juveniles in the lower one-half mile of Tammany Creek. Water and sediment quality impairments from siltation and excessive nutrients degrade spawning and rearing habitat by clogging substrates, reducing interstitial oxygen required by incubating eggs, and altering and reducing cover. Nitrite and nitrate are also toxic to fish at concentrations that are expected to occur in lower Tammany Creek. Davidson et al. (2014) found nitrate concentrations of 80-100 mg/L were related to increased mortality and other chronic health impacts (abnormal swimming behavior) in juvenile rainbow trout. Nutrients from agriculture and wastewater may increase toxicity of PBTs to juvenile Chinook salmon (O'Neill et al. 2020). Chronic exposure by fathead minnows to environmentally relevant nitrate levels may cause endocrine disruption, alter steroid hormone synthesis and metabolism in male and female fish, and may include transgenerational effects (Kellock et al. 2018). Sediment and nutrient loads are likely to reduce and contaminate prey and cause chronic lethal and sub-lethal toxicity in incubating eggs and juvenile steelhead in lower Tammany Creek. Nutrient and sediment loads make small contributions that exacerbate temperature impairments in the Snake River, (which is listed by Washington and Idaho without a TMDL in either State) and dissolved oxygen and pH impairments listed by Washington in the Snake River.

Temperature

The current Idaho water quality standards for the Snake River are 22°C as a daily maximum and 19°C as a maximum daily average, based on the goal of protection of aquatic life. If temperature criteria for the designated aquatic life use are exceeded in the receiving waters upstream of the discharge due to natural background conditions, then wastewater must not raise the receiving water temperatures by more than three tenths (0.3) °C. The current Washington water quality standard for the Snake River from its mouth to the Washington – Idaho – Oregon border (River Mile 176.1) is 20°C as a daily maximum temperature. When natural conditions exceed a daily maximum of 20.0°C, no temperature increase will be allowed, which will raise the receiving water temperature by greater than 0.3°C.

Washington lists the Snake River within the action area and Idaho as temperature impaired without a TMDL in either State (Table 11; WDOE 2021). Reduced numbers of native trees in riparian habitats and reservoir shorelines increase solar radiation to surface waters, contributing to warmer temperatures. Survival of upstream migrating adult sockeye salmon and adult Chinook salmon is reduced with increasing summer water temperatures in the Snake River (Crozier et al. 2020). Adult sockeye salmon survival fell below 50 percent when river temperatures surpassed 18ºC (Crozier et al. 2014). Warm surface water reduces use of productive shoreline habitats by juvenile salmonids during late spring and summer (Curet 1993; Tiffan et al. 2014). Warm temperatures impact juvenile salmonid habitat use patterns and survival in the Snake River in the action area upstream of the Clearwater River confluence within the backwaters of LGR, and in downriver surface layers of the Snake River. During periods when the colder Clearwater River sub-ducts beneath the warm Snake River, thermal stratification limits vertical mixing, and surface layer temperatures of LGR commonly exceed 20ºC during summer from the north shore of the Clearwater River upstream of the confluence downstream to Lower Granite Dam (Cook et al. 2003, Cook et al. 2006). Juvenile fall Chinook salmon in LGR were found to prefer shallow water habitats along natural shorelines but also used riprapped shorelines (Tiffan et al. 2014). When shorelines warm in late spring fish must move to deeper water and some were found to behaviorally thermoregulate by changing depths to variably access the cooler plume (Tiffan et al. 2009).

Stormwater discharges of warm water make small contributions to the temperature impairment of the Snake River. Warm water discharges or runoff from impervious surfaces into the Snake

River along the southern and western UA could contribute most to local warming of this critical reach within the action area, which is in the backwaters of LGR upstream from the confluence of the Clearwater River where cold water released from Dworshak Reservoir enters the Snake River. Lower Tammany Creek is also likely to be warmed from upstream stormwater discharges and from stormwater running off the highway crossing in the action area. Stormwater runoff contributes to temperature loading of the levee drainage system and ponds along the Snake and Clearwater Rivers, which then contribute to local warming along riprapped shorelines and by small increments downstream. The combined load of warmer temperature from all stormwater sources will make small contributions to warm temperatures of surface water in the temperature-impaired downstream Snake River in the action area. Adverse effects are expected to alter habitat use by causing increased avoidance of preferred shallow water habitats, temporary avoidance and reduced use of rearing habitat in the immediate vicinities of outfalls along shorelines, and from increased predation (Coutant 1973; Mesa 1994; Erhardt et al. 2018; Tiffan et al. 2020) of juvenile salmonids from warm water piscivores benefited by the warmer shorelines.

Effectiveness of Proposed Permit Provisions

The array of BMPs will be mostly nonstructural during the permit term. Structural BMPs will take more time to design, install, and implement and are not required until near the end of the permit term. At the end of the five-year permit term, only two structural pollution reduction actions will have been required, one in Tammany Creek and one in Lindsay Creek. Numerous other stormwater discharges, which drain most of the UA's stormwater runoff into the Snake and Clearwater Rivers would not have been addressed by the City/LCSC and no pollution reduction actions specific to any impaired waters are required in the ITD2 permit.

Permit requirements and BMPs include measures that are expected to reduce loads of collective pollutants upon implementation. Pollutant loads are dispersed among several parts of the UA and its roadways in diverse mixtures. Comprehensive implementation and continued maintenance and improvement will be needed to reduce pollutant loads so that stormwater discharges will minimize contributions to the existing water/sediment quality impairments that cause adverse impacts to listed salmonids.

Aside from short-term scheduling and implementation, successful reduction of pollutant loads has long term planning and maintenance requirements because, for example, it takes time for vegetation to establish and grow. A review of the efficacy of structural and non-structural BMPs follows.

When properly designed, installed, and maintained, control measures and the associated BMPs improve stormwater quality (EPA 2020; IDEQ 2020a). Structural stormwater BMPs are engineered, designed, and built to collect and treat stormwater runoff, usually by reducing flow rates, removing pollutants, or both. Structural BMPs include extended retention and detention basins, silt fences, gravity separators, rocky swales, vegetated buffers, and other designs. Green infrastructure BMPs use plant or soil systems, stormwater harvest and reuse, landscaping, or other planned designs to reduce velocity, increase filtration and infiltration. Non-structural BMPs are often associated with source control methods rather than removing pollutants after they have been mobilized (e.g., public education, removing illicit discharges, landscape planning).

BMPs in the permits that are designed to protect water and sediment quality with vegetation are expected to be most effective at reducing adverse effects to salmonids from stormwater discharges over short and long terms. Green engineering with vegetative buffers that are planted with native grass sod and mixture of shrub and tree plantings can strongly reduce pollutant loads upon implementation, with increasing reductions expected for many years as shrubs grow and eventually mature trees begin to filter contaminants from the air and change the microclimate (temperature and winds). The functional value of small streams to salmonids and their relative contribution to food in downstream rivers can be measured by the amount and state of vegetated terrestrial and riparian habitat (Inoue et al. 2013). More large-bodied terrestrial and semi-aquatic insects are produced in terrestrial and riparian vegetation than in open areas without either type or only low seral stages of vegetation (Gustafsson et al. 2010; Inoue et al. 2013). During summer, insects produced in terrestrial and riparian habitats are strong dietary components of rearing and migrating salmonids in the Snake River and LGR within the action area (Muir and Coley 1996; Tiffan et al. 2014). Terrestrial and riparian habitats that include mature trees greatly increase habitat structure and food for an increased diversity of insects (Dosskey et al. 2010). Trees along small streams and large rivers are primary interceptors and accumulators of mercury, PAHs, ozone, dust, and other air particulates (Tian et al. 2019). Trees provide shade that cools terrestrial and riparian soils several meters deep, which reduces water temperature and its variability (Kaufmann et al. 2003; Nitoiu and Beltrami 2005) and reduce wind waves and soil erosion that would otherwise dislodge contaminated sediments (Vargas et al. 2007).

Construction site runoff controls in the permits are expected to effectively reduce sediment inputs to streams. Sediment runoff rates from uncontrolled construction sites are typically 10 to 20 times greater than those from agricultural lands (EPA 2020). The majority of BMPs to be implemented at construction sites are designed to prevent or reduce total suspended solids (TSS) and provide flow control. Examples of these types of BMPs and their associated TSS mean reductions if available, include sediment basins (60-75%); sediment traps; silt fences (50-90%); construction sequencing (42%); seeding (50-100%); sod (98-99%); vegetated grass-lined channels (60-83%); mulching (53-99%); buffer strips (90%); and swales (67-99%).

Post-construction stormwater control measures for new development and redevelopment are designed to maintain the current environmental baseline from new development and to improve the current environmental baseline with redevelopment. Strategic use of nonstructural controls, in concert with site appropriate structural BMPs, effectively reduce sediment, nutrients and other pollutants that tend to bind to sediment particles, which will collectively reduce pollutants expected in MS4 discharges. Site planning and design actions in the subject permits emphasize low impact development, use of vegetated buffers, and elimination of curbs and gutters, where feasible. Vegetated filter strips are bands of dense vegetation, through which stormwater runoff is directed are typically used to manage runoff from roads, highways, railways, small parking lots, and other impervious areas. These reduce flow velocity and increase infiltration, which are expected to significantly reduce loads of TSS and associated total and dissolved metals (copper, 69% and 56%; lead, 77% and 71%; and zinc, 66% and 59%) in runoff (EPA 2020). Thus, large proportions of collective contaminants (including PBTs, metals, tire tread particles, and some common-use pesticides) are effectively filtered by vegetation (and organic carbon) and soil infiltration (Spromberg et al. 2016; McIntyre et al. 2015; Tsui and Chu 2004). Natural or manmade shallow vegetated or rocky swales can effectively reduce flow rates while transporting and infiltrating stormwater into soil (McIntyre et al. 2015). Drainage channels that use detention or retention ponds, infiltration ponds, bio-swales, and wetland basins where feasible and appropriate, are very effective at removing sediment, nutrients, PBTs, and metals.

Pollutants expected to be discharged from the MS4s will be collectively reduced by BMPs that promote settling of fine sediment particles. This includes nonstructural BMPs that actively capture fine-grained solids (street sweeping). Cleaning of solids from drop-inlets and collection basins can collectively reduce PBTs, metals, nutrients, and pesticides). Pollution prevention programs that recycle or properly dispose of consumer products can be aimed at reducing specific PBTs, metals, or other potential pollutants. Ordinances that limit use of specific products can effectively reduce discharges of PBTs and pesticides and reduced speed limits are highly effective in reducing emissions of metals and tire tread particles from vehicles and highways along streams and rivers (Brahney et al. 2021).

Comprehensive implementation and planning of well-designed structural and non-structural BMPs are expected to reduce stormwater loads of pollutants to receiving waters during the five-year permit term and beyond.

Summary of effects on salmon and steelhead

The proposed action will authorize MS4 permits that continue to discharge pollutants that contribute to the acute and chronic lethal and sub-lethal effects on ESA-listed anadromous salmonids that occur in impaired or degraded receiving water and sediments of the action area. Lethal effects and chronic sub-lethal effects to steelhead are expected in lower Tammany Creek from stormwater pulsed mixtures of tire tread particles, copper, pesticides, nutrients, and sediment. Reductions of preferred prey and contamination of prey produced in Lindsay Creek, which enters the Clearwater River may reduce growth and fitness of some juvenile salmonids. Increased temperature and loads of PBTs, PAHs, metals, pesticides, nutrients, and sediment are expected to increase avoidance and reduce fitness of some rearing and migrating salmonids in the immediate area of outfalls in the Snake and Clearwater Rivers. Total loads of mixed PBTs, PAHs, and metals discharged to the lower Clearwater and Snake Rivers are expected to make small contributions to degraded baselines that cause lethal and sub-lethal effects from chronic exposures, which reduce growth, fitness, and survival of rearing and migrating salmonids as body burdens accumulate during rearing and migration in downstream reaches. The magnitude of the effect is related to the length of time spent in the action area, and the types of exposure experienced (i.e., if the fish are present during storms or immediately following). The proposed actions’ contributions of PBTs, PAHs, metals, pesticides, and temperature will also contribute to the increased risk and incidence of predation of juvenile salmon and steelhead by resident fish in the action area. Structural and nonstructural BMPs required by permits can effectively reduce and minimize its adverse effects to water/sediment quality of receiving waters. However, the comprehensive and integrated implementation of available BMPs will be required across the UA and surrounding roadways to adequately reduce adverse effects that may reduce the survival of anadromous salmonids in the action area.

