Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation

Leavenworth National Fish Hatchery Spring Chinook Salmon Program (Reinitiation 2016)

NMFS Consultation Number: WCR-2017-7345

Action Agencies: United States Fish and Wildlife Service
United States Bureau of Reclamation
United States Environmental Protection Agency

Affected Species and Determinations:

ESA-Listed Species	**Status**	**Is the Action Likely to Adversely Affect Species or Critical Habitat?**	**Is the Action Likely To Jeopardize the Species?**	**Is the Action Likely To Destroy or Adversely Modify Critical Habitat?**
Upper Columbia River steelhead (*Oncorhynchus mykiss*)	Threatened	Yes	No	No
Upper Columbia River spring-run Chinook salmon (*O. tshawytscha*)	Endangered	Yes	No	No

Fishery Management Plan That Describes EFH in the Project Area	**Does the 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:

FOR
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Regional Administrator
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Date: 9/29/2017

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Acronyms and Abbreviations

AMIP	Adaptive Management Implementation Plan
BA	Biological Assessment
CBFWA	Columbia Basin Fish and Wildlife Authority
CFR	Code of Federal Regulations
CIG	Climate Impacts Group
COIC	Cascade Orchard Irrigation Company
CPUD	Public Utility District No. 1 of Chelan County
CR	Columbia River
CRFMP	Columbia River Fisheries Management Plan
CWT	coded-wire tag (or tagged)
DPS	distinct population segment
DPUD	Public Utility District No. 1 of Douglas County
EFH	essential fish habitat
EIS	Environmental Impact Statement
ELISA	Enzyme-linked Immunosorbent Assay
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FCRPS	Federal Columbia River Power System
FONSI	Finding of No Significant Impact
FR	Federal Register
FWCO	Mid-Columbia Fish and Wildlife Conservation Office
GPUD	Public Utility District No. 2 of Grant County
HCP	Habitat Conservation Plan
HCP HC	Habitat Conservation Plan Hatchery Committee
HETT	Hatchery Evaluation Technical Team
HGMP	Hatchery and Genetic Management Plan
HSRG	Hatchery Scientific Review Group
HUC	Hydrologic Unit Code
IA	interaction availability
ICTRT	Interior Columbia Technical Review Team
IFIM	Instream Flow Incremental Methodology
IPCC	Intergovernmental Panel on Climate Change
IPID	Icicle Peshastin Irrigation District
ISAB	Independent Scientific Advisory Board
IWG	Icicle Creek Work Group
LCR	Lower Columbia River
LNFH	Leavenworth National Fish Hatchery
MCCRP	Mid-Columbia Coho Restoration Project
MCR	Middle Columbia River
MPG	major population group
MSA	Magnuson-Stevens Fishery Conservation Act
NMFS	National Marine Fisheries Service
NNI	no net impact
NOAA	National Oceanic and Atmospheric Administration
NPCC	Northwest Power and Conservation Council
NPDES	National Pollutant Discharge Elimination System
NRC	National Research Council
NTTOC	non-target taxa of concern
NWFSC	Northwest Fisheries Science Center
OFHC	Olympia Fish Health Center
pRAS	partial recirculating aquaculture system
PCE	primary constituent element
PCSRF	Pacific Coast Salmon Recovery Funds
PFMC	Pacific Fishery Management Council
pHOS	proportion of hatchery-origin spawners
PIT	passive integrated transponder (type of tag)
PNI	proportionate natural influence
pNOB	proportion of natural-origin fish in the broodstock
RPA	Reasonable and Prudent Alternative
RRS	relative reproductive success
RTT	Upper Columbia Regional Technical Team
SBA	Supplemental Biological Opinion
SCA	Supplemental Comprehensive Analysis
SFD	Sustainable Fisheries Division
SIWG	Species Interaction Work Group
TRT	Technical Recovery Team
UCR	Upper Columbia River
UCSRB	Upper Columbia Salmon Recovery Board
USBR	U.S. Bureau of Reclamation
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
VSP	Viable Salmonid Population
WAC	Washington Administrative Code
WDOE	Washington State Department of Ecology
WSCC	Washington State Conservation Commission
WDFW	Washington Department of Fish and Wildlife
YN	Yakama Nation

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.

1.1. Background

The National Marine Fisheries Service (NMFS) prepared the reinitiated biological opinion (opinion) and incidental take statement 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.

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 (Section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available through NMFS' Public Consultation Tracking System at: *https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts*. A complete record of this consultation is on file at the Sustainable Fisheries Division (SFD) of NMFS in Portland, Oregon.

1.2. Consultation History

The first hatchery consultations in the Columbia Basin followed the first listings of Columbia Basin salmon under the ESA. Snake River sockeye salmon were listed as an endangered species on November 20, 1991, Snake River spring/summer Chinook salmon and Snake River fall Chinook salmon were listed as threatened species on April 22, 1992, and the first hatchery consultation and opinion was completed on April 7, 1994 (NMFS 1994). The 1994 opinion was superseded by "Endangered Species Act Section 7 Biological Opinion on 1995-1998 Hatchery Operations in the Columbia River Basin, Consultation Number 383" completed on April 5, 1995 (NMFS 1995). This opinion determined that hatchery actions jeopardize listed Snake River salmon and required implementation of reasonable and prudent alternatives (RPAs) to avoid jeopardy.

A new opinion was completed on March 29, 1999, after Upper Columbia River (UCR) steelhead were listed under the ESA (62 FR 43937, August 18, 1997) and following the expiration of the previous opinion on December 31, 1998 (NMFS 1999a). That opinion concluded that Federal and non-Federal hatchery programs jeopardize Lower Columbia River (LCR) steelhead and Snake River steelhead protected under the ESA and described RPAs necessary to avoid jeopardy. Those measures and conditions included restricting the use of non-endemic steelhead for hatchery broodstock and limiting stray rates of non-endemic salmon and steelhead to less than 5 percent of the annual natural population in the receiving stream. Soon after, NMFS reinitiated consultation when LCR Chinook salmon, UCR spring Chinook salmon, Upper Willamette

Chinook salmon, Upper Willamette steelhead, Columbia River chum salmon, and Middle Columbia steelhead were added to the list of endangered and threatened species (Smith 1999).

Between 1991 and the summer of 1999, the number of distinct groups of Columbia Basin salmon and steelhead listed under the ESA increased from 3 to 12, and this prompted NMFS to reassess its approach to hatchery consultations. In July 1999, NMFS announced that it intended to conduct five consultations and issue five opinions "instead of writing one biological opinion on all hatchery programs in the Columbia River Basin" (Smith 1999). Opinions would be issued for hatchery programs in the (1) Upper Willamette, (2) Middle Columbia River (MCR), (3) LCR, (4) Snake River, and (5) UCR, with the UCR NMFS' first priority (Smith 1999). Between August 2002 and October 2003, NMFS completed consultations under the ESA for approximately twenty hatchery programs in the UCR. For the MCR, NMFS completed a draft opinion and distributed it to hatchery operators and to funding agencies for review on January 4, 2001, but completion of consultation was put on hold pending several important basin-wide review and planning processes.

The increase in ESA listings during the mid to late 1990s triggered a period of investigation, planning, and reporting across multiple jurisdictions and this served to complicate, at least from a resources and scheduling standpoint, hatchery consultations. A review of Federal funded hatchery programs ordered by Congress was underway at about the same time that the 2000 Federal Columbia River Power System (FCRPS) opinion was issued by NMFS (NMFS 2000). The Northwest Power and Conservation Council (NPCC) was asked to develop a set of coordinated policies to guide the future use of artificial propagation, and RPA 169 of the FCRPS opinion called for the completion of NMFS-approved hatchery operating plans (i.e., Hatchery and Genetic Management Plans (HGMPs)) by the end of 2003. The RPA required the Action Agencies to facilitate this process, first by assisting in the development of HGMPs, and then by helping to implement identified hatchery reforms (NMFS 2000). Also at this time, a new *U.S. v. Oregon* Columbia River Fisheries Management Plan (CRFMP), which included goals for hatchery management, was under negotiation and new information and science on the status and recovery goals for salmon and steelhead was emerging from Technical Recovery Teams (TRTs). Work on HGMPs under the FCRPS opinion was undertaken in cooperation with NPCC's Artificial Production Review and Evaluation process, with CRFMP negotiations, and with ESA recovery planning (Foster 2004; Jones Jr. 2002). HGMPs were submitted to NMFS under RPA 169; however, many were incomplete and, therefore, were not found to be sufficient[1] for ESA consultation.

A biological assessment (BA) (USFWS 1999), including addenda (USFWS 2000a; USFWS 2000b), and three HGMPs (USFWS 2002a; USFWS 2002b; USFWS 2002c) were submitted for the Leavenworth, Entiat, and Winthrop National Fish Hatchery facilities, addressing their rearing

[1] "Sufficient" means that an HGMP meets the criteria listed at 50 CFR 223.203(b)(5)(i), which include (1) the purpose of the hatchery program is described in meaningful and measureable terms, (2) available scientific and commercial information and data are included, (3) the Proposed Action, including any research, monitoring, and evaluation, is clearly described both spatially and temporally, (4) application materials provide an analysis of effects on ESA-listed species, and (5) preliminary review suggests that the program has addressed criteria for issuance of ESA authorization such that public review of the application materials would be meaningful.

of UCR spring Chinook salmon. NMFS found the HGMPs to be sufficient for ESA section 7 consultation and issued a biological opinion on October 22, 2003, for hatchery operation and monitoring activities involving unlisted spring Chinook salmon as described in the HGMPs and supplemental information (NMFS 2003b). The opinion included the Leavenworth National Fish Hatchery (LNFH) spring Chinook salmon hatchery program. In that opinion, NMFS determined that operation of the spring Chinook programs would not jeopardize salmon and steelhead protected under the ESA.

NMFS (2003b) also stated a barrier to upstream fish passage associated with the LNFH program structures in Icicle Creek had been in place since 1940, and may adversely affect listed steelhead productivity in the Wenatchee River basin. This barrier to upstream fish passage was under consideration through a separate forum (the Icicle Creek Restoration Project Environmental Impact Statement (EIS) process) at the time, which included the United States Fish and Wildlife Service (USFWS), NMFS, Yakama Nation (YN), Washington Department of Fish and Wildlife (WDFW), Icicle Creek Watershed Council, and other private participants. NMFS expected that the EIS process would lead to the application of a preferred alternative that provided passage for adult and juvenile fish above the barrier, and, thus, contributed to steelhead recovery. The preferred alternative would be evaluated by NMFS for effects on ESA-listed fish through a separate section 7 consultation. The effects on ESA-listed species due to the LNFH water diversions in Icicle Creek would also be addressed by NMFS in this separate section 7(a)(2) consultation. Although an effects analysis and jeopardy determination for this portion of the LNFH operation was not rendered in the 2003 Opinion (NMFS 2003b), it was NMFS' expectation that free upstream passage for ESA-listed UCR spring Chinook salmon adults and UCR steelhead adults would be provided by the LNFH.

Following the biological opinion issued by NMFS in 2003 for the spring Chinook salmon hatchery programs at the Leavenworth, Entiat, and Methow National Fish Hatcheries, ESA consultations and an opinion were completed in 2007 for nine hatchery programs that produce a substantial proportion of the total number of salmon and steelhead released into the Columbia River annually. These programs are located in the LCR and MCR and are operated by the USFWS and by the WDFW. NMFS' opinion (NMFS 2007b) determined that operation of the programs would not jeopardize salmon and steelhead protected under the ESA.

On May 5, 2008, NMFS published a Supplemental Comprehensive Analysis (SCA) (NMFS 2008d) and an opinion and RPAs for the FCRPS to avoid jeopardizing ESA-listed salmon and steelhead in the Columbia Basin (NMFS 2008c). The SCA environmental baseline included "the past effects of hatchery operations in the Columbia River Basin. Where hatchery consultations have expired or where hatchery operations have yet to undergo ESA section 7consultation, the effects of future operations cannot be included in the baseline. In some instances, effects are ongoing (e.g., returning adults from past hatchery practices) and included in this analysis despite the fact that future operations cannot be included in the baseline. The Proposed Action does not encompass hatchery operations per se, and therefore no incidental take coverage is offered through this biological opinion to hatcheries operating in the region. Instead, we expect the operators of each hatchery to address its obligations under the ESA in separate consultations, as required" (see NMFS 2008d, p. 5-40).

Because it was aware of the scope and complexity of ESA consultations facing the co-managers and hatchery operators, NMFS offered substantial advice and guidance to help with the consultations. In September 2008, NMFS announced its intent to conduct a series of ESA consultations and that "from a scientific perspective, it is advisable to review all hatchery programs (i.e., Federal and non-Federal) in the UCR affecting ESA-listed salmon and steelhead concurrently" (Walton 2008). In November 2008, NMFS expressed again, the need for re-evaluation of UCR hatchery programs and provided a "framework for ensuring that these hatchery programs are in compliance with the Federal Endangered Species Act" (Jones Jr. 2008). NMFS also "promised to share key considerations in analyzing HGMPs" and provided those materials to interested parties in February 2009 (Jones Jr. 2009a).