Relevance of Fish Effects to Populations and MPG Viability

Most fish from most Snake River salmon and steelhead populations are present in the action area each year. Stormwater discharges from the Lewiston UA and its highways are expected to contribute small amounts of PBTs, PAHs, metals, tire tread particles, pesticides, nutrients, and temperature to the action area. Further, loads of persistent and toxic pollutants will accumulate during the five-year permit term. Out-migrating juvenile salmonid runs are extended over several months and most fish feed on benthic invertebrates in shallow water. Most effects are caused by chronic exposure to contaminated prey. Overall, moderate numbers of yearlings or older fish from affected populations will be exposed for short periods (days to weeks) to low levels of chronically harmful project-related effects. Populations that include life history types of migrating sub-yearlings and small-bodied yearlings are expected to have increased exposure and risk of lethal and sub-lethal effects because they rear and migrate at slower rates, have lower energy reserves, increased sensitivity at smaller sizes, and include higher risk of predation. Overall, few fish from affected populations will be exposed to and experience harmful project-related effects because of the episodic nature of storm events. The proposed action should not influence the productivity, spatial structure, or genetic diversity of the ESA-listed salmonid populations. Collectively, effects will not be substantial enough to influence VSP criteria at the population scale and the viability of the MPGs are also not expected to be affected.

Effects on Critical Habitat

Critical habitat within the action area has an associated combination of physical and biological features essential for supporting spawning, rearing, and migrating salmon and steelhead populations. The critical habitat PBFs most likely to be affected by the proposed action include water quality (chemical, shade/temperature, nutrients, spawning/incubation), substrate quality (chemical, fine sediment, spawning/incubation), and food.

Water Quality

Stormwater discharges of warm water contribute to the temperature impairment of the Snake River. Warm water discharges or runoff from impervious surfaces into the Snake River along the southern and western portions of the UA and into the Clearwater River from the northern portions of the Lewiston UA are likely to contribute most to local warming. Thermal contributions of the proposed action are expected to reduce water quality PBFs mostly along shorelines that receive stormwater discharges. PBTs, including PAHs, mercury, and copper will contribute to reduce water quality PBFs in the Snake and Clearwater Rivers.

Where stormwater is discharged into small streams or natural channels are used for stormwater conveyance, water quality PBFs will likely be negatively affected. The subject actions include these situations in Tammany Creek where few steelhead are expected to be present in its lower one-half mile of channel and in Lindsay Creek where salmonids are only expected to be exposed at its mouth. The Tammany Creek watershed may receive Lewiston UA runoff from a regional airport and associated gravel mines and expanding subdivisions with new construction along the length of its northern watershed boundary. A roadway that crosses lower Tammany Creek may drain contaminants into its channel that reduce water quality. The Lindsay Creek watershed receives runoff from a mixture of agricultural and UA runoff, including railways, and older industrial and commercial sites. The water quality PBF at the mouth of Lindsay Creek in the Clearwater River is likely to be negatively affected.

Nonstructural control measures in each of the two permits will reduce loading and improve water quality PBFs in receiving waters during the permit terms. The proposed City/LCSC permit requires two pollutant reduction measures (one for Tammany Creek and one for Lindsay Creek) be implemented by the end of the five-year permit term. These structural pollution reduction measures are expected to further improve water quality PBFs in lower Tammany Creek and in the Clearwater River near the mouth of Lindsay Creek.

Substrate Quality

Substrate quality will be reduced from discharge of PBTs, PAHs, metals, and common-use herbicides and pesticides (some of which include persistent active ingredients, PAHs, and metals) throughout the action area. Concentrations of these contaminants in discharges from the proposed permits when added to the environmental baselines are expected to kill sensitive prey, which are preferred by salmonids. Prey that are not killed will become contaminated by exposure to sediments containing persistent and bio-accumulative chemicals and nutrients that may be transferred throughout food webs. Several PBTs, nutrients, and some common-use herbicides are endocrine disruptors and include transgenerational effects, which can lead to long-term alterations and reductions in the function of riparian and aquatic ecosystems.

Sediment quality PBFs of critical habitat in the Snake and Clearwater Rivers will be reduced most along shorelines near outfalls and in downstream substrates where sedimentation occurs. In lower Tammany Creek, substrate quality PBFs will be negatively affected for steelhead critical habitat. Substrate quality PBFs at the mouth of Lindsay Creek along the shoreline of the Clearwater River may be negatively affected by stormwater runoff. Nonstructural control measures in both permits will reduce pollutant loads and improve substrate quality PBFs in receiving waters during the permit terms. The proposed City/LCSC permit requires two pollutant reduction measures (one for Tammany Creek and one for Lindsay Creek) be implemented by the end of the five-year permit term. These structural pollution reduction measures are expected to further improve substrate quality PBFs in lower Tammany Creek and in the Clearwater River near the mouth of Lindsay Creek.

Food

Urbanization, transportation systems, levees and shoreline armoring reduce and alter natural vegetation and thus the function of terrestrial, riparian, and aquatic habitats. The food PBF will be reduced by exposure, impermeable surfaces, the physical structure of rapidly draining conveyance systems, and from the introduction of PBTs, PAHs, metals, fine sediment, nutrients, and other contaminants. Riparian habitats are particularly important and sensitive in UAs, which tend to reduce the number and density of mature trees and shrubs that filter air particulates and shade water, streambanks, and proximate terrestrial soil (Li et al. 1984; Dosskey et al. 2010). The food PBF will be negatively affected by Lewiston UA discharges, which contribute PBTs, metals, nutrients, pesticides, sediment, and warm water to receiving waters, which in turn can contaminate invertebrates and alter their diversity and abundance. Factors that increase vegetation in terrestrial, riparian, and aquatic habitats are expected to increase prey diversity and production (Lusardi et al. 2018) and will improve the food PBF in receiving waters. Nonstructural control measures in both permits will reduce pollutant loads and improve food production and diversity of food PBFs in receiving waters during the permit terms. The proposed City/LCSC permit requires two pollutant reduction measures (one for Tammany Creek and one for Lindsay Creek) be implemented by the end of the five-year permit term. These structural pollution reduction measures are expected to further improve food PBFs in lower Tammany Creek and in the Clearwater River near the mouth of Lindsay Creek.

Summary of Effects on Critical Habitat

Stormwater discharges contribute a broad range of contaminants to the already degraded baseline water quality, substrate quality, and food PBFs in the Snake River and lower Clearwater River. The proposed action contributes to the impaired water and substrate quality of spawning/incubation, temperature, and food PBFs for steelhead critical habitat in lower Tammany Creek and to the impaired water quality, sediment quality, and food PBFs at the mouth of Lindsay Creek and downstream in the Clearwater River.

Stormwater discharges of warm water make small contributions to the temperature impairment of the Snake River and negatively affect its water quality PBFs. Stormwater from the Lewiston UA and highways will most negatively affect the Clearwater and Snake Rivers by degrading water quality, substrate quality, and food PBFs of critical habitat in the immediate vicinities of outfalls along shorelines. Stormwater runoff from a highway crossing the lower Tammany Creek and other drains that discharge into the Tammany Creek watershed will reduce water quality, sediment quality, and food PBFs for steelhead spawning/incubation and juvenile rearing in lower Tammany Creek.

Runoff from the Lewiston UA and riverside roads containing PBTs, PAHs, metals, temperature, fine sediment, and nutrients contribute to multiple stressors in the environmental baseline, which already degrade water and sediment quality in ecosystems, upon which listed salmonids rely. Impairment pollutants discharged by the MS4 permits contribute small amounts of persistent toxicants to water and sediments that exceed water and sediment effects threshold concentrations and that bioaccumulate throughout food webs. Receiving waters in the action area are impaired by increased temperature, reduced dissolved oxygen, reduced pH, *E.coli*, nutrients (including nitrogen, nitrate, and total phosphorus), sedimentation, and the PBTs of total PCBs, 2378-TCDD, 4,4'-DDE, dieldrin, toxaphene, mercury, and copper (Tables 10 and 11; IDEQ 2016; WDOE 2021; NMFS 2014a).

Nonstructural control measures that eliminate runoff of contaminants and clean sediments and solids from stormwater drains, are expected to improve critical habitat PBFs throughout the action area. The proposed City/LCSC permit requires at least two pollutant reduction measures (one for Tammany Creek and one for Lindsay Creek) be implemented by the end of the five-year permit term. Structural pollution reduction measures that reduce water velocity, increase soil infiltration and bio-filtration with vegetation (McIntyre et al. 2015) are expected to further improve PBFs for water quality, substrate quality, and food.

2.6. Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation (50 CFR 402.02 and 402.17(a)). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *versus* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.4).

Production and discharge of diverse contaminants by State and private entities in the action area is expected to be maintained at current levels or slightly increase into the future, with increasing population growth (EPA 2020). Various contaminants, including commercial and industrial by-products, metals, nutrients, and pesticides, will likely continue to be delivered to the action area from upstream sources and local industries discharges and runoff. Increased awareness of toxic and carcinogenic effects and further state regulation may reduce use of certain contaminants; however, overall concentrations in discharges and runoff are not likely to be reduced for many years. The contamination of sediments should gradually improve with continued bans on legacy organochlorine-based pesticides; however, new compounds, continued discharges, and use of other persistent contaminants is expected to continue at current rates.

States of Idaho, Washington, and Oregon are reasonably certain to continue managing water quantity in a fashion that perpetuates baseline upstream water consumption and reduced flows through the action area. Already depleted hydrographs of the upper Snake River measured at Hells Canyon Dam have recently been nearly halved during summer through winter months. These major impairments of water quantity are expected to continue and will exacerbate and perpetuate water quality impairments in the action area. Those present features of the action area will be further altered by the effects of climate change, as noted in the Environmental Baseline (Section 2.3, above).

2.7. Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

Species
Snake River fall Chinook salmon, Snake River spring/summer Chinook salmon, Snake River sockeye salmon, and SRB steelhead all migrate through the action area as adults on their way to spawning habitat upstream, and downstream as juveniles. Adults move through the action area relatively quickly (days) and generally stay in deeper water away from stormwater outfalls. Adult steelhead are the only exception to this; they may stage for several months near the Snake-Clearwater confluence, and a few adults of the Asotin Creek population (Lower Snake River MPG) may spawn and their offspring rear in lower Tammany Creek. Juveniles of all four species tend to move through the action area more slowly on their downstream migration to the ocean, stopping to eat and rest in the action area. They tend to occur in shallow water habitats, and may be found in close proximity to stormwater outfalls.

The two Chinook salmon ESUs and SRB steelhead DPS are listed as threatened, and Snake River sockeye salmon are listed as endangered. The abundance of all four species has declined since the last status review in 2016. The viability risk for most populations and MPGs are at high risk for Snake River spring/summer Chinook salmon and sockeye salmon, and marginally better for Snake River Fall Chinook and SRB steelhead. Current threats include climate change, predation, and degradation in freshwater habitats including poor water quality and increased temperatures, and mortality in the hydro system reach. To achieve recovery, all currently extant populations of Snake River spring/summer Chinook salmon will likely have to increase in abundance and productivity. Snake River fall Chinook salmon has only one extant population and diversity risk that needs to be reduced. A captive brood program is supporting Snake River sockeye salmon and substantial improvements in all four-risk parameters are needed for this species to recover, particularly with respect to survival improvements through the migration corridor. For SRB steelhead, more populations need to reach viable status through increases in abundance and productivity.

The environmental baseline in the action area is degraded. Riparian and floodplain habitat in the lower Clearwater River in the Lewiston UA is absent due to development. Hydropower, navigation, industry, agriculture, levees, and widespread bank armoring limit the availability of rearing habitat. The water and sediment in the action area have low to moderate levels of metals, pesticides, and low levels of other persistently toxic compounds, some of which bioaccumulate through food webs. These chemicals impair the growth and survival of juveniles in the action area as they are absorbed from the water (typically via the gills) or mostly by ingesting contaminated prey. The risk of lethality increases as body burdens are assimilated with extended rearing in the action area and in other contaminated downstream rivers during outmigration. Adults will likely have reduced immune response because of exposure to toxic compounds in the action area and may incur a few latent effects if carrying body burdens during warm temperatures. Adults do not feed much in freshwater and are unlikely to ingest contaminated prey. The source of the water quality degradation is from upstream areas as well as inputs from within the action area including existing stormwater inputs from roads and the Lewiston UA.

The proposed action will continue the effects of water quality degradation through the existing stormwater system in the action area. There will be instances of acute lethal and sub-lethal effects near stormwater outfalls and in lower Tammany Creek. Most effects will be from temporary narcosis or altered avoidance behaviors that result in increased predation in main stem rivers. Sedimentation and contamination of substrates and water quality will reduce growth and survival of incubating eggs and young juveniles of a few steelhead from the Asotin Creek population in lower Tammany Creek. Effects from a chronically reduced and contaminated prey base will reduce growth and survival for some juvenile fish, and will contribute to latent adverse effects of older juvenile fish further along the migratory corridor. During the five-year permit period we expect to see some reduction in pollutant loading as the nonstructural BMPs are implemented and further reductions are expected later in the permit period as the two structural BMPs are implemented or become more effective (e.g., plants mature, etc.). Despite the implementation of BMPs, the pollutant loading will still be at a level that it will contribute to reduced growth and survival of mostly the youngest juveniles from populations that migrate through the action area, and avoidance behaviors and possible sub-lethal effects for adults migrating upstream. These effects will tend to be episodic, during and immediately following storm events.

All populations migrate through the action area, which has a baseline level of sediment and water quality degradation, but we considered the following:

- Small contributions from stormwater, which occurs only during and immediately after storms;
- Sediment contaminant concentrations are patchy and higher mostly in the lower Clearwater River and downstream reach of the Snake River;
- Most contaminants partition to deep sediments if left undisturbed, and thus are not available for uptake; and
- Larger yearlings migrate faster, may not feed or feed primarily on larger (less contaminated) terrestrial and semi-aquatic insects in the action area.

Thus, we do not expect all populations or even all individuals to experience the increase in stormwater-related pollutant loading equally. The consequence is that only a subset of migrating juveniles will experience lethal and sub-lethal effects, and very few adults will experience sub-lethal effects (avoidance and olfactory effects).

The biggest concern to population-scale viability risk is a possible reduction in smaller, younger juveniles migrating downstream, and a potential impact to this life history strategy. Upstream tributaries with lower productivity and higher densities tend to produce smaller and younger migrants that are likely more vulnerable to stormwater contaminants because they spend more time in the action area feeding and resting, and they migrate later in the season when temperatures are warmer, there are more storms, and lower flows. While this is a concern, the contribution of the proposed permitted discharges is small and not enough to change the diversity risk for any one population or MPG. Population-scale abundance and productivity risk is unlikely to change as a consequence of the proposed action because too few fish from any population will be affected by the stormwater-related exposures, and because we anticipate pollutant loading will decline somewhat during permit implementation.

The effects of the proposed action will not likely be great enough to appreciably reduce the VSP parameters of listed species within the action area. Collectively, because effects will not be substantial enough to influence population level viability ratings, the viability of the MPGs and

ESU/DPS are also not expected to be affected. Further, implementation of the proposed action is not expected to impede or delay recovery of the ESUs/DPS.

Cumulative effects from future non-Federal activities are expected to perpetuate current conditions, and similarly climate change is unlikely to change habitat conditions over the next five years (although the effects of climate change are already apparent in the current habitat condition).

Thus, because the effects of the proposed action are unlikely to change the VSP of any of the MPGs in the action area, or change the trajectory towards recovery, and considering the current status of the species, baseline, and cumulative effects, the proposed action is unlikely to appreciably reduce the likelihood of the survival and recovery of the species analyzed in this opinion.

Critical Habitat

The proposed action will primarily affect the PBFs of water quality, substrate quality (including the spawning/incubation PBF for steelhead in Tammany Creek), and food. Benthic invertebrates, a primary prey species, will be negatively affected by the proposed action. Effects will be caused by pulses of stormwater that are expected to discharge low concentrations of a diverse range of conventional and chemical pollutants. Fine sediment, increased temperature, metals, nutrients, microplastics, and small amounts of PBTs are expected in the discharges, which will mostly partition to sediments in receiving water and either be buried by sedimentation or may be ingested by benthic invertebrates and accumulate into food webs where juvenile salmonids may ingest contaminated prey. Water quality will be degraded through small additions of mixtures of pollutants occurring during storm pulses. Substrate quality in LGR will then be degraded as persistent pollutants settle on substrates. These effects will occur at the scale of the action area, and will be most persistent around outfalls particularly during and immediately following storms, and to a lesser extent downstream as pollutants settle out in small, localized, quiescent habitats in LGR over the course of the five-year action.

The pollutant loading from the permitted outfalls is expected to contribute to the degraded baseline conditions in the action area. The effects of climate change are not expected to change the conservation value of the PBFs in the action area over the next five years.

The affected PBFs are localized near stormwater outfalls or in specific habitats of the action area, which comprise small proportions of critical habitat within the larger migration corridor. The project effects do not impede migration, and there are adequate less-contaminated feeding opportunities in adjacent reaches. Degraded spawning/incubation, water quality, substrate quality, and food PBFs in lower Tammany Creek will adversely affect critical habitat in one small stream within the critical habitat that one population of SRB steelhead uses (Asotin Creek population). There are adequate alternative spawning/incubation and feeding sites for that population, and the conservation value for spawning/incubation and feeding PBFs is not reduced at the scale of the designation of critical habitat.

Thus, the proposed action will not likely reduce the conservation value of the PBFs for water quality, substrate quality and food at the scale of the designation for critical habitat for Snake

River fall Chinook salmon, Snake River spring/summer Chinook salmon, Snake River sockeye salmon, and SRB steelhead.

2.8. Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' opinion that the proposed action is not likely to jeopardize the continued existence of Snake River spring-summer Chinook salmon, Snake River fall Chinook salmon, Snake River sockeye salmon, or Snake River Basin steelhead or destroy or adversely modify their designated critical habitat.

2.9. Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). On an interim basis, NMFS interprets "Harass" to mean, "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns, which include but are not limited to, breeding, feeding, or sheltering." "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

2.9.1. Amount or Extent of Take

The proposed action is reasonably certain to result in incidental take of ESA-listed species. NMFS is reasonably certain the incidental take described here will occur because: (1) MS4 permits authorize discharges to waters that support ESA-listed species; (2) contaminant loads, individually or collectively, are likely to exceed levels deemed protective of anadromous salmonids; and (3) other water quality parameters may be allowed at levels that do not support optimal growth and survival.

NMFS is unable to quantify the amount of take that is associated with the MS4 authorizations for the following reasons. The proposed action requires a selection of pollution reduction measures of variable efficacy be implemented at different times during the permits' five-year terms. The number of ESA-listed fish that are exposed to untreated or incrementally reduced discharge of pollutants is unknown and is expected to vary annually as well as seasonally in response to a myriad of factors beyond the quality or amount of discharge. Furthermore, it is not possible to count the number of fish that may be adversely affected, as the majority of effects are anticipated to be sub-lethal or behavioral in nature. The actual exposure of ESA-listed fish to harmful concentrations of pollutants and pollutant mixtures, and the duration of such exposures, is unpredictable. There is a large degree of variability in effects that could occur if fish were exposed to pollutant concentrations of sufficient magnitude and for a sufficient period of time. For these reasons, NMFS will use a surrogate to measure the extent of take caused by the action.

The extent of incidental take anticipated and analyzed in the opinion is exceeded if:

1. Implementation schedules of BMPs required by permits are not achieved.

   This surrogate functions as an effective re-initiation trigger because it is directly related to the amount of stormwater pollutant loading and thus harm to listed salmonids. Further, it is possible to monitor compliance with the implementation schedules of each permit and determine if the extent of take analyzed in this opinion is exceeded.

2.9.2 Effect of the Take

In the opinion, NMFS determined that the amount or extent of anticipated take, coupled with the scheduled implementation of permit requirements in the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

2.9.3. Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02).

The EPA shall:

1. Minimize incidental take from MS4 discharges by including new pollutants for reduction and by revising some of the proposed BMPs.

2. Ensure completion of a monitoring and reporting program to confirm that the terms and conditions in this ITS are effective in avoiding and minimizing incidental take from permitted activities and that the extent of take is not exceeded.

2.9.4. Terms and Conditions

The terms and conditions described below are non-discretionary, and the EPA or any applicant must comply with them in order to implement the RPMs (50 CFR 402.14). The EPA or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for subsequent discharges would likely lapse.

1. To implement RPM 1 (minimize take from MS4 discharges), EPA will ensure the following as permit conditions:

    a. The permits will include and implement by April 3, 2025 the conditions, set forth in 1.c. below, to reduce loading of the following Snake River stormwater impairment pollutants not considered in the proposed action: Total PCBs, 2378-TCDD, 4,4'-DDE, dieldrin, toxaphene, mercury, dissolved oxygen, pH, and temperature.

    b. The permits will include and implement by April 3, 2025 the conditions, set forth in 1.c. below, to reduce loading of the following stormwater pollutants not considered in the proposed action: Copper, PAHs, and tire tread particles.

    c. The permits will include and implement conditions that reduce accumulated loads of impairment pollutants and copper, PAHs, and tire tread particles from the MS4s; specifically, requirements that permittees:
        i. Clean storm drains and catchment basins of existing solids.
        ii. Disconnect outfalls from older development sites.
        iii. Minimize the installation of new outfalls from new development through implementation of onsite stormwater retention and/or treatment.
        iv. Maximize use of green infrastructure to manage/reduce sediment loading runoff.

2. To implement RPM 2 (monitoring and reporting), in addition to the existing monitoring and reporting requirements specified in the permits, EPA will ensure the following as permit conditions:

    a. The permits will include monitoring and reporting requirements to address the implementation schedule for the pollutants identified in term and conditions 1.a and 1.b of this opinion.

    b. The permits will include monitoring and reporting requirements that demonstrate progress towards the implementation and completion of the terms and conditions identified under 1.c. of this opinion.

    c. The permits will include monitoring and reporting requirements that assess the pollutant load reductions associated with the proper removal and cleaning of solids found in storm drains and catchment basins.

2.10. Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

Conservation recommendations for this consultation are as follows:

1. Reduce use of common-use herbicides and pesticides that degrade into weak acids (e.g., atrazine, glyphosate) or that include persistent ingredients or additives.

2. Develop and implement long-term terrestrial and riparian vegetation management plans (VMPs) within SWMPs that will include establishing and maintaining vegetation where practicable. VMPs should be designed to improve riparian function along Lindsay and Tammany Creeks and ephemeral drainages throughout the Lewiston UA. These VMPs should consider and implement actions that buffer air deposition of pollutants, provide shade to reduce temperature, reduce erosion, and increase forage production to receiving waters.