On April 28, 2010 (Walton 2010), NMFS issued a letter to "co-managers, hatchery operators, and hatchery funding agencies" that described how NMFS "has been working with co-managers throughout the Northwest on the development and submittal of fishery and hatchery plans in compliance with the Federal Endangered Species Act (ESA)." NMFS stated, "In order to facilitate the evaluation of hatchery and fishery plans, we want to clarify the process, including consistency with *U.S. v. Oregon* Management Agreement, habitat conservation plans and other agreements…." With respect to "Development of Hatchery and Harvest Plans for Submittal under the ESA," NMFS clarified: "The development of fishery and hatchery plans for review under the ESA should consider existing agreements and be based on best available science; any applicable multiparty agreements should be considered, and the submittal package should explicitly reference how such agreements were considered. In the Columbia River, for example, the *U.S. v. Oregon* Management Agreement is the starting place for developing hatchery and harvest plans for ESA review…."

In response to NMFS' 2008 announcement to review all hatchery programs, an HGMP was submitted to NMFS for the USFWS LNFH spring Chinook salmon hatchery program in March 2009, to which NMFS replied with a sufficiency letter on July 8, 2009, that explained NMFS' understanding of the proposed action (Jones Jr. 2009b). This HGMP included information to address effects on listed species' upstream fish passage and water withdrawals not addressed in the previous opinion (NMFS 2003b). NMFS provided comments and suggested edits to this HGMP and on subsequent versions of the HGMP on February 9, June 25, and July 8, 2010.

On October 20, 2010, NMFS emailed the USFWS with comments regarding fish passage, fish screens, and instream flow management at LNFH.

On December 20, 2010, NMFS held a conference call with the USFWS and the U.S. Bureau of Reclamation (USBR) to discuss remaining issues regarding operation of the LNFH.

On March 21, 2011, the LNFH HGMP was revised to include the USFWS bull trout terms and conditions that may apply to steelhead and formally submitted to NMFS (USFWS 2011c).

In late 2011 and in 2012, there were continuing discussions and exchanges of information between USFWS, USBR, and NMFS leading to a letter from the USFWS proposing to amend the proposed action (Irving 2012a) to include a compliance schedule in order to meet NMFS's 2011 screening criteria for anadromous fish passage (NMFS 2011c). With this amendment, NMFS moved forward with the USFWS request for initiation of formal consultation under section 7(a)(2) of the ESA for continuance of the LNFH spring Chinook salmon program (USFWS 2011c). NMFS received comments and additional information for consideration from both the USFWS (Gale 2012a; Gale 2012b) and the USBR (Camp 2012a; Camp 2012b; Puckett 2012).

On April 30, 2012, NMFS released a draft schedule to USFWS and USBR for the LNFH section 7(a)(2) consultation. NMFS also communicated that the schedule may be subject to change based on workload and priorities of NMFS staff (Wilson 2012).

In 2013, as the NMFS biological opinion for the LNFH HGMP was nearing completion, two new studies were released by the USFWS that were highly relevant to NMFS' analysis and determination of effects for operation of LNFH the: *Icicle Creek Instream Flow and Fish Habitat Analysis for the Leavenworth National Fish Hatchery* (Skalicky et al. 2013), and the *Icicle Creek Fish Passage Evaluation for the Leavenworth National Fish Hatchery* (Anglin et al. 2013). NMFS received the new information on October 23, 2013 and promptly completed its review of the data and analyses. On October 25, 2013, NMFS notified the USFWS that the studies represented best available science and included substantial new scientific information that would have a bearing on NMFS' analysis of the LNFH HGMP. On October 28, 2013, NMFS provided revised flow recommendations to the USFWS and USBR and met with the agencies to discuss the recommendations and the analytical basis for the recommendations.

On November 3, 2013, NMFS distributed the draft terms and conditions. On December 9, 2013, the USFWS provided their comments to NMFS' revised terms and conditions.

On December 10, 2013, NMFS distributed a revised biological opinion, including the previously distributed terms and conditions, to the USFWS and USBR for consideration and requested a meeting in early January to receive comments from the USFWS and USBR and to make progress towards completing section 7(a)(2) consultation.

On January 29, 2014, NMFS and USFWS met in Ellensburg, Washington, to discuss the draft opinion terms and conditions. At that meeting, NMFS and the USFWS revised the terms and conditions associated with the LNFH water delivery system. NMFS agreed to the revised terms and conditions, and, shortly thereafter, distributed them to the USFWS and USBR for final review (Wilson 2014b).

On February 24, 2014, NMFS provided USFWS and USBR with an updated draft biological opinion for review including the terms and conditions developed during interagency consultation on January 29, 2014.

On April 7, 2014, NMFS received an inquiry from USFWS regarding the designation of steelhead critical habitat in Icicle Creek. On April 9, 2014, NMFS provided information to the USFWS that confirmed the extent of the steelhead critical habitat designation in Icicle Creek (Wilson 2014c). USFWS also notified NMFS that they wanted to provide additional information on steelhead use of Icicle Creek for the draft biological opinion.

On April 21, 2014, USFWS requested a meeting with NMFS to discuss finalization of the draft biological opinion for the LNFH spring Chinook salmon hatchery program. On April 30, 2014, the USFWS provided: (1) a cover letter with general comments on the draft opinion and an outline of additional information the USFWS planned to provide NMFS in the near future; (2) specific comments in a marked version of the draft opinion; and (3) a final report entitled, "*Steelhead Use of Icicle Creek: A Review*" (Irving 2014b).

On May 14, 2014, the USFWS, USBR, and NMFS met to discuss the draft biological opinion. Also in attendance was the Bonneville Power Administration (BPA). At that meeting, NMFS was advised that the USFWS and USBR intended to clarify the proposed action and submit new materials, including a proposed action and analysis of effects (particularly for operation of LNFH's Structure 2 in the historical channel), to NMFS for consultation purposes before the end of calendar year 2014.

In response to the USFWS and USBR expressed intentions to revisit the proposed action and supporting materials and analysis (i.e., the HGMP for LNFH), NMFS advised that it "did not intend to conduct any further work on the matter while we waited for the action agencies to submit a revised proposed action and associated information". NMFS also communicated that we were in agreement on a request to extend the period for consultation under 50 CFR 402.14(e) and included recommended measures that would be important components of the revised proposed action (Jones Jr. 2014).

On June 24, 2014, NMFS received a letter from USFWS describing its intentions to: (1) extend the LNFH section 7 consultation until the end of calendar year 2014; (2) provide additional environmental analysis of LNFH water management and operation of the structures in the Icicle Creek historical channel; (3) provide a new proposed action including a number of the conservation measures proposed by NMFS (e.g., updated fish salvage procedures and screening compliance); and (4) clarify that USFWS did not propose to revisit the HGMP submitted in 2009 for consultation. The letter also requested that NMFS provide a description of the role that Icicle Creek played in the survival and recovery of ESA-listed species. The USFWS stated that they would also consider other measures proposed by NMFS but are reserving consideration of implementing those measures in light of potential conflicts with water rights and commitments under the *U.S. v. Oregon* Management Agreement and tribal trust responsibilities (Irving 2014c).

On July 31, 2014, NMFS provided information intended to expedite the action agencies' analysis of effects on steelhead from operation of LNFH (i.e., *Appendix A: The role Icicle Creek plays in the survival and recovery of UCR steelhead*) (Jones 2014b).

On August 7, 2014, NMFS held a conference call with USFWS technical staff to discuss items needed and the timing of the LNFH supplemental biological assessment (SBA) for completion of the LNFH section 7(a)(2) consultation.

On November 4, 2014, NMFS received a letter and supplemental information from the USFWS for completion of the LNFH section 7(a)(2) consultation. The USFWS clarified that the submitted materials supplemented their original HGMP and associated documents, and clarified the information and analysis in NMFS' new draft biological opinion dated February 18, 2014

(Irving 2014a). Supplemental documents included a: (1) SBA addressing the operation and maintenance of LNFH's water delivery system and historical channel structures; (2) *Memorandum: LNFH Spring Chinook Upper Wenatchee River Impact Analysis*; and (3) *Memorandum: Determination of steelhead emergence timing in Icicle Creek*.

On November 17, 2014, NMFS requested that USFWS provide clarification on the information in the LNFH SBA regarding the operation and maintenance of the LNFH water delivery system and historical channel structures (Wilson 2014a).

On November 24, 2014, NMFS and USFSW conducted a conference call to review comments and ask questions regarding the LNFH SBA.

On December 2, 2014, NMFS, the USFSW, USBR, and BPA met to discuss completion of the LNFH section 7(a)(2) consultation. At the meeting, NMFS explained that it had completed its review of the supplemental materials provided by the USFWS and USBR and it could find nothing in the materials that attempted to address NMFS' concerns about LNFH diversions and their effects on flow conditions in the Icicle Creek historical channel. Under these circumstances, NMFS advised the USFWS and USBR that the proposed action was likely an adverse modification of designated critical habitat for ESA-listed UCR steelhead.

On April 6, 2015, NMFS requested additional clarification on specific contents of the LNFH SBA and information provided for the draft biological opinion. On April 9, 2015, USFWS provided additional clarification and information on the SBA for the draft biological opinion.

On April 17, 2015, NMFS released to the USFWS and USBR a draft biological opinion for review and comment containing an adverse modification determination for UCR steelhead critical habitat and associated Reasonable and Prudent Alternative (RPA).

On April 29, 2015, USFWS and USBOR provided NMFS comments regarding the April 17, 2015 LNFH draft biological opinion, which included concerns about the analysis (USBR 2015; USFWS 2015a).

On May 1, 2015, NMFS, USFWS, USBR, and BPA met to discuss the draft biological opinion. NMFS, USFWS and USBR assigned a technical team to devise a solution that would further improve Icicle Creek instream flow conditions while allowing the LNFH to meet its production targets under *U.S. v. Oregon* Management Agreement to produce 1.2 million spring Chinook salmon annually.

On May 4 and May 6, 2015, the NMFS, USFWS, and USBR developed a proposal containing short-term and long-term changes to the LNFH water delivery system and hatchery infrastructure.

On May 11, 2015, the USFWS and USBR submitted a letter to NMFS requesting we consider their amendment to the proposed action (i.e., SBA) (Irving 2015a). This amendment included the short-term and long-term changes to the LNFH operations. Also on May 11, 2015, the technical team met to discuss remaining comments from the USFWS and USBR on the draft biological opinion.

On May 14, 2015, NMFS sent a copy of the proposed action from the draft biological opinion (Wilson 2015), which incorporated additional details and clarification regarding the operation of the LNFH water delivery system described in the USFWS amendment (Irving 2015), to the USFWS and USBR for review and confirmation. The same day USFWS and USBR provided comments on the proposed action so that the Services could finalize the amendment.

NMFS completed a new analysis and draft biological opinion on May 18, 2015. This draft biological opinion was distributed to the USFWS and USBR for review and comment. NMFS addressed action agency comments and distributed a courtesy copy of the draft biological opinion to USFWS and USBR on May 28, 2015.

On May 29, 2015, the new biological opinion (2015 Opinion) for the LNFH was completed.

Subsequently, on July 21, 2015, the 2015 Opinion for the LNFH was challenged in court.[2]

On October 18, 2016, the U.S. Environmental Protection Agency (EPA) submitted to NMFS a request for informal ESA consultation on a proposed National Pollution Discharge Elimination System (NPDES) permit issuance for the LNFH.

On November 22, 2016, the U.S. District Court for the Eastern District of Washington determined that the 2015 Opinion was arbitrary and capricious on the basis of how the 2015 Opinion considered climate change in the analysis of the future operations and water use at LNFH. The court remanded to NMFS for further section 7 consultation consistent with the court's opinion.

In light of the court's decision, NMFS thoroughly searched for any new scientific or commercial information that would be relevant for reanalyzing the effects of LNFH operations in the context of climate change, as described below.

Through December 2016 and January 2017, NMFS was in contact with the University of Washington Climate Impacts Group to determine whether new and relevant information is available for this opinion. On February 3, 2017, NMFS attended a climate change workshop hosted by the Bonneville Power Administration that was related to the work done by this Climate Impacts Group. The findings through this research effort are summarized in (Kondo 2017l) and are consistent with what was described in the 2015 Opinion.

On January 9, 2017, NMFS received Turner (2011) from USFWS. Upon following up with the author from USBR through e-mails dating from January 24 to February 6, 2017, NMFS determined that the data used for this report is outdated and would be inappropriate to use as a basis for analyzing the effects of the proposed action under future climate change.

[2] *Wild Fish Conservancy v. Irving*, 221 F. Supp. 3d 1224 (E.D. Wash. 2016).

With the help from YN, on January 27, 2017, NMFS received USDA (2017a); USDA (2017b) from the U.S. Forest Service (USFS). On February 7, 2017, NMFS received a spreadsheet extracting the temperature predictions from USDA (2017a) from the Confederated Tribes of the Colville Reservation (CTCR). On February 27, 2017, NMFS extracted flow predictions from USDA (2017b).