These conservation recommendations will help increase survival and productivity of most Snake River salmon and steelhead populations, contribute to cleaner water and air, cooler temperatures, and increase the quantity, quality, and conservation value of critical habitat in Tammany Creek and the Clearwater and Snake Rivers.

2.11. Re-initiation of Consultation

This concludes formal consultation for the EPA's National Pollution Discharge Elimination System Municipal Stormwater Permits (IDS028061 and IDS028258), Lewiston, Idaho.

As 50 CFR 402.16 states, re-initiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) The amount or extent of incidental taking specified in the ITS is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT RESPONSE

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. Under the MSA, this consultation is intended to promote the conservation of EFH as necessary to support sustainable fisheries and the managed species' contribution to a healthy ecosystem. For the purposes of the MSA, EFH means "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity", and includes the physical, biological, and chemical properties that are used by fish (50 CFR 600.10). Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) of the MSA also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects of the action on EFH [CFR 600.905(b)]

This analysis is based, in part, on the EFH assessment provided by the EPA and descriptions of EFH for Pacific Coast salmon (PFMC 2014) contained in the fishery management plans developed by the PFMC and approved by the Secretary of Commerce.

3.1. Essential Fish Habitat Affected by the Project

The action area, as described in Section 2.3 of the above opinion, except for areas above natural barriers to fish passage, is also EFH for Chinook salmon and coho salmon (PFMC 2014).

3.2. Adverse Effects on Essential Fish Habitat

Based on the information provided in the BE and the analysis of effects presented in the ESA portion of this document, NMFS concludes that the proposed action will have the following adverse effects on EFH designated for Chinook and coho salmon: (1) temporary reductions in water quality from impairment pollutants delivered in stormwater runoff from the Lewiston UA and associated roadways, incremental temperature and sediment increases from runoff of exposed and impermeable surfaces; (2) temporary pulses and small reductions in substrate condition from loads of PBTs, PAHs, and heavy metals in runoff from various sources within the Lewiston UA; (3) temporary reductions of food for salmonids associated with loss of vegetation from impermeable surfaces and toxicity of contaminants to some prey species; and (4) small contributions of contaminated prey to salmonids within the EFH that contribute to chronic sub-lethal reductions in fitness (reduced growth, energy reserves, behavioral avoidance) and survival of salmonids within the EFH.

3.3. Essential Fish Habitat Conservation Recommendations

NMFS determined that the following conservation recommendations are necessary to avoid, minimize, mitigate, or otherwise offset the impact of the proposed action on EFH.

1. The permits will reduce loading of the following Snake River stormwater impairment pollutants not considered in the proposed action: Total PCBs, 2378-TCDD, 4,4’-DDE, dieldrin, toxaphene, mercury, dissolved oxygen, pH, and temperature.

2. The permits will reduce loading of the following stormwater pollutants not considered in the proposed action: Copper, PAHs, and tire tread particles.

3. The Permits will include conditions to reduce accumulated loads of impairment pollutants and copper, PAHs, and tire tread particles from the MS4s; specifically:
    1. Clean storm drains and catchment basins of existing solids.
    2. Disconnect outfalls from older development sites.
    3. Minimize the installation of new outfalls from new development through implementation of onsite stormwater retention and/or treatment.
    4. Maximize use of green infrastructure to manage/reduce sediment-loading runoff.

Fully implementing these EFH conservation recommendations would protect, by avoiding or minimizing the adverse effects described in Section 3.2, above, for Pacific Coast salmon.

3.4. Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, EPA must provide a detailed response in writing to NMFS within 30 days after receiving an EFH conservation recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH conservation recommendations unless NMFS and the federal agency have agreed to use alternative timeframes for the federal agency response. The response must include a description of measures proposed by the agency for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the conservation recommendations, the federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we ask that in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

3.5. Supplemental Consultation

The EPA must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH conservation recommendations [50 CFR 600.920(l)].

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The DQA specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

4.1. Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended user of this opinion is EPA. Other interested users could include IDEQ, ITD, permittees, citizens of Lewiston, Idaho and surrounding affected areas, and others interested in the conservation of the affected ESUs/DPS. Individual copies of this opinion were provided to the EPA. The document will be available within 2 weeks at the NOAA Library Institutional Repository (https://repository.library.noaa.gov/welcome). The format and naming adhere to conventional standards for style.

4.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

4.3 Objectivity

Information Product Category: Natural Resource Plan.

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion and EFH consultation contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

5. REFERENCES

Alvarez, D., S. Perkins, E. Nilsen, and J. Morace. 2014. Spatial and temporal trends in occurrence of emerging and legacy contaminants in the Lower Columbia River 2008-2010. Science of the Total Environment 484: 322-330.

Amato, E.D., C.P.M. Marasinghe Wadige, A.M. Taylor, W.A. Maher, S.L. Simpson, and D.F. Jolley. 2018. Field and laboratory evaluation of DGT for predicting metal bioaccumulation and toxicity in the freshwater bivalve *Hyridella australis* exposed to contaminated sediments. Environmental Pollution 243: 862-871.

Arkoosh, M., S. Strickland, A. Gaest, G. Ylitalo, L. Johnson, G. Yanagida, T. Collier, J. Dietrich. 2011. Trends in organic pollutants and lipids in juvenile Snake River spring Chinook salmon with different out-migrating histories through the Lower Snake and Middle Columbia Rivers. Science of the Total Environment 409: 5086-5100.

Arkoosh, M., A.L. Van Geist, S.A. Strickland, G.P. Hutchinson, A.B. Krupkin, and J.P. Dietrich. 2017. Alteration of thyroid hormone concentrations in juvenile Chinook salmon (*Oncorhynchus tshawytscha*) exposed to polybrominated diphenyl ethers, BDE-47 and BDE-99. Chemosphere 171: 1-8.

Baker, D. Hatchery Manager, Idaho Department of Fish and Game, November 2, 2021. Personal communication, email to Chad Fealko, NMFS Fish Biologist, regarding sockeye returns to the Sawtooth Valley.

Bakshi, A., and A. Panigrahi. 2018. A comprehensive review on chromium induced alterations in freshwater fishes. Toxicology Reports 5: 440-447.

Baldwin, D.H., J.A. Spromberg, T.K. Collier, and N.L. Scholz. 2009. A fish of many scales: extrapolating sub-lethal pesticide exposures to the productivity of wild salmon populations. Ecological Applications 19: 2004-2015.

Baldwin, A.K., B.A. Poulin, J. Naymik, C. Hoovestol, G.M. Clark, and D.P. Krabbenhoft. 2020. Seasonal dynamics and inter-annual variability in Mercury Concentrations and loads through a three-reservoir complex. Environmental Science and Technology. https://dx.doi.org/10.1021/acs.est.9b07103

Battin, J., M.W. Wiley, M. H. Ruckelshaus, R. N. Palmer, E. Korb, K. K. Bartz, and H. Imaki. 2007. Projected impacts of climate change on salmon habitat restoration. Proceedings of the National Academy of Sciences of the United States of America 104: 6720–6725.

Beecraft, L., and R. Rooney. 2021. Bioconcentration of glyphosate in wetland biofilms. Science of the Total Environment 756: 143993. https://doi.org/10.1016/j.scitotenv.2020.143993

Bennett, D., and others. 1983. Status of the Warmwater Fishery and the Potential of Improving Warmwater Fish Habitat in the Lower Snake Reservoirs. Report to the U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, WA.

Bennett, D., M. Madsen, T. Dresser Jr., and T. Curet. 1995. Monitoring fish community activity at disposal and reference sites in lower Granite Reservoir, Idaho-Washington, Report to the U.S. Army Corps of Engineers, Walla Walla District, Walla Walla, WA.

Bettaso, J.B., and D.H. Goodman. 2010. A comparison of mercury contamination in mussel and ammocoete filter feeders. Journal of Fish and Wildlife Management 1: 142–145; e1944-687X. doi:10.3996/112009-JFWM-019

Bjornn, T.C., and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. Pages 83–138 *in* W.R. Meehan, editor. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society, Special Publication 19. Bethesda, Maryland.

Bjornn, T.C., D.R. Craddock, and D.R. Corley. 1968. Migration and survival of Redfish Lake, Idaho, sockeye salmon, *Oncorhynchus nerka*. Transactions of the American Fisheries Society 97: 360-373.

Botta, F., G. Lavison, G. Couturier, F. Alliot, E. Moreau-Guigon, N. Fauchon, B. Guery, M. Chevreuil, and H. Blanchoud. 2009. Transfer of glyphosate and its degradate AMPA to surface waters through urban sewerage systems. Chemosphere 77: 133-139.

Boyle, D., G.A. Al-Bairuty, C.S. Ramsden, K.A. Sloman, T.B. Henry, and R.D. Handy. 2013. Subtle alterations in swimming speed distributions of rainbow trout exposed to titanium dioxide nanoparticles are associated with gill rather than brain injury. Aquatic Toxicology 126: 116-127.

Brahney, J., N. Mahowald, M. Prank, G. Cornwell, Z. Klimont, H. Matsui, and K.A. Prather. 2021. Constraining the atmospheric limb of the plastic cycle. Proceedings of the National Academy of Sciences of the U.S.A. 118: e2020719118. https://doi.org/10.1073/pnas.2020719118

Braun, C.L., J.T. Wilson, P.C. Van Metre, R.J. Weakland, R.L. Fosness, and M.L.Williams. 2012. Grain-size distribution and selected major and trace element concentrations in bed-sediment cores from the Lower Granite Reservoir and Snake and Clearwater Rivers, eastern Washington and northern Idaho, 2010. U.S. Geological Survey Scientific Investigations Report 2012–5219. 81 pp.

Bravo, C.F., L.R. Curtis, M.S. Myers, J.P. Meador, L.L. Johnson, J. Buzitis, T.K. Collier, J.D. Morrow, C.A. Laetz, F.J. Loge, and M.R. Arkoosh. 2011. Biomarker responses and disease susceptibility in juvenile rainbow trout Oncorhynchus mykiss fed a high molecular weight PAH mixture. Environmental Toxicology and Chemistry 30: 704-714.

Bringolf, R.B., W.G. Cope, S. Mosher, M.C. Barnhart, and D. Shea. 2007. Acute and chronic toxicity of glyphosate compounds to glochidia and juveniles of *Lampsilis siliquoidea* (Unionidae).

Broussard, L.A., C.A. Hammett-Stabler, R.E. Winecker, and J.D. Ropero-Miller. 2002. The toxicology of mercury. Laboratory Medicine 8: 614-625.

Buchman, M.F. 2008. NOAA Screening Quick Reference Tables. NOAA OR&R Report 08-1, Seattle, WA, Office of Response and Restoration Division, National Oceanic and Atmospheric Administration. 34 pp.

Campanale, C., C. Massarelli, I. Savino, V. Locaputo, and V.F. Uricchio. 2020. A detailed review study on potential effects of microplastics and additives of concern on human health. International Journal of Environmental Research and Public Health 17: 1212; doi:10.3390/ijerph17041212

Chapman, D., W. Platts, D. Park and M. Hill. 1990. Status of Snake River sockeye salmon. Final Report to PNUCC, June 26. Don Chapman Consultants Inc.: Boise, Idaho. 96 p.

Collier, T.K., B.F. Anulacion, M.R. Arkoosh, J.P Dietrich, J.P. Incardona, L.L. Johnson, G.M Ylitalo, and M.S. Myers. 2014. Effects on fish of polycyclic aromatic hydrocarbons (PAHS) and naphthenic acid exposures. Organic Chemical Toxicology of Fishes 33: 195-255.

Connor, W.P., A.R. Marshall, T.C. Bjornn, and H.L. Burge. 2001. Growth and long-range dispersal by wild subyearling spring and summer Chinook salmon in the Snake River Basin. Transactions of the American Fisheries Society 130: 1070-1076.