NMFS also received modeling results from the EPA in April and May 2017. These results predicted dissolved oxygen and pH levels at the mouth of Icicle Creek from proposed interim and final limits for phosphorus in the draft NPDES permit.

NMFS also communicated with USFWS in February and March 2017 to obtain clarifying information about the hatchery's use of therapeutic chemicals.

NMFS continued to exchange information with the action agencies and the tribes. Substantive communications include:

- NMFS requesting review of the first half of the opinion (through Section 2.3) on March 21, 2017, via e-mail.
    - YN submitted comments via email on March 31, 2017.
    - USFWS submitted comments via e-mail on April 3, 2017.
- NMFS requesting review of the second half of the opinion (from Section 2.4) with some placeholders on April 10, 2017, via e-mail.
    - The EPA submitted comments via e-mail on April 18, 2017 and on April 19, 2017.
- NMFS requesting review of the complete draft opinion, including the climate change analysis, via e-mail. NMFS sent the draft biological opinion to the tribes on April 18, 2017, and to the action agencies on April 20, 2017.
    - USFWS submitted comments via e-mail on April 26, 2017.
    - USBR submitted comments via phone on April 26, 2017, suggesting clarifying language for the climate change analysis.
    - USBR submitted comments via e-mail on April 27, 2017.
- NMFS requesting review of a second draft of complete opinion on August 30, 2017.
    - USFWS submitted additional information about the release numbers for the Entiat program via e-mail on September 5, 2017.
    - The EPA submitted comments via e-mail on September 13, 2017.
    - USFWS and CTCR submitted comments via e-mail on September 14, 2017.
    - USBR submitted comments via e-mail on September 17, 2017.
- In addition, numerous e-mails and phone calls were exchanged to clarify some questions that arose from the comments received.

1.3. Proposed Action

"Action" means all activities, of any kind, authorized, funded, or carried out, in whole or in part, by the action agency or action agencies (50 CFR 402.02). Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02).

NMFS describes a hatchery program as a group of fish that have a separate purpose and that may have independent spawning, rearing, marking and release strategies (NMFS 2008b). The operation and management of every hatchery program is unique in time, and specific to an identifiable stock and its native habitat (Flagg et al. 2004).

The proposed action considered in this reinitiation is the operation of the LNFH spring Chinook salmon hatchery program to mitigate for impacts caused by the construction and operation of Grand Coulee Dam. Also included in this opinion is the EPA's proposed action to issue an NPDES permit associated with hatchery effluent discharges.

In this specific case, the proposed operation of the hatchery is described in the March 21, 2011, HGMP (USFWS 2011c) with supplemented information by Anglin et al. (2013); Camp (2012a); Gale (2012a); Gale (2012b); Irving (2012a); Irving (2012c); Puckett (2012); Skalicky et al. (2013), Gale and Cooper (2014), Hall (2014), USFWS (2014), Irving (2014a), Irving (2014b), Gale (2015a), Gale (2015b), and Wilson (2015).

The proposed NPDES permit (currently in draft form, to be issued by the EPA) is described in (EPA 2016a; EPA 2016b). The NPDES permit establishes effluent limitations and monitoring requirements for each waste stream from the facility to ensure protection of water quality and human health, pursuant to the Clean Water Act. The draft NPDES permit includes a 10-year compliance schedule for final temperature and phosphorus limitations and performance-based interim limits to be met prior to compliance with the final effluent limitations. The permit also contains monitoring requirements for the hatchery effluent.

The proposed hatchery operation is funded by the USBR and USFWS (Table 1). The USFWS proposes to continue operation of the LNFH spring Chinook salmon program. These hatchery spring Chinook salmon are released into Icicle Creek, which is a tributary to the Wenatchee River basin, are more than moderately diverged from the UCR spring Chinook salmon evolutionarily significant unit (ESU) and, therefore, are not included in the ESU that is listed as endangered under the ESA (NMFS 2003c). ESA-listed natural-origin spring Chinook salmon currently use Icicle Creek as a migration and spawning area to some degree (Hillman et al. 2014; USFWS 2011c); however, little productivity is expected to occur (NMFS 1999b; UCSRB 2007).

The hatchery program, as described in Section 1.8 of the HGMP is an isolated program and provides fish for harvest. Fish from the program are not intended to spawn naturally and are not intended to establish, supplement, or support any spring Chinook salmon natural population(s).

Table 1. Leavenworth National Fish Hatchery HGMP, the action proponent, and funding agencies.

Hatchery and Genetics Management Plan	Action Proponent	Funding Agency
LNFH Spring Chinook Salmon	USFWS	USBR and USFWS*

* USBR funds the program from Grand Coulee operations budget, approximately 92 percent of which is reimbursed by the Bonneville Power Administration (BPA). The LNFH is part of the Leavenworth Fisheries Complex, owned by USFWS, and was built to mitigate for the construction and operation of Grand Coulee Dam.

The location of the LNFH in the Upper Columbia River Basin is shown in Figure 1.

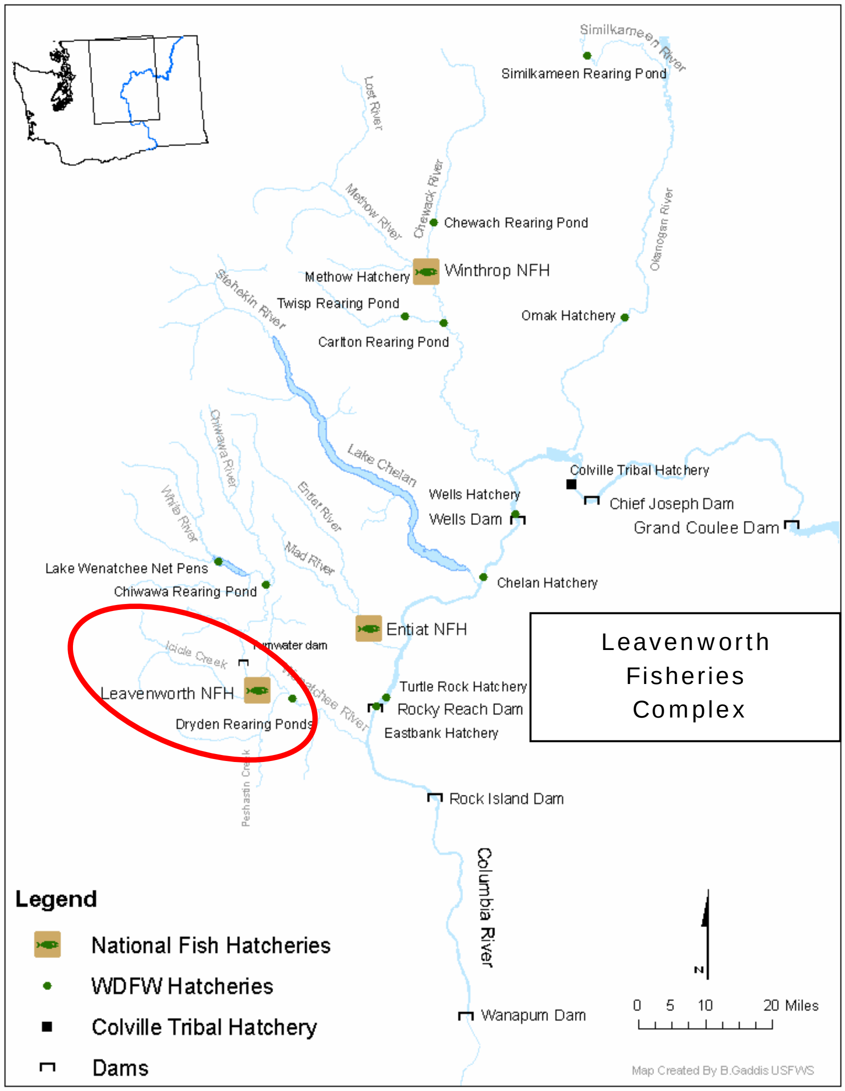


Figure 1. Location of LNFH (USFWS 2006).

Describing the Proposed Action

Proposed hatchery broodstock collection

- Broodstock origin and number: Broodstock used by the hatchery are more than moderately diverged from the local natural population and are not included in the UCR Spring-run Chinook Salmon ESU. Around 1,000 adult spring Chinook salmon would be collected (averaging 1087 fish from 2012 through 2016[3]) for hatchery broodstock annually (Irving 2012c; Kondo 2017n). LNFH depends on Carson-stock spring Chinook salmon adult returns to Icicle Creek for broodstock; these spring Chinook salmon are not ESA-listed or part of the UCR Spring-Run Chinook Salmon ESU. Salmon volunteering to LNFH fish ladder satisfy 100 percent of the program's broodstock requirements.

- Proportion of natural-origin fish in the broodstock (pNOB): The pNOB goal is zero since the LNFH does not use broodstock from the local UCR Spring-run Chinook Salmon ESU. LNFH spring Chinook salmon, identifiable by an adipose fin clip, would be used for hatchery broodstock (see also Encounters, sorting, and handling, with ESA-listed fish, adults, and juveniles below).

- Broodstock selection: A representative sample from throughout the hatchery-origin fish return would be used for broodstock purposes.

- Method and location for collecting broodstock: Broodstock would be collected as they voluntarily enter LNFH through the facility's fish ladder.

- Duration of collection: LNFH would keep the fish ladder open from May through July to cover the full spectrum of the run within the operational constraints of the hatchery[4].

- Encounters, sorting, and handling, with ESA-listed fish, adults and juveniles: All natural-origin spring Chinook salmon incidentally encountered would be returned to Icicle Creek after determining origin through a scale reading[5]. When encounters with ESA-listed hatchery spring Chinook salmon occur, the USFWS will hold ESA-listed conservation program hatchery-origin fish (identified by CWT and adipose fin present) up to three days in order to identify and coordinate with the associated hatchery program operators to determine the appropriate action for those fish (e.g., return to conservation programs for broodstock in safety-net programs, release in downstream areas, surplus, etc.). The remaining ESA-listed safety-net hatchery-origin spring Chinook salmon, because they cannot be visually differentiated from LNFH production, may be inadvertently incorporated into the LNFH broodstock or excessed for tribal subsistence and ceremonial purposes. Up to 3 natural-origin, 50 coded-wire tagged (CWT) conservation hatchery, and 120 adipose-clipped hatchery spring Chinook salmon (i.e., from the Wenatchee conservation programs), volunteering into the LNFH ladder may be incidentally killed

[3] These numbers include green, bad, or spent adults that are not incorporated into the broodstock.
[4] When the capacity of the adult broodstock collection pond is exceeded, the ladder is closed for a short period to allow processing of fish to occur.
[5] Scale readings are used to ensure that a mis-clipped LNFH fish is not mistaken for a natural-origin adult spring Chinook salmon.

during annual broodstock collection (up to 173 total annual incidental mortality) (Section 2.8.1.1; Table 40). No adult management activities are proposed for UCR steelhead; frequencies of natural-origin and hatchery-origin adult encounters are low (i.e., <10 adult steelhead during broodstock collection), and up to 50 juvenile steelhead may be encountered during broodstock collection (Section 2.8.1.2; Table 41); because juvenile steelhead are indistinguishable from resident rainbow trout, this number is likely to include fish from both life history strategies, and these juvenile fish will be referred to, collectively, as *O. mykiss* in this document.

Proposed mating protocols

- A 1:1 female-to-male spawning ratio is proposed. There would be no selectivity in mating. The Enzyme-Linked Immunosorbent Assay (ELISA) method would be used to detect bacterial kidney disease, and eggs would not be combined until fish health reports are complete.

Proposed protocols for each release group (annually)

- Life stage: Pre-smolts and smolts at 16-23 fish per pound (USFWS 2011c).
- Acclimation (Y/N) and duration of acclimation: Yes. Fish are reared onsite at LNFH for approximately 18 months and then released directly from the facility.
- Volitional release (Y/N): No. Fish will be force-released directly from the hatchery ponds into Icicle Creek in the run below the fish ladder and spillway pool (RM 2.8) when the majority of fish exhibit smolt behavior (i.e., silvering in color, shedding of scales). The LNFH attempts to correlate pre-smolt and smolt release with a high stream-flow event that encourages downstream migration in any remaining hatchery yearlings. If necessary, water flow in the release area (i.e., spillway dam) of Icicle Creek is increased for several days prior to and following hatchery releases to provide an additional stimulus for downstream migration. Staff may increase stream flows in the hatchery channel by lowering the radial gates at Structure 2 to facilitate smolt emigration during release starting in late April for 7 to 10 days. Force-releases are designed to limit the period that hatchery fish co-occur with natural-origin spring Chinook salmon and steelhead (Section 2.4.1.6).
- External mark(s): 100 percent of all fish released would be adipose fin-clipped.
- Internal marks/tags: At least 200,000 fish would receive a coded-wire-tag (CWT). To evaluate post-release migration, passive integrated transponder (PIT) tags would be used as appropriate (USFWS 2011c).

- Maximum number released: Maximum annual production would be 1.2 million yearling spring Chinook salmon smolts (USFWS 2011c).[6]

- Release location(s): All fish would be acclimated and released from LNFH in Icicle Creek at river mile (RM) 2.8.

- Time of release: April or early May.