Connor, W.P., and H.L. Burge. 2003. Growth of wild subyearling fall Chinook salmon in the Snake River. North American Journal of Fisheries Management 23: 594-599.

Connor, W.P., J.G. Sneva, K.F. Tiffan, R.K. Steinhorst, and D. Ross. 2005. Two alternative juvenile life history types for fall Chinook salmon in the Snake River Basin. Transactions of the American Fisheries Society 134: 291-304.

Cook, C. B., Richmond, M. C., Coleman, A. M. Rakowski, C. L., Titzler, P. Scott, and M. D. Bleich. 2003. Numerically Simulating the Hydrodynamic and Water Quality Environment for Migrating Salmon in the Lower Snake River. United States. doi:10.2172/15003970.

Cook, C.B., B. Dibrani, M.C. Richmond, M.D. Bleich, P.S. Titzler, and T. Fu. 2006. Hydraulic Characteristics of the Lower Snake River During Periods of Juvenile Fall Chinook Salmon Migration.

Counihan, T.D., I.R. Waite, E.B. Nilsen, J.M. Hardiman, E. Elias, G. Gelfenbaum and S.D. Zaugg. 2014. A survey of benthic sediment contaminants in reaches of the Columbia River estuary based on channel sedimentation characteristics. Science of the Total Environment 484: 331-343.

Coutant, C.C. 1973. Effect of thermal shock on vulnerability of juvenile salmonids to predation. Journal of the Fisheries Research Board of Canada 30: 965-973.

Coutant, C.C., and R.R. Whitney. 2006. Hydroelectric system development: effects on juvenile and adult migration. Pages 249–324 in R. N. Williams, editor. Return to the River-Restoring Salmon to the Columbia River. Elsevier Academic Press, Amsterdam.

Crozier, L.G., B.J. Burke, B.P. Sandord, G.A. Axel, and B.L. Sanderson. 2014. Passage and survival of adult Snake River sockeye salmon within and upstream from the Federal Columbia River Power System. NMFS, Seattle, Washington. July 2014. 78 pp.

Crozier L.G., J.E. Siegel, L.E. Wiesebron, E.M. Trujillo, B.J. Burke, B.P. Sandford, and D.L. Widener. 2020. Snake River sockeye and Chinook salmon in a changing climate: Implications for upstream migration survival during recent extreme and future climates. PLoS ONE 15(9): e0238886. https://doi.org/10.1371/journal.pone.0238886

Curet, T. 1993. Habitat use, food habits, and the influence of predation on subyearling Chinook salmon in Lower Granite Reservoir, Washington. Master's thesis. University of Idaho, Moscow.

Daley, J.M., T.A. Leadley, T.E. Pitcher, and K.G. Drouillard. 2012. Bio-amplification and the selective depletion of persistent organic pollutants in Chinook salmon larvae. Environmental Science and Technology 46: 2420–2426.

Daley, J.M., T.A. Leadley, T.E. Pitcher, and K.G. Drouillard. 2013. The effect of food provisioning on persistent organic pollutant bio-amplification in Chinook salmon larvae. Chemosphere 92: 10-15.

Das, P, M.A. Xenopoulos, and C.D. Metcalfe. 2013. Toxicity of silver and titanium dioxide nanoparticle suspensions to the aquatic invertebrate, *Daphnia magna*. Bulletin of Environmental Contamination and Toxicology 91: 76-82.

Dauble D. D., L. R. Johnson, and A. P. Garcia. 1999. Fall Chinook Salmon Spawning in the Tailraces of Lower Snake River Hydroelectric Projects. Transactions of the American Fisheries Society, 128:4, 672–679.

Dauble, D. D., R. L. Johnson, R. P. Mueller, and C.S Abernethy. 1995. Spawning of Fall Chinook Salmon Downstream of Lower Snake River Hydroelectric Projects 1994. Prepared for U.S. Army Corps of Engineers Walla Walla District, by Pacific Northwest Laboratory.

Dauble D. D., R. L. Johnson, R. P. Mueller, C. S. Abernethy, B. J. Evans, and D. R. Geist. 1994. Identification of Fall Chinook Salmon Spawning Sites Near Lower Snake River Hydroelectric Projects. Prepared for U.S. Army Corps of Engineers Walla Walla District, by Pacific Northwest Laboratory.

Davidson, J., C. Good, C. Welsh, and S.T. Summerfelt. 2014. Comparing the effects of high vs. low nitrate on the health, performance, and welfare of juvenile rainbow trout *Oncorhynchus mykiss* within water recirculating aquaculture systems. Aqua cultural Engineering 59: 30-40.

Davis, M., I. Woo, C. Ellings, S. Hodgson, D. Beauchamp, G. Nakai, and S. De La Cruz. 2018. Integrated diet analyses reveal contrasting trophic niches for wild and hatchery juvenile Chinook salmon in a large river delta. Transactions of the American Fisheries Society 147: 818-841.

Defarge, N., J. Spiroux de Vedomois, and G. Seralini. 2018. Toxicity of formulants and heavy metals in glyphosate-based herbicides and other pesticides. Toxicology Reports 5: 156-163.

de March, B.G.E. 1988. Acute toxicity of binary mixtures of five cations (Cu2+, Cd2+, Zn2+, Mg2+, and K+) to the freshwater amphipod Gammarus lacustris (Sars): alternative descriptive models. Canadian Journal of Fisheries and Aquatic Sciences 45: 625-633.

Dosskey, M., P. Vidon, N. Gurwick, C. Allan, T. Duval, and R. Lowrance. 2010. The role of riparian vegetation in protecting and improving chemical water quality in streams. Journal of the American Water Resources Association 46: 261-277.

Ecovista, Nez Perce Tribe Wildlife Division, and Washington State University Center for Environmental Education. 2003. Draft Clearwater Subbasin Assessment, Prepared for Nez Perce Tribe Watersheds Division and Idaho Soil Conservation Commission. 463 p.

Eisler, R. 1970. Acute toxicities of organochlorine and organophosphorus insecticides to estuarine fishes. U.S. Dept. Inter. Bur. Sport fish. Wildlife. Tech. Pap 46.

Eisler, R. 1985. Cadmium hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish and Wildlife Service Biological Report 85 (1.2). 30 pp.

Eisler, R. 1986a. Chromium hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish and Wildlife Service Biological Report 85 (1.6). 60 pp.

Eisler, R. 1986b. Polychlorinated biphenyl hazards to fish, wildlife, and invertebrates: A synoptic review. U. S. Geological Survey, Biological Science Report 85(1.7). Contaminant Hazard Reviews, April 1986. Report No. 7.

Eisler, R. 1987. Mercury hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish and Wildlife Service Biological Report 85 (1.10). 63 pp.

Eisler, R. 1998. Nickel hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Geological Survey, Biological Resources Division, Biological Science Report USGS/BRD/BSR—1998-0001. 76 pp.

Eisler, R. 1993. Zinc hazards to fish, wildlife, and invertebrates: A synoptic review. U. S. Fish and Wildlife Service, Biological Report 10, Contaminant Hazard Reviews Report 26.

Erhardt, J., K. Tiffan and W. Connor. 2018. Juvenile Chinook salmon mortality in a Snake River Reservoir: smallmouth bass predation revisited. Transactions of the American Fisheries Society 147: 316-328.

Everest, F. H. and D. W. Chapman. 1972. Habitat selection and spatial interaction by juvenile Chinook salmon and steelhead trout in two Idaho streams. Journal of the Fisheries Research Board of Canada 29: 91-100.

Farag, A.M., D.F. Woodward, J.N. Goldstein, W. Brumbaugh, and J.S. Meyer. 1998. Concentrations of metals associated with mining waste in sediments, biofilm, benthic macroinvertebrates, and fish from the Coeur d'Alene River Basin, Idaho. Archives of Environmental Contamination and Toxicology 34: 119-127.

Farag, A., D. Woodward, W. Brumbaugh, J. Goldstein, E. MacConnell, C. Hogstrand, and F. Barrows. 1999. Dietary effects of metals-contaminated invertebrates from the Coeur d' Alene River, Idaho, on cutthroat trout. Transactions of the American Fisheries Society 128: 578-592.

Farag, A.M., T. May, G.D. Marty, M. Easton, D.D. Harper, E.E. Little, et al. 2006. The effect of chronic chromium exposure on the health of Chinook salmon (*Oncorhynchus tshawytscha*). Aquatic Toxicology 76: 246-257.

Federici, G., B.J. Shaw, and R.D. Handy. 2007. Toxicity of titanium dioxide nanoparticles to rainbow trout (*Oncorhynchus mykiss*): gill injury, oxidative stress, and other physiological effects. Aquatic Toxicology 84: 415-430.

Feist, G.W., M.A.H. Webb, D.T. Gundersen, E.P. Foster, C.B. Schreck, A.G. Maule, and M.S. Fitzpatrick. 2005. Evidence of Detrimental Effects of Environmental Contaminants on Growth and Reproductive Physiology of White Sturgeon in Impounded Areas of the Columbia River. Environmental Health Perspectives 113: 1675-1682.

Felts, E. A., B. Barnett, M. Davison, C. J. Roth, J. R. Poole, R. Hand, M. Peterson, and E. Brown. 2019. Idaho adult Chinook Salmon monitoring. Annual report 2018. Idaho Department of Fish and Game Report 19–10.

Fitzgerald, W.F. 1998. The case for atmospheric mercury contamination in remote areas. Environmental Science and Technology 32: 1-7.

Fleck, J.A., M. Marvin-DiPasquale, C.A. Eagles-Smith, J.T. Ackerman, M.A. Lutz, M. Tate, C.N. Alpers, B.D. Hall, D.P. Krabbenhoft, and C.S. Eckley. 2016. Mercury and methylmercury in aquatic sediment across western North America. Science of the Total Environment 568: 727-738.

Ford, M. J. (ed.) 2011. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-113, 281 p. https://www.westcoast.fisheries.noaa.gov/publications/status_reviews/salmon_steelhead/multiple_species/5-yr-sr.pdf

FPC (Fish Passage Center). 2019. Chinook salmon adult return data downloaded from the Fish Passage Center website (https://www.fpc.org/) in October, 2019.

Garland, R.D., K.F. Tiffan, D.W. Rondorf, and L.O. Clark. 2002. Comparison of subyearling fall Chinook salmon's use of riprap revetments and unaltered habitats in Lake Wallula of the Columbia River. North American Journal of Fisheries Management 22: 1283-1289.

Gauthier, P.T., W.P. Norwood, E.E. Prepas, and G.G. Pyle. 2014. Metal–PAH mixtures in the aquatic environment: A review of co-toxic mechanisms leading to more-than-additive outcomes. Aquatic Toxicology 154: 253-269.

Gauthier, P.T., W.P. Norwood, E.E. Prepas, and G.G. Pyle. 2015. Metal−polycyclic aromatic hydrocarbon mixture toxicity in *Hyalella azteca*. 2. metal accumulation and oxidative stress as interactive co-toxic mechanisms. Environmental Science and Technology. DOI: 10.1021/acs.est.5b03233

Gilliom, R. J., J. E. Barbash, C. G. Crawford, P. A. Hamilton, J. D. Martin, N. Nakagaki, L. H. Nowell, J. C. Scott, P. E. Stackelberg, G .P. Thelin, and D. M. Wolock. 2006. The Quality of Our Nation's Waters—Pesticides in the Nation's Streams and Ground Water, 1992–2001: U.S. Geological Survey Circular 1291,172 pp.

Gilliom, R.J. 2007. Pesticides in U.S. streams and groundwater. Environmental Science and Technology 41: 3408–3414.

Good, T. P., R. S. Waples, and P. Adams (editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-66, 598 p.