- Fish health certification: Reporting and control of specific fish pathogens would be in accordance with USFWS' Fish Health Policy and Implementation Guidelines through the Olympia Fish Health Center (OFHC).

Proposed adult management

- Anticipated number or range in hatchery fish returns originating from this program: Working with the parties to the *U.S. v. Oregon* Management Agreement (*U.S. v. Oregon* 2009), the LNFH has made a number of changes to production in the past 25 years. LNFH reduced spring Chinook yearling production from 2,200,000 to 1,625,000 in release year 1993 to address USFWS' concerns over water quality, fish health, and hatchery infrastructure issues. From 1995 to 2004, approximately 7,485 adults returned to Icicle Creek and vicinity with average returns per spawner of 8.41 for the ten-year time period (USFWS 2011c). Beginning in 2008, LNFH reduced production again to 1.2 million yearling spring Chinook salmon to address USFWS' concerns over water quality, fish health, hatchery infrastructure issues, and ESA straying risks (*U.S. v. Oregon* 2009). In 2012, approximately 5,370 adults returned to Icicle Creek and vicinity with an average smolt-to-adult return (SAR) of 0.45% and in 2013, approximately 2,773 adults returned to Icicle Creek and vicinity with an average SAR of 0.23% (LaVoy 2015).

- Removal of hatchery-origin fish and the anticipated number of natural-origin fish encountered: All LNFH spring Chinook salmon that enter the fish ladder in Icicle Creek would be removed, and they would not be returned to Icicle Creek. Working in conjunction with the WDFW and Public Utility District No. 1 of Chelan County (CPUD), all LNFH spring Chinook salmon encountered at Tumwater Dam would also be removed. This is intended to reduce the potential for genetic introgression with the Wenatchee natural-origin spring Chinook salmon population in the Upper Wenatchee Basin. All natural-origin spring Chinook salmon incidentally encountered would be returned to Icicle Creek after determining origin through a scale reading. When encounters with ESA-listed hatchery spring Chinook salmon occur, the USFWS will hold ESA-listed conservation program hatchery-origin fish (identified by CWT and adipose fin present) up to three days in order to identify and coordinate with the associated hatchery program operators to determine the appropriate action for those fish (e.g., return to conservation

[6] The YN agreed to the reduction in spring Chinook production from 1.625 million (2005-2007) to 1.2 million as an interim action to achieve the current objectives with respect to present USFWS concerns over water quality, fish health, hatchery infrastructure issues, and ESA straying risks. Restoration back to the 1.625 million 2005-2007 Interim Agreement program level is the goal of the Parties in the future with resolution of these issues (*U.S. v. Oregon* 2009). Restoration of higher production levels may require reinitiation pursuant to 50 CFR 402.16; for example, reinitiation may be required to assess potential changes in ecological effects.

programs for broodstock in safety-net programs, release in downstream areas, surplus, etc.). The remaining ESA-listed safety-net hatchery-origin spring Chinook salmon, because they cannot be visually differentiated from LNFH production, may be inadvertently incorporated into the LNFH broodstock or excessed for tribal subsistence and ceremonial purposes. Up to 3 natural-origin, 50 coded-wire tagged (CWT) conservation hatchery, and 120 adipose-clipped hatchery spring Chinook salmon (i.e., from Wenatchee safety-net programs) volunteering into the LNFH ladder may be incidentally killed during annual broodstock collection (up to 173 total annual incidental mortality) (Section 2.8.1.1; Table 40). No adult management activities are proposed for UCR steelhead; natural-origin and hatchery-origin adult encounters are low (i.e., 10 adult steelhead), and up to 50 juvenile *O. mykiss* may be encountered during broodstock collection (Section 2.8.1.2, Table 41).

- Appropriate uses for LNFH-origin hatchery fish that are removed: Adult returns are used for hatchery broodstock, harvest, and donation for human consumption (i.e., tribal ceremonial and subsistence purposes, non-profit groups, etc.).

- Are hatchery fish intended to spawn naturally (Y/N): No

- Performance standard for pHOS (proportion of naturally spawning fish that are of hatchery-origin): The USFWS does not propose a pHOS standard for the LNFH program but intends to collect returning LNFH adults for broodstock that have escaped the spring Chinook salmon fisheries in the ocean, Columbia River, lower Wenatchee River, and Icicle Creek.

- Performance standard for stray rates into natural spawning areas: stray rates are minimized by removing LNFH-origin spring Chinook salmon at Tumwater Dam and through operation of the ladder to reduce within-basin and out-of-basin hatchery influence (i.e., Wenatchee and Entiat spring Chinook salmon natural-origin populations).

Proposed research, monitoring, and evaluation

- Adult sampling, purpose, methodology, location, and the number of ESA-listed fish handled: The Program Operators will monitor and report information on hatchery returns, stray rates, biological characteristics of the hatchery stock, fish marking, tag recovery, and other aspects of the hatchery program. Sampling and marking of non-listed Carson-stock spring Chinook salmon (for genetic analysis, disease pathology, smolt condition, fin clipping and/or tagging, etc.) within the LNFH would not be associated with incidental take of listed species and would not pose a risk to listed spring Chinook salmon and steelhead. Annual snorkel surveys would occur from the boulder field (RM 5.7) downstream to the mouth of Icicle Creek, including below the hatchery barrier and in the pool near the fish ladder in August[7] to determine the number of adults present after the collection ladder has been closed; spawning areas or redds (the location of eggs; "nests") would not be disturbed. Numbers of fish released and associated harvest would be estimated from CWT recoveries and creel surveys. Other than analysis of CWT

[7] Annual snorkel surveys occur when the spring Chinook fishery season ends, the broodstock collection ladder closes, and in-river flows and conditions allow.

recoveries, there is no directed research proposed for the LNFH spring Chinook salmon program at this time.

- Juvenile sampling, purpose, methodology, location, and the number of ESA-listed fish handled: None is proposed at this time.

Proposed operation, maintenance, and construction of existing hatchery facilities

- Water source(s) and quantity for hatchery facilities: The Proposed action includes a combination of the following:

(1) A surface diversion at RM 4.5 (not to exceed 42 cubic feet per second[8] (cfs) annually from Icicle Creek) (i.e., Structure 1);
(2) A water control feature at RM 3.8 (i.e.., Structure 2) used to direct flow between the historical and hatchery channels of Icicle Creek (i.e., not a water source or a point of withdrawal) with the intent to block upstream passage of LNFH-origin spring Chinook salmon during broodstock collection (May through July), increase flows in the hatchery channel to promote smolt emigration, recharge hatchery wells, aid in flood control, and perform routine maintenance of structures;
(3) Seven wells; and
(4) Supplemental flow from Snow/Nada Lake Reservoirs through Snow Creek (confluence located 1 RM above LNFH's intake system).

Structure 1: The primary intake system is a diversion structure (i.e.,., low head dam, Structure 1) that spans Icicle Creek at RM 4.5. The low-head structure consists of a concrete base with flashboards on top and a pool-and-weir fish ladder. No more than 42 cfs for the LNFH[9] is diverted into a concrete water conveyance channel with a grizzly rack (a type of exclusion rack) at the entrance. Since 2010, from mid-July through September, LNFH staff have placed a section of cyclone fence[10] in front of the outer grizzly rack to prevent adult spring Chinook salmon from entering the conveyance channel, and will continue to do so until the intake is updated or replaced and screening is provided by May 2023 (see Water diversions meet NMFS screen criteria (Y/N) below). Water entering the conveyance channel is transported to an intake structure that sorts coarse and fine objects that may enter the pipeline. The intake structure is inspected twice daily (beginning and end of working day) to remove accumulated debris from racks and ensure adequate flow. Inspections occur more often during higher flows and during cold temperature periods when ice accumulates on the racks.

[8] The total water withdrawal will not exceed 54 cfs: 42 cfs for LNFH year round and 12 cfs for Cascade Orchard Irrigation Company (COIC) during the irrigation season (typically May – September, though the irrigators may turn on their system in late-April to ensure the system is working and can withdraw water into the first week of October). Although the USFWS and COIC share a water diversion at RM 4.5 on Icicle Creek, only the LNFH water withdrawals are included in this proposed action.
[9] Again, although the USFWS and COIC share a water diversion at RM 4.5 on Icicle Creek, only the LNFH water withdrawals (42 cfs year round) are included in this proposed action. From May to September, total diversions at this site are 54 cfs, which includes 12 cfs for COIC.
[10] Cyclone fencing is plastic-coated, 4-inch mesh.

Structure 2: Structure 2 is a water control feature that can control instream flows in the Icicle Creek historical and hatchery channels (from approximately RM 2.8 upstream to RM 3.8). From approximately 1940 to 2001, LNFH operations of Structures 2 and 5 blocked fish passage during most of the year and controlled surface flows between the two channels. Since 2001, the LNFH has adaptively managed Structure 2 (in tandem with Structure 5) to block upstream passage of LNFH-origin spring Chinook salmon during broodstock collection[11], increase flows in the hatchery channel to promote smolt emigration, recharge hatchery wells, aid in flood control, and perform routine maintenance of structures. The proposed action includes a 60% historical channel / 40% hatchery channel stream flow proposal (NMFS 2015a) with a collective (i.e., all water users) instream flow goal of 100 cfs[12] (i.e., monthly average flow), measured in the historical channel of Icicle Creek.

One aspect of operation of Structure 2 is the use of streamflow to percolate through the hatchery channel streambed to recharge the local aquifer. Aquifer recharge is primarily conducted in the months of September, October, November, February, and March for up to a maximum of five times a year[13], fifteen consecutive days at a time (75 days a year maximum combination of separate events) (Irving 2015a; NMFS 2015a). The hatchery wells (see *LNFH Wells,* described below) draw from shallow and deep aquifers. The shallow aquifer is directly affected by river stage, and the bed of the hatchery channel appears to be more porous than the historical channel (GeoEngineers 1995).

Flows in the historical channel may deviate from the collective instream flow goal in average or dry water years or during two or more consecutive years of drought (Section 2.4.2.6.2, Tables 25, 26 and 27). Likewise, in average to wet years, instream flows may be markedly better than the proposed instream flows (Irving 2015a).

Structure 5: Structure 5 is a legacy feature of past hatchery practices. It is a channel-spanning concrete sill located in the historical creek channel just above the confluence of the hatchery channel with Icicle Creek. It presently is used to seasonally prevent upstream passage of hatchery spring Chinook salmon through the historical creek channel. This is accomplished by installing picketed panels on top of dam boards, which are installed in each bay of the structure. It may also be used to facilitate monitoring by using pickets to limit the width of the dam over which fish may pass. Located downstream of Structure 2, Structure 5 cannot be used to regulate flow. Structure 5 will remain open except during times described below. Structure 5 will not be closed for more than one week between May 15th and July 7th without LNFH operating fish traps in Structure 5 to capture spring Chinook salmon, bull trout, and steelhead, and manually moving pre-spawned steelhead (i.e., kelts are placed downstream) and natural-origin spring Chinook salmon upstream of Structure 5 (i.e., hatchery-origin spring Chinook salmon are placed downstream or transferred to the hatchery).

[11] Broodstock collection typically occurs May through July.

[12] The collective instream flow goal of 100 cfs includes the LNFH and all water users in Icicle Creek. The instream flow would be calculated as a monthly average flow.

[13] Typical operation of Structure 2 for aquifer recharge is twice per year, fifteen consecutive days at a time.

LNFH Wells: The LNFH uses seven wells for hatchery fish production. Five hatchery wells are located on the west bank of the hatchery channel and two wells are located near the hatchery's main entrance road (USFWS 2014). Hatchery wells #1-4 and #7 draw water from the shallow aquifer; well #5 delivers water from the deep aquifer; and well #6 has the capacity to draw water from both aquifers (USFWS 2014). Recharge of the shallow aquifer for well water depends on, among other things, how much surface water is present to seep into groundwater in the historical and hatchery channels in Icicle Creek. Groundwater from wells is used to supplement and cool surface water for fish production or to warm creek water in the facility when surface water is too cold. Hatchery production is sustained year round by surface water, well water, and re-circulated water (i.e., water re-circulated through hatchery raceways) (USFWS 2014).

Snow/Nada Lake Supplementation Reservoirs: The LNFH reservoirs from Snow and Nada Lakes would provide up to 50 cfs of supplemental flow in August and September to meet hatchery production needs (Irving 2015a; NMFS 2015a). Two or more years of drought may alter release operations. If this occurs, and the USFWS determines it is necessary to alter Snow/Nada Lake Supplementation releases, re-initiation of consultation may be necessary (Cappellini 2014). A drought for more than two consecutive years is unlikely, but it would likely require a reduction in supplemental flow from the Snow/Nada Lake Supplementation Reservoirs (Cappellini 2014). The amount of reduction is unknown and would be largely dependent on the environmental conditions at the time.

The Icicle Creek Work Group[14] (IWG) is working to develop an integrated water management plan for Icicle Creek. An instream flow subcommittee evaluated available information (e.g., Anglin et al. 2013) and developed a set of instream flow targets for all water users that the IWG adopted to improve the habitat quality and ecological function of Icicle Creek. These recommendations were a minimum flow of 100 cfs in an average water year (50th exceedance) and a minimum flow of 60 cfs during a dry water year (90th exceedance) (Irving 2015). As described above, the USFWS has established a collective instream flow management goal of 100 cfs in Icicle Creek[15] (Irving 2015a) as part of its proposed action. The following describes short-term and long-term actions that the LNFH would implement by May 2023 regarding surface water withdrawals and operation of Structure 2 to contribute towards achieving this collective instream flow goal for all Icicle Creek water users.

SHORT-TERM OPERATIONS OF LNFH SURFACE WATER WITHDRAWAL

- Surface water withdrawals would divert up to 42 cfs year-round to meet production needs for the rearing of 1.2 million spring Chinook salmon as

[14] A coalition of local water users, federal, state, and local government biologists, and other interested parties working together to improve efficiency of water use and instream flows in Icicle Creek.

[15] Again, this goal is based on recommendations of the Icicle Creek Work Group (IWG), a coalition of local water users, federal, state, and local biologists, stakeholders, and interested parties working together to develop an integrated water management plan for Icicle Creek Irving, D. B. 2015a. Addendum to the USFWS Supplemental Biological Assessment - Water Use at Leavenworth National Fish Hatchery: A Plan for Interim and long-term actions to further improve stream flows. May 11, 2015. U.S. Fish and Wildlife Service, Leavenworth, Washington..

described in the USFWS Supplemental Biological Assessment (SBA) (NMFS 2015a) until infrastructure improvements are completed that have the potential to reduce water diversions by as much as 20 cfs annually.

  - USFWS has adopted a collective (i.e., all water users) instream flow goal of 100 cfs in Icicle Creek.
  - LNFH would maximize instream flows to the extent practicable while continuing Structure 1 diversions of up to 42 cfs. The instream flow goal of 100 cfs would likely be met in most years (i.e., average and dry water years combined). Circumstances where the LNFH may need to deviate from this collective instream flow goal to meet production targets are described and analyzed in Section 2.4.2.6.2, Table 30, Table 31, and Table 32.

- Use of Snow/Nada Lake Supplementation Reservoirs would be evaluated to determine the efficiency and scope of expanded use of this resource as a means to ensure access to the LNFH's surface water right, and improve instream flows outside of the current supplementation period (i.e., August and September).

SHORT-TERM OPERATIONS OF STRUCTURE 2 FOR AQUIFER RECHARGE

- During dry water years, given the current water use in Icicle Creek, availability of adequate natural instream flows, and the use of Structure 2 for aquifer recharge, meeting a 100 cfs instream flow may be problematic outside of April – July time period[16]. To address this issue, the LNFH will do the following:
  - Structure 2 will not be operated for aquifer recharge in August.
  - In September, if the natural flow remaining after subtracting the amount of water diverted by the LNFH and all water users is less than 60 cfs, the LNFH will not route more water into the hatchery channel than the volume of its Snow/Nada Lake storage release (up to 50 cfs) minus the diversion at Structure 1 (up to 42 cfs).
  - In March, Structure 2 will be operated only if adult steelhead have not been detected in Icicle Creek[17].
  - The collective instream flow goal of 100 cfs would be met in most years (i.e., average and wetter years). When the LNFH production cannot be maintained by achieving a collective instream flow goal of 100 cfs, the LNFH would operate in a manner intended to maintain daily instream flow goals (e.g., altering operation of Structure 2 as needed, working with IWG, managing storage water flexibly) of 40 cfs in October, 60 cfs November - February, and 80 cfs in March in the Icicle Creek historical channel. Circumstances where the LNFH would need to deviate from the 100 cfs instream flow goal are described and analyzed in (Section 2.4.2.6.2, Table 32).

[16] As expressed as a monthly average flow when examining monthly average instream flows from 1994 to 2014.

[17] Steelhead presence will be determined through examination of PIT detection data in the mainstem Columbia River, the Wenatchee River, and lower Icicle Creek Irving, D. B. 2015a. Addendum to the USFWS Supplemental Biological Assessment - Water Use at Leavenworth National Fish Hatchery: A Plan for Interim and long-term actions to further improve stream flows. May 11, 2015. U.S. Fish and Wildlife Service, Leavenworth, Washington..

LONG-TERM OPERATIONS OF LNFH SURFACE WATER WITHDRAWAL

- As part of the proposed action, LNFH is committed to changes in hatchery operations that contribute to the consistent achievement of an 100 cfs instream flow goal (collectively) through the following actions:
  - LNFH will develop and evaluate plans for installation of a partial recirculating aquaculture system (pRAS) to reduce the amount of surface water needed to meet salmon production targets established under the *U.S. v. Oregon* Management Agreement *(U.S. v. Oregon 2009)*. It is expected that a pRAS system could reduce water needs by at least 20 cfs. If successful, the unused portion of LNFH's surface water right would be placed in a water trust for purposes of instream flows. Implementation of this action is expected to enable greater operational flexibility for the hatchery to provide additional instream flow in Icicle Creek. The LNFH is developing final design documents for a pilot pRAS to be tested at the hatchery. Infrastructure improvements[18] were completed in 2015 to allow this system to be put in place (W. Gale, USFWS, personal communication, February 28, 2017). We anticipate the pilot application of the pRAS to begin within the next 3-4 years.
  - LNFH will continue to work cooperatively with other major water users in the Icicle Creek watershed through the IWG or another similar entity. Actions by LNFH alone are not likely to be sufficient to meet the collective instream flow goal of 100 cfs during all months of the year. Improvements and changes to the water delivery system(s) for the other major water users in Icicle Creek are also needed.

[18] Infrastructure improvements include valve and pipeline replacement and repair.

LONG-TERM OPERATIONS OF STRUCTURE 2 FOR AQUIFER RECHARGE

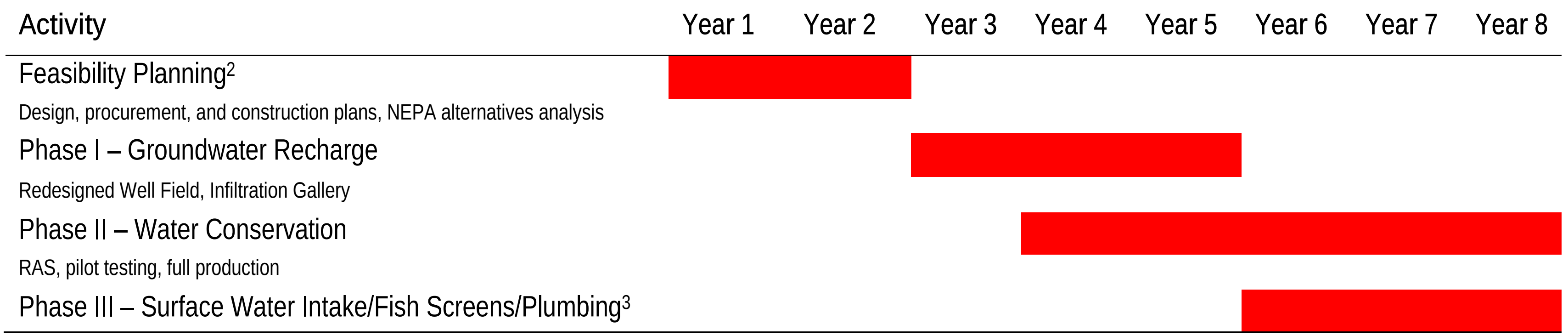
- For over two years, LNFH has been pursuing options to replace the use of structure 2 for aquifer recharge. Ongoing feasibility studies are expected to be completed within one year. LNFH will identify a preferred option and implement this option by May 2023, or sooner, if possible. The LNFH is considering the following alternatives[19] for the replacement of the use of structure 2 for aquifer recharge:
    - The LNFH has requested the permitting of a new point of discharge from EPA (NPDES permit) and the WDOE (Clean Water Act 401 certification) to allow the pump back of LNFH effluent to the hatchery channel. A water quality study requested through the permitting process has been completed and submitted to the WDOE. Once all permitting is in place, absent other actions that obviate the need for aquifer recharge, LNFH will pursue implementation of this option.
        - In August and September of 2015, LNFH implemented an emergency effluent pump back evaluation for a system that was designed to recirculate effluent to the hatchery channel for aquifer recharge. USFWS and LNFH (2016) summarizes the results of the emergency effluent pump back evaluation and provides refined analysis of what would be needed to implement a permanent effluent pump back system to improve water supply to LNFH.
    - The LNFH is conducting exploration work for the development of additional well resources and/or an infiltration gallery that would preclude the need to operate structure 2 for aquifer recharge. The results of these evaluations will be completed in the next year; potential solutions will be identified, and priority ranked for implementation.

- Water diversions meet NMFS screen criteria (Y/N): No. The primary intake on the LNFH's point of diversion and water withdrawal system does not comply with NMFS's current screening criteria (NMFS 2011c). Both secondary screen chambers meet NMFS's earlier screening criteria (NMFS 1996). Although construction activities are not included in this proposed action, the surface water delivery system would be examined and upgraded or a new water delivery system at the LNFH—which would be expected to reduce impacts on ESA-listed fish—would be completed by May 2023. The primary diversion intake would be screened and, thus, would meet NMFS criteria for protecting anadromous salmonids (Irving 2012a). Fish salvage procedures have been developed to reduce effects on ESA-listed species, which are described in Section 2.4.2.6.1. The proposed action commits to providing NMFS-approved screening at the LNFH primary intake by May 2023. Incidental take of ESA-listed spring Chinook salmon and steelhead associated with the water delivery system are described in Sections 2.8.1.1 and 2.8.1.2 (Table 40 and Table 41). Maintenance at the point of diversion (i.e., sluicing or dredging material from the conveyance channel, sand settling chamber, and fish ladder) causes a temporary increase in turbidity. These activities are conducted within the Water Quality Standards for Surface Water set by the WDOE (WAC 173-2011A). When the sand

[19] Although preliminary stages of multiple projects can occur simultaneously, there is a limit to the number of capital improvement projects that can be implemented with certainty within any given period.

settling chamber is cleaned of sediment, water is drawn down and any fish entrained are netted and released back into Icicle Creek.

Implementation Schedule for Infrastructure Improvements at LNFH[1]



[1] The implementation schedule allows for final design, procurement, and construction. Ability to proceed is subject to Congressional appropriations. With the exception of overall completion of infrastructure improvements by year 8 (i.e., May 2023), the remaining beginning and end of dates for each activity are estimated and subject to change.

[2] Feasibility study would include development of 30% designs and procurement plans to identify how best to implement Phases 1 through 3. The action agencies are in the early stages of NEPA compliance efforts for the infrastructure improvements. The timeline for NEPA compliance will vary according to the needs of each project.

[3] Since the aggregate benefit of the long-term LNFH infrastructure upgrades is greater than the installation of screens alone, and the infrastructure upgrades are likely to dictate what type of screening is required, this warrants additional time necessary to complete long-term infrastructure improvements and develop screening on the LNFH primary intake that complements the new water delivery system.

Figure 2. Proposed schedule for implementation of long-term actions for improving Icicle Creek instream flow conditions and the efficiency and reliability of hatchery water use (Irving 2015).

- Permanent or temporary barriers to juvenile or adult fish passage (Y/N): Yes. There is a rubble masonry diversion structure at RM 4.5 and two structures (Structures 2 and Structure 5) in the Icicle Creek historical channel at approximately RM 3.8 and 2.8, respectively, that may seasonally impede upstream passage to ESA-listed species. Structure 2 can alter the amount of wetted habitat in the Icicle Creek historical channel when operated by adjusting the radial gates. To increase the opportunity for upstream fish passage through both structures and improve habitat within the Icicle Creek historical channel, Structures 2 and 5 will remain open all year except during certain conditions[20] when, specifically:

    (1) Returning adult spring Chinook salmon (50 or more) pass upstream of Structure 5 during broodstock collection (May through July),

    (2) Stream flow through the hatchery channel is not sufficient to promote pre-smolt emigration during juvenile release (late April),

    (3) Stream flow in the hatchery channel is not sufficient to recharge the aquifer and hatchery well production is affected (late summer, fall, and early winter),

    (4) High stream flows are endangering downstream infrastructure (during seasonal spring runoff and rain on snow events), or

    (5) Maintenance of Structure 5 is being conducted.

    Also, Structures 2 or 5 may be operated to improve flow or increase fish passage opportunities, with prior notification to NMFS SFD. For example, in 2015, one board was added to each bay, except for the middle bays, of Structure 5 to concentrate and raise the stream flow through the middle bays to address extreme low flows (lowest on record) (USFWS 2016). This is likely to be done through working with the adaptive management group (consisting of personnel from the WDFW, NMFS, YN, CTCR, and USFWS) and only to benefit the fish and fish passage.