Gottfried, P., D. Gillette, and N. Nichols. 2011. Synthesis Report on Use of Shallow-Water Dredge Spoil on Habitat Availability and Use by Salmonids and other Aquatic Organisms in Lower Granite Reservoir, Washington 1983-2010. Contract W912EF-11-P-5008. March 25, 2011. U.S. Army Corps of Engineers, Walla Walla, Washington. 50 pp.

Grunblatt, J., B.E. Meyer, and M.S. Wipfli. 2019. Invertebrate prey contributions to juvenile coho salmon diet from riparian habitats along three Alaska streams: implications for environmental change. Journal of Freshwater Ecology 34: 617-631.

Gustafsson, P., E. Bergman, and L.A. Greenberg. 2010. Functional response and size-dependent foraging on aquatic and terrestrial prey by brown trout (Salmo trutta L.). Ecology of Freshwater Fish 19: 170-177.

Hauck, F. R. 1953. The Size and Timing of Runs of Anadromous Species of Fish in the Idaho Tributaries of the Columbia River. Prepared for the U.S. Army Corps of Engineers by the Idaho Fish and Game Department, April 1953. 16 pp.

Hecht SA, Baldwin DH, Mebane CA, Hawkes T, Gross SJ, and Scholz NL. 2007. An overview of sensory effects on juvenile salmonids exposed to dissolved copper: Applying a benchmark concentration approach to evaluate sub-lethal neurobehavioral toxicity. National Marine Fisheries Service, NOAA Technical Memorandum NMFS-NWFSC-83, Seattle, WA.

Hegg, J.C., B.P. Kennedy, P.M. Chittaro, and R.W. Zabel. 2013. Spatial structuring of an evolving life history strategy under altered environmental conditions. Oecologia DOI 10.1007/s00442-012-2564-9.

Henning, J.A., R.E. Gresswell, and I.A. Fleming. 2006. Juvenile salmonid use of freshwater emergent wetlands in the floodplain and its implications for conservation management. North American Journal of Fisheries Management 26: 367-376.

Hinck, J.E., C.J. Schmitt, V.S. Blazer, N.D. Denslow, T.M. Bartish, P.J. Anderson, J.J. Coyle, G.M. Dethloff, and D.E. Tillitt. 2006. Environmental contaminants and biomarker responses in fish from the Columbia River and its tributaries: spatial and temporal trends. Science of the Total Environment 366: 549-578.

Hites, R.A. 2004. Polybrominated diphenyl ethers in the environment and in people: a meta-analysis of concentrations. Environmental Science and Technology 38: 945-956.

Hook, S., A. Skillman, J. Small, and I. Schultz. 2006. Gene expression patterns in rainbow trout, *Oncorhynchus mykiss*, exposed to a suite of model toxicants. Aquatic Toxicology 77: 372-385.

ICTRT (Interior Columbia Technical Recovery Team). 2003. Working draft. Independent populations of Chinook, steelhead, and sockeye for listed evolutionarily significant units within the Interior Columbia River domain. NOAA Fisheries. July.

ICTRT. 2007. Viability Criteria for Application to Interior Columbia Basin Salmonid ESUs, Review Draft March 2007. Interior Columbia Basin Technical Recovery Team: Portland, Oregon. 261 pp.

ICTRT. 2010. Status Summary – Snake River Spring/Summer Chinook Salmon ESU. Interior Columbia Technical Recovery Team: Portland, Oregon.

IDEQ (Idaho Department of Environmental Quality). 2001. Middle Salmon River–Panther Creek Sub-basin Assessment and TMDL. IDEQ: Boise, Idaho. 114 p.

IDEQ. 2016. Idaho's 2016 Integrated Report. Idaho Department of Environmental Quality.

IDEQ. 2020. Idaho's 2018/2020 Integrated Report, Final. IDEQ. Boise, Idaho. 142 p.

IDEQ. 2020a. Idaho Catalog of Storm Water Best Management Practices. Idaho Department of Environmental Quality. April 2020.

IDEQ and U.S. Environmental Protection Agency (EPA). 2003. South Fork Clearwater River Sub-basin Assessment and Total Maximum Daily Loads. IDEQ: Boise, Idaho. 680 p.

Inoue, M., S. Sakamoto, and S. Kikuchi. 2013. Terrestrial prey inputs to streams bordered by deciduous broadleaved forests, conifer plantations, and clear-cut sites in southwestern Japan: effects on the abundance of red-spotted masu salmon. Ecology of Freshwater Fish 22: 335-347.

ISAB (Independent Scientific Advisory Board). 2007. Climate change impacts on Columbia River Basin fish and wildlife. ISAB Climate Change Report, ISAB 2007-2, Northwest Power and Conservation Council, Portland, Oregon.

Iwata, M. 1995. Downstream migratory behavior of salmonids and its relationship with cortisol and thyroid hormones: a review. Aquaculture 135: 131-139.

Janssens, L., and R. Stoks. 2017. Stronger effects of Roundup than its active ingredient glyphosate in damselfly larvae. Aquatic Toxicology 193: 210-216.

Johnson, E.L., C.C. Kozfkay, J.H. Powell, M.P. Peterson, D.J. Baker, J.A. Heindel, K.E. Plaster, J.L. McCormick, and P.A. Kline. 2020. Evaluating artificial propagation release strategies for recovering endangered Snake River sockeye salmon. North American Journal of Aquaculture 82: 331-344.

Johnson, A., and D. Norton. 2005. Concentrations of 303(d) Listed Pesticides, PCBs, and PAHs Measured with Passive Samplers Deployed in the Lower Columbia River. Washington State Department of Ecology, Olympia, WA. Publication No. 05-03-006.

Johnson, L.L., G.M. Ylitalo, M.R. Arkoosh, A.N. Kagley, C. Stafford, J.L. Bolton, J. Buzitis, B.F. Anulacion, and T.K. Collier. 2006. Contaminant exposure in out-migrant juvenile salmon from Pacific Northwest estuaries of the United States. Environmental Monitoring and Assessment 87: 1-28.

Johnson, L.L., G.M. Ylitalo, C.A. Sloan, B.F. Anulacion, A.N. Kagley, M.R. Arkoosh, T.A. Lundrigan, K. Larson, M. Siipola, and T.K. Collier. 2007. Persistent organic pollutants in out-migrant juvenile Chinook salmon from the Lower Columbia Estuary, USA. Science of the Total Environment 374: 342–366.

Johnson, L.L., B. Anulacion, M. Arkoosh, O.P. Olson, C. Sloan, S.Y. Sol, J. Spromberg, D.J. Teel, G. Yanagida, and G. Ylitalo. 2013a. Persistent organic pollutants in juvenile Chinook salmon in the Columbia River Basin: implications for stock recovery. Transactions of the American Fisheries Society 142: 21-40. DOI: 10.1080/00028487.2012.720627

Johnson, L.L., B.F. Anulacion, M.R. Arkoosh, D.G. Burrows, D.A.M. da Silva, J.P. Dietrich, M.S. Myers, J. Spromberg, and G.M. Ylitalo. 2013b. Effects of legacy persistent organic pollutants (POPs) in fish—current and future challenges. Fish Physiology 33: 53-140.

Johnson, V.G., R.E. Peterson, and K.B. Olsen. 2005. Heavy metal transport and behavior in the lower Columbia River, USA. Environmental Monitoring and Assessment 110: 271-289.

Jonsson, S., A. Andersson, M.B. Nilsson, U. Skyllberg, E. Lundberg, J.K. Schaefer, S. Akerblom, and E. Bjorn. 2017. Terrestrial discharges mediate trophic shifts and enhance methylmercury accumulation in estuarine biota. Science Advances 3: e1601239.

Jorgensen, J.C., M.M. McClure, M.B. Sheer, and N.L. Munn. 2013. Combined effects of climate change and bank stabilization on shallow water habitats of Chinook salmon. Conservation Biology 27: 1201-1211.

Kapp, K.J., and E. Yeatman. 2018. Microplastic hotspots in the Snake and lower Columbia rivers: a journey from the Greater Yellowstone Ecosystem to the Pacific Ocean. Environmental Pollution 241: 1082-1090.

Kaufmann, R.K., L. Zhou, R.B. Myneni, C.J. Tucker, D. Slayback, N.V. Shabanov, and J. Pinzon. 2003. The effect of vegetation on surface temperature: a statistical analysis of NVDI and climate data. Geophysical Research Letters 30: 2147. doi:10.1029/2003GL018251

Keefer, M.L., C.T. Boggs, C.A. Peery, and C.C. Caudill. 2008. Overwintering distribution, behavior, and survival of adult summer steelhead: variability among Columbia River populations. North American Journal of Fisheries Management 28: 81-96.

Kellock, K.A., A.P. Moore, and R.B. Bringolf. 2018. Chronic nitrate exposure alters reproductive physiology in fathead minnows. Environmental Pollution 232: 322-328.

Kjaer, J., V. Ernstsen, O. Jacobsen, N. Hansen, L. Wollesen de Jonge, and P. Olsen. 2011. Transport modes and pathways of the strongly sorbing pesticides glyphosate and pendimethalin through structured drained soils. Chemosphere 84: 471-479.

Kubsad, D., E. Nilsson, S. King, I. Sadler-Riggleman, D. Beck and M. Skinner. 2019. Assessment of glyphosate induced epigenetic transgenerational inheritance of pathologies and sperm epimutations: Generational toxicology. Scientific Reports 9: 6372.

Laetz, C.A., D.H. Baldwin, T.K. Collier, V. Hebert, J.D. Stark, and N.L. Scholz. 2009. The synergistic toxicity of pesticide mixtures: implications for risk assessment and the conservation of endangered Pacific salmon. Environmental Health Perspectives 117: 348-353.

Layshock, J., M. Webb, O. Langness, J.C. Garza, L. Heironimus, and D. Gundersen. 2021. Organochlorine and metal contaminants in the blood plasma of green sturgeon caught in Washington coastal estuaries. DOI: https://doi.org/10.21203/rs.3.rs-172046/v1

Li, H.W., C.B. Schreck, and R.A. Tubb. 1984. Comparison of habitats near spur dikes, continuous revetments, and natural banks for larval, juvenile, and adult fishes of the Willamette River. Oregon Cooperative Fishery Research Unit, Oregon State University, Water Resources Research Institute, Project 373905, Contract 14-08-001-G-864, Technical report, Corvallis.

Lindsey, R., and L. Dahlman. 2020. Climate change: Global temperature. https://www.climate.gov/news-features/understanding-climate/climate-change-globaltemperature

Lundin, J.I., J.A. Spromberg, J.C. Jorgensen, J.M. Myers, P.M. Chittaro, R.W. Zabel, et al. 2019. Legacy habitat contamination as a limiting factor for Chinook salmon recovery in the Willamette Basin, Oregon, USA. PLoS ONE 14(3): e0214399. https://doi.org/10.1371/journal.pone.0214399

Lusardi, R., C. Jeffries, and P. Moyle. 2018. Stream macrophytes increase invertebrate production and fish habitat utilization in a California stream. River Research Application 34: 1003-1012.

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000a. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Archives of Environmental Contamination and Toxicology 39:20-31.

MacDonald, D.D., L.M. Dipinto, J. Field, C.G. Ingersoll, E.R. Long, and R.C. Swartz. 2000b. Development and evaluation of consensus-based sediment effect concentrations for polychlorinated biphenyls. Environmental Toxicology and Chemistry 19: 1403-1413.

Macneale, K., P. Kiffney, and N. Scholtz. 2010. Pesticides, aquatic food webs, and the conservation of Pacific salmon. Frontiers in Ecology and the Environment 8: 475-482.

Major K.M., B.M. DeCourten, J. Li, M. Britton, M.L. Settles, A.C. Mehinto, R.E. Connon, and S.M. Brander. 2020. Early Life Exposure to Environmentally Relevant Levels of Endocrine Disruptors Drive Multigenerational and Transgenerational Epigenetic Changes in a Fish Model. Frontiers in Marine Science 7: 471. doi: 10.3389/fmars.2020.00471

Mantua, N., I. Tohver, and A. Hamlet. 2009. Impacts of climate change on key aspects of freshwater salmon habitat in Washington State. Climate Impacts Group, University of Washington, Seattle.

Matthews, G. M., R. S. Waples. 1991. Status Review for Snake River Spring and Summer Chinook Salmon. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-F/NWC-200. https://www.nwfsc.noaa.gov/publications/scipubs/techmemos/tm201/

McClure, M., T. Cooney, and ICTRT. 2005. Updated population delineation in the interior Columbia Basin. May 11, 2005 Memorandum to NMFS NW Regional Office, Co-managers, and other interested parties. NMFS: Seattle. 14 p.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-42, Seattle, 156 pp.

McIntyre, J.K., D.H. Baldwin, D.A. Beauchamp, and N.L. Scholz. 2012. Low-level copper exposures increase visibility and vulnerability of juvenile coho salmon to cutthroat trout predators. Ecological Applications. 22: 1460–1471. http://dx.doi.org/10.1890/11-2001.1

McIntyre, J.K., J.W. Davis, C. Hinman, K.H. Macneale, B.F. Anulacion, N.L. Scholz, and J.D. Stark. 2015. Soil bio-retention protects juvenile salmon and their prey from the toxic impacts of urban stormwater runoff. Chemosphere 132, 213–219.

Meador, J.P., J.E. Stein, W.L. Reichert, and U. Varanasi. 1995. Bioaccumulation of polycyclic aromatic hydrocarbons by marine organisms. Reviews of Environmental Contamination and Toxicology 143: 79-165.

Meador, J.P., T.K. Collier, and J.E. Stein. 2002. Use of tissue and sediment-based threshold concentrations of polychlorinated biphenyls (PCBs) to protect juvenile salmonids listed under the US Endangered Species Act. Aquatic Conservation 12: 493–516.

Meador, J.P. 2014. Do chemically contaminated river estuaries in Puget Sound (Washington, USA) affect the survival rate of hatchery-reared Chinook salmon? Canadian Journal of Fisheries and Aquatic Sciences 71: 162–180. dx.doi.org/10.1139/cjfas-2013-0130

Mebane, C., and D. Arthaud. 2010. Extrapolating growth reductions in fish to changes in population extinction risks: copper and Chinook salmon. Human and Ecological Risk Assessment 16: 1026-1065.

Melillo, J. M., T. C. Richmond, and G. W. Yohe, eds. 2014. Climate change impacts in the United States: The third national climate assessment. U.S. Global Change Research Program, Washington, D.C.

Mesa, M.G. 1994. Effects of multiple acute stressors on the predator avoidance ability and physiology of juvenile Chinook salmon. Transactions of the American Fisheries Society 123: 786-793.

Mote, P. W., and E. P. Salathé. 2009. Future climate in the Pacific Northwest. Climate Impacts Group, University of Washington, Seattle.

Motta, E., K. Raymann, and N. Moran. 2018. Glyphosate perturbs the gut microbiota of honey bees. Proceedings of the National Academy of Sciences USA 115: 10305-10310.

Mueller, R. P. 2009. Survey of Fall Chinook Salmon Spawning Areas Downstream of Lower Snake River Hydroelectric Projects, 2008. Prepared for the U.S. Army Corps of Engineers, Walla Walla District, by Battelle Pacific Northwest Division.

Muir, W.D. and T.C. Coley. 1996. Diet of yearling Chinook salmon and feeding success during downstream migration in the Snake and Columbia Rivers. Northwest Science 70: 298-305.

Neff, J. 1985. Polycyclic aromatic hydrocarbons. Pages 416-454 in G.M. Rand and S.R. Petrocelli, editors. Fundamentals of aquatic toxicology. Hemisphere Publishing, Washington, D.C.

Nilsen, E., S. Zaugg, D. Alvarez, J. Morace, I. Waite, T. Counihan, J. Hardman, L. Torres, R. Patino, M. Mesa, and R. Grove. 2014. Contaminants of legacy and emerging concern in largescale suckers (*Catastomus macrocheilus*) and the food web in the lower Columbia River, Oregon and Washington, USA. Science of the Total Environment 484: 344-352.

Nilsen, E., W. Hapke, B. McIlraith and D. Markovchick. 2015. Reconnaissance of contaminants in larval Pacific lamprey (*Entosphenus tridentatus*) tissues and habitats in the Columbia River Basin, Oregon and Washington, USA. Environmental Pollution 201: 121-130.

Nitoiu, D., and H. Beltrami. 2005. Subsurface thermal effects of land use changes. Journal of Geophysical Research 110: F01005.doi:10.1029/2004JF000151

NMFS 2004. Endangered Species Act-Section 7 Consultation Biological Opinion and Magnuson-Stevens fishery Conservation and Management Act Essential Fish Habitat Consultation For Potlatch Pulp And Paper Mill, Lewiston, Idaho, National Pollution Discharge Elimination System (NPDES) Permit No.: ID-000116-3 For The Discharge Of Effluents Into The Snake River, Nez Perce County, Idaho And Asotin County, Washington. NMFS Tracking No.:2000/01449. April 2, 2004.

NMFS. 2006. National Marine Fisheries Service's comments and preliminary recommended terms and conditions for an application for a major new license for the Hells Canyon hydroelectric project (FERC No. 1971). National Marine Fisheries Service, Seattle. January 24, 2006.

NMFS. 2012. Endangered Species Act Section 7 Consultation and Magnuson-Stevens Essential Fish Habitat Response for the Pest Management Program for Corps of Engineers Managed Lands in the Walla Walla District in Oregon, Idaho, and Washington. NMFS 2012/00353. August 29, 2012.

NMFS. 2014a. Endangered Species Act Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation Idaho Water Quality Standards for Toxic Substances. National Marine Fisheries Service, West Coast Region. NMFS Consultation Number: 2000-1484. May 7, 2014. 528 pp.

NMFS. 2014b. Endangered Species Act section 7 Formal Consultation and Magnuson-Stevens Act Essential Fish Habitat Consultation for the 20142015 Channel Maintenance Dredging in the Lower Snake River and Clearwater River (5th Field HUCs: 1706011004, 1706011001, 1706010708, 1706010702, 1706010303, 1706030613); Walla Walla, Columbia, Garfield, and Asotin Counties, Washington; Nez Perce County, Idaho. NMFS Tracking Number: WCR-2014-1723. November 14, 2014. 92 pp.

NMFS. 2015. ESA Recovery Plan for Snake River Sockeye Salmon (*Oncorhynchus nerka*), June 8, 2015. NOAA Fisheries, West Coast Region. 431 pp. https://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/snake/snake_river_sockeye_recovery_plan_june_2015.pdf

NMFS. 2016. 2016 5-year review: Summary and evaluation of Snake River sockeye, Snake River spring-summer Chinook, Snake River fall-run Chinook, Snake River basin steelhead. NOAA Fisheries, West Coast Region. 138 pp.

NMFS. 2017a. ESA Recovery Plan for Snake River Spring/Summer Chinook & Steelhead. NMFS. https://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/snake/Final%20Snake%20Recovery%20Plan%20Docs/final_snake_river_spring-summer_chinook_salmon_and_snake_river_basin_steelhead_recovery_plan.pdf

NMFS. 2017b. ESA Recovery Plan for Snake River Fall Chinook Salmon (*Oncorhynchus tshawytscha*). https://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/interior_columbia/snake/Final%20Snake%20Recovery%20Plan%20Docs/final_snake_river_fall_chinook_salmon_recovery_plan.pdf

NMFS. 2019. Biological Opinion for the Aquatic Pest Management Program of the Army Corps of Engineers. NOAA Fisheries, West Coast Region, Interior Columbia Basin Office. Reference No. WCRO-2018-00389. May 31, 2019. 119 pp.

NMFS. 2020. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the proposed EPA promulgation of freshwater aquatic life criteria for aluminum in Oregon. June 30, 2020.

Nunes, S.M., M.E. Josende, M. Gonzalez-Durruthy, C.P. Ruas, M.A. Gelesky, L.A. Romano, D. Fattorini, F. Regoli, J.M. Monserrat, and J. Ventura-Lima. 2018. Different crystalline forms of titanium dioxide nanomaterial (rutile and anatase) can influence the toxicity of copper in golden mussel *Limnoperna fortunei*? Aquatic Toxicology 205: 182-192.

NWFSC (Northwest Fisheries Science Center). 2015. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. 356 pp.

Obrist D., J.L. Kirk, L. Zhang, E.M. Sunderland, M. Jiskra, and N.E. Selin. 2018. A Review of Global Environmental Mercury Processes in Response to Human and Natural Perturbations: Changes of Emissions, Climate, And Land Use. Ambio 47: 116-140.

ODFW (Oregon Department of Fish and Wildlife) and WDFW (Washington Department of Fish and Wildlife). 2019. 2019 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and other Species. Joint Columbia River Management Staff. 97 pp.

ODFW and WDFW. 2020. 2020 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and other Species. Joint Columbia River Management Staff.

ODFW and WDFW. 2021. 2021 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and other Species. Joint Columbia River Management Staff. 107 pp.

O'Neill, S.M., A.J. Carey, L.B. Harding, J.E. West, G.M. Ylitalo, and J.W. Chamberlin. 2020. Chemical tracers guide identification of the location and source of persistent organic pollutants in juvenile Chinook salmon (*Oncorhynchus tshawytscha*), migrating seaward through an estuary with multiple contaminant inputs. Science of the Total Environment 712: https://doi.org/10.1016/j.scitotenv.2019.135516

Palermo, F., W. Risso, J. Simonato, C. Martinez. 2015. Bioaccumulation of nickel and its biochemical and genotoxic effects on juveniles of the neotropical fish Prochilodus lineatus. Ecotoxicology and Environmental Safety 116: 19-28.

PFMC. 2014. Appendix A to the Pacific Coast Salmon Fishery Management Plan, as modified by Amendment 18. Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon.

Primost, J., D. Marino, V.C. Aparicio, J.L. Costa, and P. Carriquiriborde. 2017. Glyphosate and AMPA, “pseudo-persistent” pollutants under real-world agricultural management practices in the Mesopotamic Pampas agroecosystem, Argentina. Environmental Pollution 229: 771-779.

Relyea, R.A., and N. Diecks. 2008. An unforeseen chain of events: lethal effects of pesticides on frogs at sub-lethal concentrations. Ecological Applications 18: 1728–1742.

Rochman, C.M., E. Hoh, T. Kurobe, and S.J. Teh. 2013. Ingested plastic transfers hazardous chemicals to fish and induces hepatic stress. Scientific Reports 3: 3263. DOI: 10.1038/srep03263.

Rochman, C.M., B.T. Hentschel, and S.J. Teh. 2014. Long-term sorption of metals is similar among plastic types: implications for plastic debris in aquatic environments. PLoS ONE 9: e85433. doi:10.1371/journal.pone.0085433

Scholz, N.L., M.S. Myers, S.G. McCarthy, J.S. Labenia, J.K. McIntyre, G.M. Ylitalo, L.D. Rhodes, C.A. Laetz, C.M. Stehr, B.L. French, B. McMillan, D. Wilson, L. Reed, K.D. Lynch, S. Damm, J.W. Davis, and T.K. Collier. 2011. Recurrent die-offs of adult coho salmon returning to spawn in Puget Sound lowland urbans streams. PLoS ONE 6: e28013. doi.10.1371/journal.pone.0028013.