    When adjustments are made to Structures 2 and 5[21], it would be done slowly and incrementally to avoid rapid water level changes and prevent fish stranding (USFWS 2014). A stranded fish is any fish not in an area of water that is sufficiently connected to the mainstream channel (Cappellini 2014). Ramping rates would be conducted according to the WDOE Clean Water Act 401 certification process and would not exceed one inch per hour (WDOE 2010). Ramping rates may increase during emergency flood control actions but a rate has not been established for emergencies (Cappellini 2014). The Icicle Creek historical channel would be surveyed for stranded fish after adjustments are made

[20] As described in the USFWS LNFH Supplemental Biological Assessment NMFS. 2015a. Endangered Species Act - Section 7(a)(2) Consultation Biological Opinion And Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation. Leavenworth National Fish Hatchery Spring Chinook Salmon Program Draft Adverse Modification to UCR Steelhead Critical Habitat Opinion and Associated RPA. April 17, 2015. NMFS, Portland, Oregon..

[21] Adjustments include raising or lowering gates at Structure 2, installing or removing flashboards or weirs at Structure 5.

to Structure 2 if radial gate(s) are lowered (USFWS 2011c). When making adjustments to Structures 2 and 5, USFWS also monitors turbidity through water sampling to ensure compliance with Water Quality Standards for Surface Waters (WAC 173-201A) (USFWS 2014).

In addition, LNFH shares a point of diversion with the Cascade Orchard Irrigation Company (COIC) at RM 4.5. Hatchery personnel would check the COIC upwelling chamber twice a day for entrained species (Cappellini 2012).

- Instream structures (Y/N): Yes. There is an entrance to the hatchery fish ladder at RM 2.8, a fish ladder at the low dam at RM 4.5, and a water return via pipeline (below the fish ladder) at RM 4.5.
- Stream bank armoring or alterations (Y/N): Yes. Streambank armoring may be necessary at three locations: (1) Structures 1 and 2; (2) water return; and (3) the entrance to the fish ladder to the adult broodstock ponds. In the past, the area from below the LNFH spillway structure to approximately 500 feet downstream required stream bank restoration after a flooding event undermined the LNFH adult fish ladder and nearly breached the pollution abatement pond. This area may require stream bank repair, as well as at the LNFH diversion structure (RM 4.5), if affected by future flooding (Cappellini 2014). No construction activities are included in the proposed action. Any stream bank armoring or alterations would be analyzed under a separate ESA consultation.
- Pollutant discharge and location(s): Yes. All water diverted into LNFH water delivery system is eventually discharged into Icicle Creek (minus any leakage or evaporation) at one of four locations, including the:

  (1) Base of the fish ladder (Outfall 001; RM 2.8);

  (2) Top of the fish ladder (Outfall 004; RM 2.8; for approximately one week during pre-smolt release to facilitate hatchery fish emigration);

  (3) Pumped/piped fish release (Outfall 005; RM 2.75; for approximately one to two weeks during pre-smolt release to facilitate hatchery fish emigration; when Outfall 005 is in operation, the discharge from Outfall 001 is reduced by the amount released at Outfall 005); and

  (4) Outfall for the pollution abatement ponds (Outfall 002; RM 2.7)(USFWS 2011a).

Outfall 003 (at RM 3.8) is currently not used as a discharge point by the hatchery. In the past, Outfall 003 was operated intermittently as a fish return bypass for the water delivery system, meaning that fish in Icicle Creek screened from entering the LNFH water supply pipeline were returned to Icicle Creek through Outfall 003. The most recent LNFH NPDES Permit Application information from 2012 states that there is no flow through Outfall 003; however, the LNFH requested inclusion of this outfall in the NPDES authorization for potential future use.

Outfall 006 is a newly proposed discharge location in the NPDES permit application. Outfall 006 is located at RM 3.3 in the hatchery channel, upstream from Outfall 001, and will be used when necessary to keep flow in the hatchery channel. When in operation, the discharge from Outfall 001 is reduced by the amount of effluent released at Outfall 006.

The majority of river and well water used for hatchery operations is returned to Icicle Creek near the base of the adult return ladder, except during pond cleaning and maintenance activities when all water is routed through the pollution abatement ponds (USFWS 2011a). The LNFH complies with several water rights associated with Icicle Creek, Snow and Nada Lakes, and the seven wells located on the property. Maintenance of water diversions includes sediment removal of LNFH's intake conveyance channel through flushing with normal water use. Maintenance of the water supply reservoirs includes twice-a-year service of flow gages, debris removal, and safety inspections.

The LNFH operates and monitors its water discharge, including cleaning and sediment disposal to maintain the pollution abatement ponds, consistent with NPDES Permit No. WA-000190-2. In November 2005, the LNFH submitted an application to the EPA for a new NPDES discharge permit. A draft permit was developed by the EPA in December 2010; however, through the review process it was determined that the LNFH had made significant changes to its operations since the 2005 submittal for a NPDES permit and a new permit application would need to be submitted to address these changes. Changes included hatchery modifications to reflect actions to improve the health of the hatchery's spring Chinook salmon and to improve the water quality (i.e., lower phosphorus levels) discharged into Icicle Creek. Changes include, but are not limited to the:

(1) Reduction in hatchery production from 1,625,000 to 1,200,000 million spring Chinook salmon;

(2) Use of low phosphorus feed (when commercially available) during the critical months of March, April, July, August, and September (with the exception of fry in the nursery); and

(3) Construction and operation of a second pollution abatement pond, which was completed in 2010.

The LNFH submitted an additional NPDES application for additional outfalls to the EPA in October 2011. As part of the permit process in EPA's 2005 draft NPDES permit, WDOE issued a Clean Water Act (CWA) 401 Certification (WDOE 2010) to the LNFH. The WDOE did not terminate this certification to the LNFH. The EPA did not complete the NPDES permitting process; however, the WDOE 401 certification order remained in effect (EPA 2010). The LNFH submitted a new CWA 401 certification application to address significant changes to hatchery operations to the WDOE in October 2011. In 2016, WDOE terminated the WDOE 401 certification.

In 2013, the USFWS completed two reports for the Final 401 CWA Certification Order No. 7192: (1) Icicle Creek instream flow and fish habitat analysis (Skalicky et al. 2013); and (2) Icicle Creek fish passage evaluation for the LNFH (Anglin et al. 2013).

In October 2016, EPA proposed a new NPDES permit. The new draft NPDES permit establishes effluent limitations that are more stringent for some pollutants than the levels analyzed in the 2015 Opinion. As proposed, the permit would allow discharge into Icicle Creek at Outfalls 001, 002, 004, and 005, with Outfall 003 listed for potential future use; in addition, the draft permit includes a new discharge location (Outfall 006, located at ~RM 3.3) in the hatchery channel of Icicle Creek. If permitted and feasible, this newly proposed discharge location would be used to pump hatchery water back to the hatchery channel for aquifer recharge. Final decision on the permit application is still pending. In the interim, the LNFH continues to operate and monitor its water discharge in accordance with NPDES Permit No. WA-000190-2.

1.4. Action Area

The "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). The action area for this action is defined to encompass the Wenatchee Basin, including the lower 5.5 RM of Icicle Creek (Figure 3). The action area also includes the Entiat Basin where LNFH adult strays have been encountered at a low rate and may spawn naturally.

Icicle Creek originates at Josephine Lake at an altitude of 4,681 feet near the crest of the Cascade Range. Its name comes from the Indian word "na-sik-elt," meaning narrow canyon (Brokenshire 1993). The Icicle Creek Basin is mountainous and mostly undeveloped land within the Wenatchee National Forest and Alpine Lake Wilderness. The Icicle Creek drainage is fed by multiple high mountain crests and glaciers. Only the final 6 miles of the creek are moderately developed with scattered homes and pasture, children's camp, small housing development, and the LNFH.

The operation of hatchery facilities has the potential to affect ESA-listed spring Chinook salmon and steelhead in Icicle Creek through the diversion of surface water or the maintenance of instream structures (e.g., the water intake and discharge structures) and the release of effluent. Under the proposed action, the hatchery facilities would be used to spawn, incubate, and rear spring Chinook salmon for the LNFH program, which includes:

- Leavenworth National Fish Hatchery (ground and facilities)
- LNFH fish ladder and broodstock holding ponds
- Primary intake and low head dam (i.e., Structure 1) and associated water intake system[22]
- Hatchery Channel (i.e., aquifer for hatchery well recharge)
- Structure 2 water control feature for hatchery well recharge
- Structure 5
- Snow/Nada Lakes Supplementation Reservoir

The action area includes the hatchery facilities/structures listed above (Figure 3, below) and portions of Icicle Creek where water withdrawals are affecting ESA-listed species through

[22] This includes the shared intake between LNFH and the COIC, grizzly rack, pipeline, sand settling chamber, etc.

sediment transport, increased water temperatures, etc. (e.g., water diversions, maintenance activities).

NMFS considered whether the mainstem Columbia River, the estuary, and the ocean should be included in the action area but the effects analysis was unable to detect or measure effects of the proposed action beyond the area described above, based on best available scientific information (Section 2.4.2.4)(NMFS 2009a).

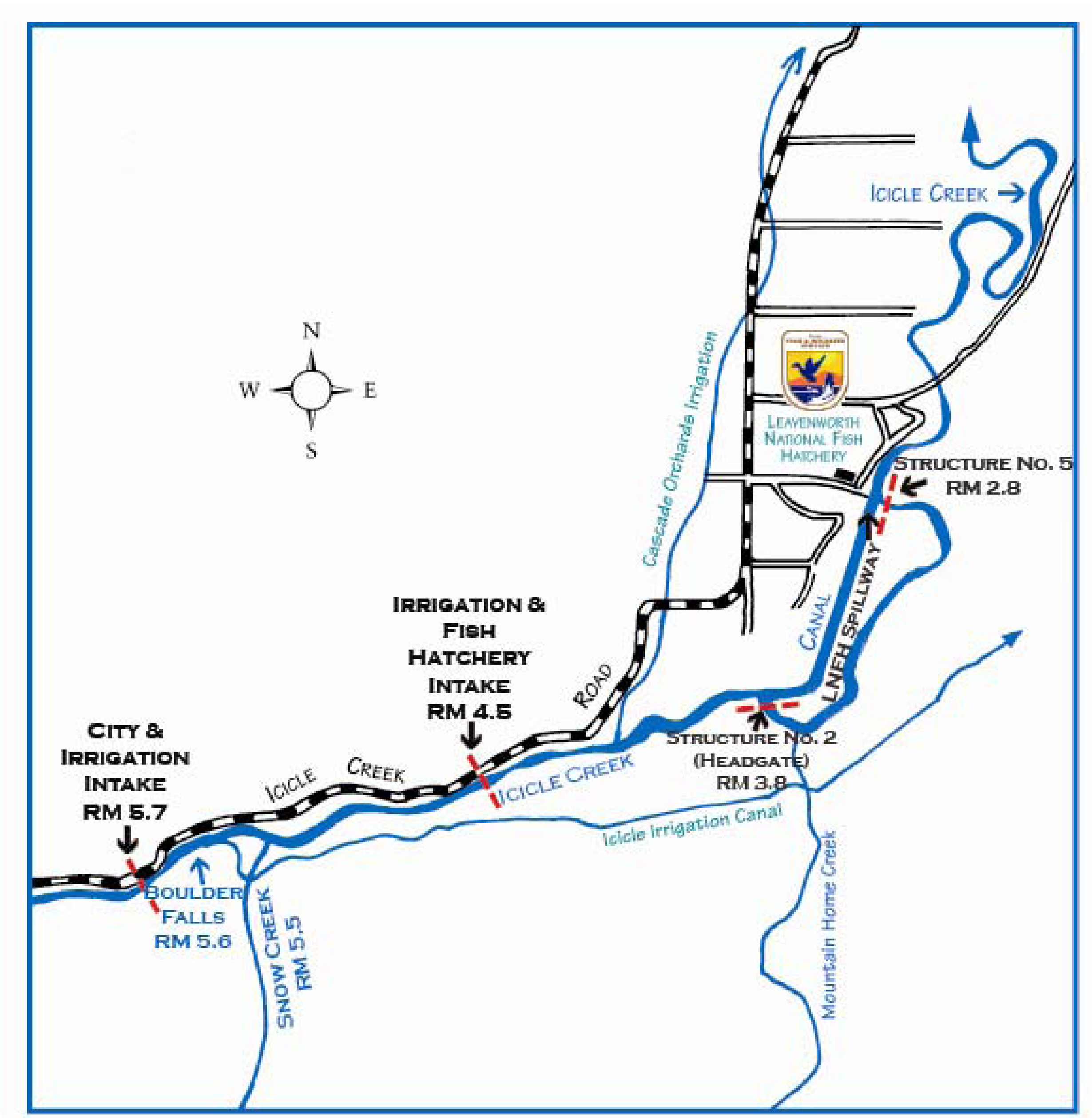


Figure 3. Leavenworth National Fish Hatchery and Vicinity (USFWS 2004a).

ESA-listed species in the action area that may be affected by the proposed action include UCR Chinook salmon and UCR steelhead (Table 2). The action area is used by both UCR spring Chinook salmon and UCR steelhead. UCR spring Chinook salmon critical habitat is designated in the upper and lower mainstem Wenatchee River, including tributaries above Tumwater Dam that serve as major migration, spawning, and rearing areas for adults and juveniles but not tributaries below Tumwater Dam, such as Icicle Creek (NMFS 2005a). UCR steelhead critical habitat is designated in the upper Wenatchee River and lower mainstem areas as well as tributaries above and below Tumwater Dam, including Icicle Creek, that serve as major migration, spawning, and rearing areas for adults and juveniles (NMFS 2005a). The action area is also designated as essential fish habitat (EFH) for Chinook and coho salmon (PFMC 2003).

Table 2. Federal Register notices for the final rules that list species, designate critical habitat, or apply protective regulations to ESA listed species considered in this consultation.

Species	Listing Status	Critical Habitat	Protective Regulations
Chinook salmon (*Oncorhynchus tshawytscha*)			
Upper Columbia River spring-run	Endangered 70 FR 37160; June 28, 2005	70 FR 52630; Sept 2, 2005	Not applicable[23]
Steelhead (*Oncorhynchus mykiss*)			
Upper Columbia River steelhead	Threatened 71 FR 834; January 5, 2006	70 FR 52630; Sept 2, 2005	71 FR 5178; February 1, 2006

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, Federal agencies must ensure that their 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 provides an opinion stating how the agency's actions would affect listed species and their critical habitat. If incidental take is expected, section 7(b)(4) requires NMFS to provide an incidental take statement (ITS) that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures and terms and conditions to minimize such impacts.

2.1. Analytical Approach--Overview

This biological opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of a listed species," which is "to engage in an action that 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.

[23] For species listed as endangered, Section 9 prohibitions apply automatically.

For its critical habitat analysis, this biological opinion relies on the definition of “destruction or adverse modification,” which is “a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features” (81 FR 7214, February 11, 2016).

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

Identify the range-wide status of the species and critical habitat

This section describes the status of species and critical habitat that are the subject of this opinion. The status review starts with a description of the general life history characteristics and the population structure of the ESU/DPS, which can include components of the ESU/DPS referred to as strata or major population groups (MPG). NMFS has developed specific guidance for analyzing the status of salmon and steelhead populations in a “viable salmonid populations” (VSP) paper (McElhany et al. 2000). The VSP approach considers four attributes—the abundance, productivity, spatial structure, and diversity of each population (natural-origin fish only)—as part of the overall review of a species’ status. For salmon and steelhead protected under the ESA, the VSP criteria therefore encompass the species’ “reproduction, numbers, or distribution” (50 CFR 402.02). In describing the range-wide status of listed species, NMFS reviews available information on the VSP parameters including abundance, productivity trends (information on trends, supplements the assessment of abundance and productivity parameters), spatial structure, and diversity. We also summarize available estimates of extinction risk that are used to characterize the viability of the populations and ESU/DPS, and the limiting factors and threats. To source this information, NMFS relies on viability assessments and criteria in technical recovery team documents, ESA Status Review updates, and recovery plans. We determine the status of critical habitat by examining its physical and biological features (also called “primary constituent elements” or PCEs[24]). Status of the species and critical habitat are discussed in Section 2.2

Describe the environmental baseline

The environmental baseline includes the past and present impacts of Federal, state, or private actions and other human activities *in the action area* on ESA-listed species. It includes the anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation and the impacts of state or private actions that are contemporaneous with the consultation in process. The environmental baseline is discussed in Section 2.3 of this opinion.

[24] The new critical habitat regulations (81 FR 7214) replace 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 biological opinion, we use the term PCE to mean PBF or essential feature, as appropriate for the specific critical habitat.

Analyze the effects of the proposed action on both species and their habitat

In this section, NMFS analyzes the Proposed Action in terms of effects the Proposed Action would be expected to have on ESA-listed species and on designated critical habitat, based on the best scientific information available. A Proposed Action is analyzed for beneficial, neutral, and adverse effects on ESA-listed species by assessing the effects on four key parameters or attributes (abundance, productivity, spatial structure, and diversity). For hatchery programs, the analysis is broken down into seven factors, which are discussed in more detail in Section 2.4.1.

Describe the cumulative effects in the action area

Cumulative effects, as defined in NMFS' implementing regulations (50 CFR 402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the Proposed Action are not considered because they require separate section 7 consultation. Cumulative effects are considered in Section 2.5 of this opinion.

Integrate and synthesize the above factors

Integration and synthesis of information from previous sections occurs in Section 2.6 of this opinion. In this step, NMFS adds the expected effects of the Proposed Action (Section 2.4) on the status of ESA protected populations in the Action Area under the environmental baseline (Section 2.3) and to cumulative effects (Section 2.5), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or (2) result in a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features. Impacts on individuals within the affected populations are analyzed to determine their effects on the VSP parameters for the affected populations, and these are combined with the overall status of the stratum/MPG to determine the effects on the ESA-listed species (ESU/DPS).

Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified

Based on the Integration and Synthesis analysis in Section 2.6 the opinion determines whether the Proposed Action is likely to jeopardize ESA protected species or destroy or adversely modify designated critical habitat in Section 2.7.

If necessary, suggest a reasonable and prudent alternative to the Proposed Action

If NMFS determines that the action under consultation is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, NMFS must identify an RPA or RPAs to the Proposed Action.

2.2. Range-wide Status of the Species and Critical Habitat

This opinion examines the status of each species (as defined below) that would be affected by the Proposed Action. The species and the designated critical habitat that are likely to be affected by the Proposed Action, and any existing protective regulations, are described in Table 2. 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. The species status section helps to inform the description of the species' current "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 and coastal and marine environments that make up the designated area, and discusses the current function of the essential physical and biological features that help to form that conservation value.

"Species" Definition: The ESA of 1973, as amended, 16 U.S.C. 1531 et seq. defines "species" to include any "distinct population segment (DPS) of any species of vertebrate fish or wildlife which interbreeds when mature."

To identify DPSs of salmon species, NMFS follows the "Policy on Applying the Definition of Species under the ESA to Pacific Salmon" (56 FR 58612). Under this policy, a group of Pacific salmon is considered a distinct population, and hence a "species" under the ESA if it represents an evolutionarily significant unit (ESU) of the biological species. The group must satisfy two criteria to be considered an ESU: (1) It must be substantially reproductively isolated from other conspecific population units; and (2) It must represent an important component in the evolutionary legacy of the species. For example, UCR Chinook salmon constitutes an ESU of the taxonomic species *O. tshawytscha* and therefore is considered a "species" under the ESA.

To identify DPSs of steelhead, NMFS applies the joint FWS-NMFS DPS policy (61 FR 4722). Under this policy, a DPS of steelhead must be discrete from other populations, and it must be significant to its taxon. For example, the UCR steelhead constitute a DPS of the taxonomic species *O. mykiss* and is considered a "species" under the ESA.

2.2.1. Status of Listed Species

A population is a group of individuals of a single species inhabiting a specific area. As described above, NMFS commonly uses spatial structure, diversity, abundance, and productivity as parameters to assess the viability of the populations that, together, constitute the species (McElhany et al. 2000). These VSP parameters therefore encompass the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. When these parameters are collectively at appropriate levels, they maintain a population's capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment. These attributes are influenced by survival, behavior, and experiences throughout a species' entire life cycle, and these characteristics, in turn, are influenced by habitat and other environmental conditions.

"Abundance" generally refers to the number of naturally-produced adults (i.e., the progeny of naturally-spawning parents) in the natural environment (e.g., on spawning grounds).

"Productivity," as applied to viability factors, refers to the number of individuals produced during a fish's entire life cycle; i.e., the number of naturally-spawning adults produced per their naturally spawning parental pair. When the number of progeny replaces or exceeds the number of parents, a population is stable or increasing. When the number of progeny fail to replace the number of parents, the population is declining. McElhany et al. (2000) use the terms "population growth rate" and "productivity" interchangeably when referring to reproduction over the entire life cycle. They also refer to "trend in abundance," which is the manifestation of long-term population growth rate.

"Spatial structure" refers both to the spatial distributions of individuals in the population and the processes that generate that distribution. A population's spatial structure depends fundamentally on quality and spatial configuration of habitat and the dynamics and dispersal characteristics of individuals in the population.

"Diversity" refers to the distribution of traits within and among populations. These range in scale from DNA sequence variation at single genes to complex life history traits (McElhany et al. 2000).

For species with multiple populations, once the biological status of a species' populations has been determined, NMFS assesses the status of the entire species using criteria for groups of populations, as described in recovery plans and guidance documents from technical recovery teams. Considerations for species viability include having multiple populations that are viable, ensuring that populations with unique life histories and phenotypes are viable, and that some viable populations are both widespread, to avoid concurrent extinctions from mass catastrophes, and spatially close, to allow functioning as metapopulations (McElhany et al. 2000).

One additional factor affecting the status of ESA-listed species considered in this opinion and aquatic habitat at large is climate change. Climate change affects salmon and their habitat throughout Washington State. This topic is discussed in more detail in Section 2.2.3, Climate Change.

The summaries that follow describe the status of the two ESA-listed species that occur within the action area considered in this opinion and their designated critical habitats. More detailed information on the status and trends of these listed resources, and their biology and ecology, are in the listing regulations and critical habitat designations published in the Federal Register (Table 2).

2.2.1.1. Life History and Status of UCR Chinook Salmon

Chinook salmon (*Oncorhynchus tshawytscha)* have a wide variety of life history patterns that include: variation in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution; ocean migratory patterns; and age and season of spawning migration. Two distinct races of Chinook salmon are generally recognized: "stream-type" and "ocean-type" (Healey 1991; Myers et al. 1998). ESA-listed UCR spring Chinook salmon are stream-type. Stream-type Chinook salmon spend 2 to 3 years in coastal ocean waters, and enter freshwater in February through April; adults return to the Wenatchee River during late March through early May and peak spawning occurs from August through September. Spring Chinook salmon also spawn and rear high in the Wenatchee watershed and reside in freshwater for a year before migrating downstream. Very little ocean harvest occurs for UCR spring Chinook salmon (NMFS 2008b).

Genetic differences exist between this ESU and others containing stream-type fish but the ESU boundary was defined using ecological differences in spawning and rearing habitat (Myers et al. 1998). The Grand Coulee Fish Maintenance Project (1939 through 1943) may have had a major influence on this ESU because fish from multiple populations were mixed into one relatively homogenous group and redistributed into streams throughout the UCR region (NMFS 2004a).

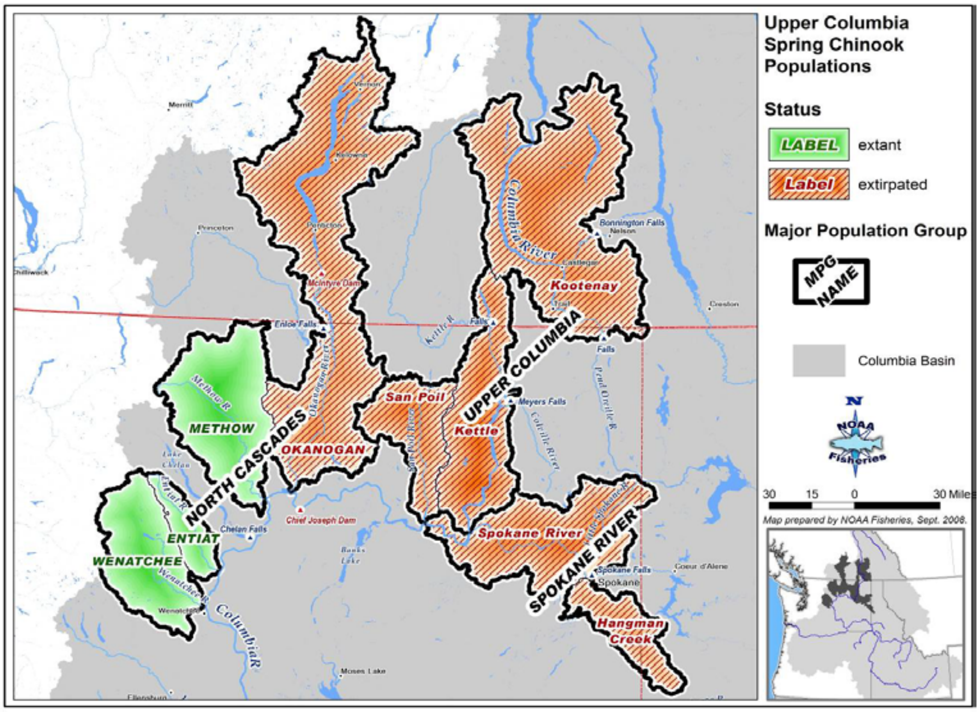


Figure 4. Upper Columbia River Spring-run Chinook Salmon ESU (ICTRT 2008).

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the UCR Spring-run Chinook Salmon ESU, is at high risk of extinction in a 100-year time period and remains at endangered status (Table 3) (NWFSC 2015). The UCR Spring-run Chinook Salmon ESU is not currently meeting the viability criteria (i.e., recovery criteria, adopted from the Interior Columbia Basin Technical Recovery Team (ICTRT)) in the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan (NWFSC 2015).