Scholz, N.L., E. Fleishman, L. Brown, I. Werner, M.L. Johnson, M.L. Brooks, C.L. Mitchelmore, and D. Schlenk. 2012. A perspective on modern pesticides, pelagic fish declines, and unknown ecological resilience in highly managed ecosystems. BioScience 62: 428-434.

Scully-Engelmeyer, K., E.F. Granek, M. Nielsen-Pincus, A. Lanier, S.S. Rumrill, P. Moran, E. Nilsen, M.L. Hladik, and L. Pillsbury. 2021. Exploring biophysical linkages between coastal forestry management practices and aquatic bivalve contaminant exposure. Toxics 9: 46-71. https://doi.org/10.3390/toxics9030046

Seiders, K., C. Deligeannis, and P. Sandvik. 2007. Washington State Toxics Monitoring Program: Toxic Contaminants in Fish Tissue and Surface Water in Freshwater Environments, 2004-2005. Washington State Department of Ecology, Olympia, WA. Publication No. 07-03-024.

Seiders, K., C. Deligeannis, and M. Friese. 2011. Focus on Fish Testing: Snake River Fish Tested for Chemicals. Washington State Department of Ecology, Olympia, WA. Publication No. 11-03-067. 6 pp. https://apps.ecology.wa.gov/publications/documents/1103067.pdf

Seiders, K., and P. Sandvik. 2020. Freshwater Fish Contaminant Monitoring Program, Publication 20-03-106. Washington State Department of Ecology, Olympia. https://fortress.wa.gov/ecy/publications/SummaryPages/2003106.html.

Sergeant, C.J., and D.A. Beauchamp. 2006. Effects of physical habitat and ontogeny on lentic habitat preferences of juvenile Chinook salmon. Transactions of the American Fisheries Society 135: 1191-1204.

Sevcikova, M., H. Modra, A. Slaninova, and Z. Svobodova. 2011. Metals as a cause of oxidative stress in fish: a review. Veterinarni Medicina 56: 537-546.

Sharma, R.K., and M. Agrawal. 2005. Biological effects of heavy metals: an overview. Journal of Environmental Biology 26: 301-313.

Skidmore, J.E. 1964. Toxicity of zinc compounds to aquatic animals, with special reference to fish. Quarterly Review of Biology 39: 227-248.

Sloan, C.A., B.F. Anulacion, J.L. Bolton, D. Boyd, O.P. Olsen, S.Y. Sol, G.M. Ylitalo, and L.L. Johnson. 2010. Polybrominated diphenyl ethers in out-migrant juvenile Chinook salmon from the lower Columbia River and Estuary and Puget Sound, Washington. Archives of Environmental Contaminant Toxicology 58: 403-414.

Soto, A.M., K.L. Chung, and C. Sonnenschein. 1994. The pesticides endosulfan, toxaphene, and dieldrin have estrogenic effects on human estrogen-sensitive cells. Environmental Health Perspectives 102: 380-383.

Spence, B., G. Lomnicky, R. Hughes, and R.P. Novitski. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. ManTech Environmental Research Services Corp.: Corvallis, Oregon.

Spromberg, J.A., D.H. Baldwin, S.E. Damm, J.K. McIntyre, M. Huff, C.A. Sloan, B.F. Anulacion, J.W. Davis, and N.L. Scholz. 2016. Coho salmon spawner mortality in western US urban watersheds: bio-infiltration prevents lethal storm water impacts. Journal of Applied Ecology 53: 398–407.

Stohs, S. and D. Bagchi. 1995. Oxidative mechanisms in the toxicity of metals ions. Free Radical Biology and Medicine 2: 321–336.

Stone, D. 2006. Polybrominated diphenyl ethers and polychlorinated biphenyls in different tissue types from Chinook salmon (*Oncorhynchus tshawytscha*). Bulletin of Environmental Contamination and Toxicology 76: 148-154.

Tattam, I. A., J. R. Ruzycki, H. W. Li, and G. R. Giannico. 2013. Body size and growth rate influence emigration timing of Oncorhynchus mykiss. Transactions of the American Fisheries Society 142: 1406-1414.

Thompson, J. N. and D. A. Beauchamp. 2014. Size-selective mortality of steelhead during freshwater and marine life stages related to freshwater growth in the Skagit River, Washington. Transactions of the American Fisheries Society 143: 910-925.

Tian, L., S. Yin, Y. Ma, H. Kang, X. Zhang, H. Tan, H. Meng, and C. Liu. 2019. Impact factor assessment of the uptake and accumulation of polycyclic aromatic hydrocarbons by plant leaves: morphological characteristics have the greatest impact. Science of the Total Environment 652: 1149–1155.

Tian, Z., and 28 others. 2020. A ubiquitous tire rubber-derived chemical induces acute mortality in coho salmon. Science 10.1126/science.abd6951.

Tiffan, K.F., T.J. Kock, W.P. Connor, R.K. Steinhorst, and D.W. Rondorf. 2009. Behavioral thermoregulation by subyearling fall (autumn) Chinook salmon *Oncorhynchus tshawytscha* in a reservoir. Journal of Fish Biology 74: 1562-1579.

Tiffan, K.F., T.J. Kock, W.P. Connor, F. Mullins, and R.K. Steinhorst. 2012. Downstream movement of fall Chinook salmon juveniles in the Lower Snake River reservoirs during winter and early spring. Transactions of the American Fisheries Society 141: 285-293. DOI: 10.1080/00028487.2012.662203

Tiffan, K. F. and J. R. Hatten. 2012. Estimates of Subyearling Fall Chinook Salmon Rearing Habitat in Lower Granite Reservoir Draft Report of Research -Sediment Management Program Report 2011-W68SBV00829562, November 2012.

Tiffan, K., J. Erhardt, and S. St. John. 2014. Prey availability, consumption, and quality contribute to variation in growth of subyearling Chinook salmon rearing in riverine and reservoir habitats. Transactions of the American Fisheries Society 143: 219-229.

Tiffan, K., J. Hatten, and D. Trachtenbarg. 2016. Assessing juvenile salmon rearing habitat and associated predation risk in a lower Snake River reservoir. River Research and Applications 32: 1030-1038.

Tiffan K.F., J.M. Erhardt, and B.K. Bickford. 2017. Ecology of the opossum shrimp (*Neomysis mercedis*) in a lower Snake River reservoir, Washington. Northwest Science 91:124–139.

Tiffan, K.F., T.J. Kock, W.P. Connor, M.C. Richmond, and W.A. Perkins. 2018. Migratory behavior and physiological development as potential determinants of life history diversity in fall Chinook salmon in the Clearwater River. Transactions of the American Fisheries Society 147: 400-413.

Tiffan, K.F., J.M. Erhardt, R.J. Hemingway, B.K. Bickford, and T.N. Rhodes. 2020. Impact of smallmouth bass predation on subyearling fall Chinook salmon over a broad river continuum. Environmental Biology of Fish 103: 1231-1246.

Tremblay, A., and M. Lucotte. 1997. Accumulation of total mercury and methyl mercury in insect larvae of hydroelectric reservoirs. Canadian Journal of Fisheries and Aquatic Sciences 54: 832-842.

Tsui, M.K., and L.M. Chu. 2004. Comparative toxicity of glyphosate-based herbicides: aqueous and sediment porewater exposures. Archives of Environmental Contamination and Toxicology 46: 316–323.

Tsui, M.K., W. Wang, and L.M. Chu. 2005. Influence of glyphosate and its formulation (Roundup) on the toxicity and bioavailability of metals to *Ceriodaphnia dubia*. Environmental Pollution 138: 59-68.

USACE (COE). 2005. Lewiston Pond Temperature Summary. Prepared by S.T.J. Juul. U.S. Army Corps of Engineers, Walla Walla District. Walla Walla Washington. 3 pp.

USEPA (EPA). 2019. Biological Evaluation for the National Pollutant Discharge Elimination System Permit for Clearwater Paper Lewiston Mill NPDES Permit Number ID0001163. U.S. EPA Region 10 Office of Water and Watersheds. March 2019.

USEPA (EPA). 2020. Biological Evaluation and Essential Fish Habitat Assessment for Endangered Species Act Section 7 Consultation on National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permits Located in the Lewiston, Idaho Urbanized Area: City of Lewiston and Lewis-Clark State College (IDS028061) and Idaho Transportation Department District #2 (IDS028258). U.S. EPA Region 10. August 2020.

USEPA (EPA). 2020a. NPDES Municipal Stormwater Permit: City of Lewiston and Lewis-Clark State College (IDS028061). https://www.epa.gov/npdes-permits/draft-npdes-stormwater-permit-city-lewiston-and-lewis-clark-state-college-idaho

USEPA (EPA). 2020b. NPDES Municipal Stormwater Permit: Idaho Transportation Department District #2 (IDS028258). https://www.epa.gov/npdes-permits/draft-npdes-stormwater-permit-idaho-transportation-department-district-2

USFWS. 2004. Biological and Conference Opinions NPDES Permit for The Potlatch Corporation (NPDES Permit No.: ID-000116-3). United States Fish and Wildlife Service.

USGCRP (U.S. Global Change Research Program). 2018. Impacts, risks, and adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D. R., C. W. Avery, D. R. Easterling, K. E. Kunkel, K. L. M. Lewis, T. K. Maycock, et al. (eds.)] Washington, D.C., USA. DOI: 10.7930/NCA4.2018.

Vargas, K.E., E. McPherson, E. Gregory, J.R. Simpson, P.J. Peper, S.L. Gardner, and Q. Xiao. 2007. Temperate Interior West community tree guide: benefits, costs, and strategic planting. Gen. Tech. Rep. PSW-GTR-206. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 108 pp.

Varanasi, U., W.L. Reichert, J.E. Stein, D.W. Brown, and H.R. Sanborn. 1985. Bioavailability and biotransformation of aromatic hydrocarbons in benthic organisms exposed to sediment from an urban estuary. Environmental Science and Technology 19: 836-841.

Vanderputte I., J. Lubbers, and Z. Kolar. 1981. Effect of pH on uptake, tissue distribution and retention of hexavalent chromium in rainbow trout (*Salmo gairdneri*). Aquatic Toxicology 1: 3-18.

Walker, M.K., and R.E. Peterson. 1994. Toxicity of 2,3,7,8-tetrachlorodibenzo-P-dioxin to brook trout (*Salvelinus fontinalis*) during early development. Environmental Toxicology Chemistry 13: 817–820.

Wang, F., C.S. Wong, D. Chen, X. Lu, F. Wang, and E. Zeng. 2018. Interaction of toxic chemicals with microplastics: a critical review. Water Research 139: 208-219.

WAC (Washington Administrative Code). 2021. PBT list and criteria. WAC 173-333-320, Certified October 25, 2019. https://apps.leg.wa.gov/wac/default.aspx?cite=173-333-310

WDOE. 2006. PBDE Flame Retardants in Washington Rivers and Lakes: Concentrations in Fish and Water, 2005-06. Publication No. 06-03-027. August 2006. 116 pp. https://apps.ecology.wa.gov/publications/documents/0603027.pdf

WDOE. 2021. https://ecology.wa.gov/Waste-Toxics/Reducing-toxic-chemicals/Addressing-priority-toxic-chemicals.

Williams, M. 2020. Geomean data sheet with five year averages for Interior salmon and steelhead populations (UCR and MCR steelhead, Chinook, SR steelhead, sockeye, fall chinook). Communication to L. Krasnow (NMFS) from M. Williams (NOAA Affiliate, NWFSC), 2/14/2020.

Zhang, S., H. Yao1, Y. Lu1, X. Yu1, J. Wang, S. Sun1, M. Liu, D. Li1, Y. Li and D. Zhang. 2017. Uptake and translocation of polycyclic aromatic hydrocarbons (PAHs) and heavy metals by maize from soil irrigated with wastewater. Scientific Reports 7: 12165. DOI:10.1038/s41598-017-12437-w