Returns of UCR spring Chinook salmon to the Columbia River mouth in the 1980s averaged around 20,300 adults (37% natural-origin). Returns declined severely during the 1990s averaging

9,500 adults (20% natural-origin). During the early 2000s, the annual returns improved, averaging 21,500 adults (e.g., 2,200 natural-origin fish; 10% natural-origin). ODFW and WDFW (2015) reported that the UCR natural-origin component was 133% of the recent 10-year average (2,300 fish) and represented 17% of the UCR spring Chinook salmon adult total run (hatchery and natural combined) in 2014.

For the period considered in the most recent Status Review (2005-2014), abundance has increased for all three populations, but productivity for all three populations remains below replacement (Table 3)(NWFSC 2015). Possible contributing factors include density-dependent effects, differences in spawning distribution relative to habitat quality, and reduced fitness of hatchery-origin spawners. For spatial structure and diversity, the proportion of natural-origin fish on the spawning grounds in the Wenatchee population declined by nearly half, and by nearly two-thirds for the Methow population; the Entiat population has fluctuated between 47 and 74 percent natural-origin spawners, with the most recent 5-year average being the highest proportion of natural-origin spawners. Natural-origin fish now make up fewer than fifty percent of the spawners in two of the three (Wenatchee and Methow) populations (Table 4).

Although increases in natural-origin abundance relative to the extremely low levels observed during the mid-1990s are encouraging, overall productivity has decreased to extremely low levels for the two largest populations (Wenatchee and Methow). The predominance of hatchery fish on the spawning grounds, particularly for the Wenatchee and Methow populations, is an increasing risk, and populations that rely on hatchery spawners are not viable (McElhany et al. 2000). Based on the combined ratings for abundance/productivity and spatial structure/diversity, all three extant populations and the ESU remain at high risk of extinction (Figure 5; Table 3).

Table 3. Risk levels and viability ratings for natural-origin UCR spring Chinook salmon populations from 2005-2014 (NWFSC 2015).

Population	**Abundance and Productivity (A/P)**				**Spatial Structure and Diversity (SS/D)**			**Overall Risk**
	Minimum Abundance Threshold	**Spawning Abundance**	**Productivity**	**A/P Risk**	**Natural Processes Risk**	**Diversity Risk**	**SS/D Risk**	
Wenatchee River	2000	545 (311-1030)	0.60	High	Low	High	High	High
Entiat River	500	166 (78-354)	0.94	High	Moderate	High	High	High
Methow River	2000	379 (189-929*)*	0.46	High	Low	High	High	High

The integrated spatial structure and diversity risk ratings for all three populations in this ESU are at “high” risk. The spatial processes component is “low” for the Wenatchee River and Methow River populations and “moderate” for the Entiat River (loss of production in the lower section increases effective distance to other populations) (see “Recovery Criteria for UCR Spring-run Chinook and UCR Steelhead”, below). All three of the populations in this ESU are at “high” risk for diversity, driven primarily by chronically high proportions of hatchery-origin spawners (up to 76%) in natural spawning areas and lack of genetic diversity among the natural-origin spawners

(NWFSC 2015).This effect is particularly high in the Wenatchee and Methow populations with hatchery-origin spawners composing 65% and 73%, respectively (NWFSC 2015). The high proportion of hatchery-origin spawners reflects the large increase in releases from the directed supplementation programs in those two drainages. While a high number of hatchery-origin releases occurred in the past, according to long-term Habitat Conservation Plans (HCPs) in the UCR Basin, hatchery production levels were adjusted (i.e., lowered) in 2013 and similar readjustment would occur every 10 years thereafter to minimize deleterious hatchery effects while still using hatchery programs to achieve desirable population abundance levels (see Section 2.3, Environmental Baseline). With regard to non-listed spring Chinook salmon, production from the LNFH spring Chinook hatchery program was reduced by 26% (1.625 to 1.2 million) in the Wenatchee Basin since 2008 (Section 2.3). With regard to ESA-listed spring Chinook salmon, in 2013, production from the Chiwawa spring Chinook salmon supplementation program was reduced by 52% (i.e., from 298,000 to 144,026) in the Wenatchee Basin. The Entiat NFH spring Chinook salmon program was terminated in 2007 because of potential effects on natural-origin spring Chinook salmon, and numbers of hatchery fish on the spawning grounds in the Entiat Basin are expected to decline. The Nason Creek program began production in the Wenatchee Basin for about 150,000 spring Chinook salmon smolt release (Grant County PUD et al. 2009); the White River spring Chinook salmon program (for 150,000 smolt release) was terminated in 2013 (Jones 2014).

Populations included in the UCR Spring-run Chinook Salmon ESU occurring in the action area are the Wenatchee River and Entiat River populations. Natural-origin spawners are what NMFS considers in population viability and ESU status determinations.

Table 4. Estimates of the percent natural-origin spawners for UCR spring Chinook salmon populations (NWFSC 2015).

Population	**% Natural-origin (5-year average)**			
	1995 to 1999	**2000 to 2004**	**2005 to 2009**	**2010-2014**
Wenatchee River	66	54	24	35
Entiat River	70	56	47	74
Methow River	61	16	24	27

The UCR recovery plan (UCSRB 2007) calls for improvement in each of the three extant spring Chinook salmon populations (no more than a 5% risk of extinction in 100 years) and for a level of spatial structure and diversity that restores the distribution of natural populations to previously occupied areas and allows natural patterns of genetic and phenotypic diversity to be expressed. This corresponds to a threshold of at least “viable” status for each of the three natural populations. Based on the combined ratings for abundance/productivity and spatial structure/diversity, all three extant populations and the ESU remain at high risk of extinction in the next 100 years (Figure 5).

Risk for Abundance/Productivity	Risk for Spatial Structure / Diversity: Very Low	Low	Moderate	High
Very Low (<1%)	Highly Viable	Highly Viable	Viable	Maintained
Low (1-5%)	Viable	Viable	Viable	Maintained
Moderate (6-25%)	Maintained	Maintained	Maintained	High
High (>25%)	High	High	High	High: Wenatchee Entiat Methow

Figure 5. Matrix used to assess population status across VSP parameters for UCR spring Chinook salmon. Percentages for abundance and productivity scores represent the probability of extinction in a 100-year time period (NWFSC 2015).

2.2.1.2. Life History and Status of UCR Steelhead

Steelhead (*O. mykiss*) occur as two basic anadromous run types based on the level of sexual maturity at the time of river entry and the duration of the spawning migration (Burgner et al. 1992). The stream-maturing type (inland), or summer steelhead, enters freshwater in a sexually immature condition and requires several months in freshwater to mature and spawn. The ocean-maturing type (coastal), or winter steelhead, enters freshwater with well-developed gonads and spawns shortly after river entry (Barnhart 1986).

UCR steelhead are summer steelhead, which return to freshwater between May and October, and require up to 1 year in freshwater to mature before spawning (Chapman et al. 1994). A portion of the returning run overwinters in the mainstem reservoirs, passing over the Upper Columbia River dams in April and May of the following year. Spawning occurs between January and June. In general, summer steelhead prefer smaller, higher-gradient streams relative to other Pacific salmon, and they spawn farther upstream than winter steelhead (Behnke and American Fisheries Society 1992; Withler 1966). Progeny typically reside in freshwater for two years before migrating to the ocean, but freshwater residence can vary from 1-7 years (Peven et al. 1994). For UCR steelhead, marine residence is typically one year, although the proportion of two-year ocean fish can be substantial in some years. They migrate directly offshore during their first summer rather than migrating nearer to the coast as do salmon. During fall and winter, juveniles move southward and eastward (Hartt and Dell 1986).

The UCR Steelhead DPS includes all naturally spawned steelhead populations below natural and man-made impassable barriers in streams in the Columbia River Basin upstream of the Yakima River, Washington to the U.S. – Canada border. The UCR Steelhead DPS also includes six artificial propagation programs: the Wenatchee River, Wells Hatchery (in the Methow and Okanogan Rivers), Winthrop NFH, Omak Creek, and the Ringold steelhead hatchery programs.

The UCR Steelhead DPS consisted of three MPGs before the construction of Grand Coulee Dam, but it is currently limited to one MPG with four extant populations: Wenatchee, Methow, Okanogan, and Entiat. A fifth population in the Crab Creek drainage is believed to be functionally extinct. What remains of the DPS includes all naturally spawned populations in all tributaries accessible to steelhead upstream from the Yakima River in Washington State, to the U.S. – Canada border (Figure 6). The proposed LNFH spring Chinook salmon hatchery program may affect the Wenatchee River and Entiat River steelhead populations through various ecological and genetic effects (Section 2.4.2) since LNFH-origin adults are encountered upstream in the Wenatchee River at Tumwater Dam and in the Entiat River (Cooper 2014; Ford 2011; Hall 2014; NMFS 2011a).

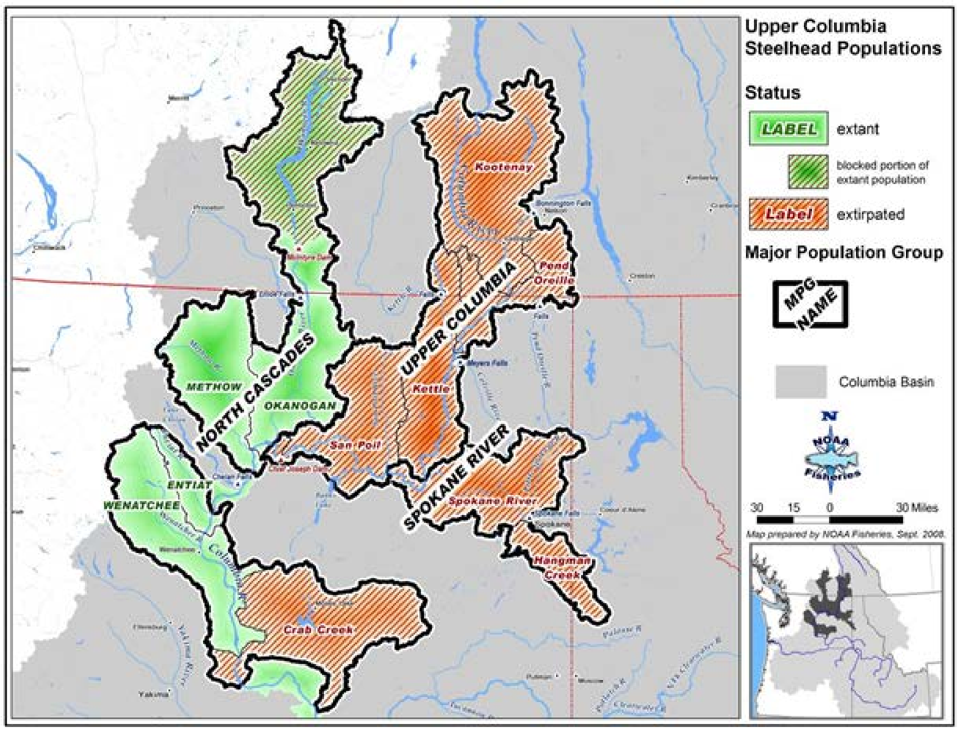


Figure 6. Upper Columbia River steelhead DPS (ICTRT 2008).

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the UCR Steelhead DPS is at high risk and remains at threatened status (Table 5)(NWFSC 2015).

For the period considered in the most recent Status Review (2005-2014), abundance has increased for natural-origin spawners in each of the four extant populations (Table 5). Annual returns (ESA-listed hatchery and natural-origin fish combined) have also increased relative to returns for the 5-year period reported in the 2005 BRT review (Good et al. 2005); however, natural-origin returns remain well below target levels for three of the four populations. Productivity remained the same for three of the four populations and decreased for the Entiat population relative to the last review (NWFSC 2015). For spatial structure and diversity, hatchery-origin returns continue to constitute a high fraction (Table 6) of total spawners in natural spawning areas for the DPS as a whole (NWFSC 2015). The predominance of hatchery fish on the spawning grounds is a continuing risk, and populations that rely solely on hatchery spawners are not viable over the long-term (McElhany et al. 2000).

Table 5. Risk levels and viability ratings for natural-origin UCR steelhead populations from 2005-2014 (NWFSC 2015).

Population	**Abundance and Productivity (A/P)**				**Spatial Structure and Diversity (SS/D)**			**Overall Risk**
	Minimum Abundance Threshold	**Spawning Abundance**	**Productivity**	**A/P Risk**	**Natural Processes Risk**	**Diversity Risk**	**SS/D Risk**	
Wenatchee River	1000	1025 (386-2235)	1.207	Low	Low	High	High	Maintained
Entiat River	500	146 (59-310)	0.434	High	Moderate	High	High	High
Methow River	1000	651 (365-1105)	0.371	High	Low	High	High	High
Okanogan River	750	189 (107-310)	0.154	High	High	High	High	High

The integrated spatial structure and diversity risk ratings for three populations of UCR steelhead are at “high” risk (Table 5), except for the Wenatchee population, which remains at “maintained” (see “Recovery Criteria for UCR Spring-run Chinook and UCR Steelhead”, below, for definition of terms). These ratings are largely driven by chronic high levels of hatchery spawners (42% to 87%) within natural spawning areas and lack of genetic diversity among the populations (NWFSC 2015)(Table 6). The relative effectiveness of hatchery-origin spawners and the long-term impact on productivity of high levels of hatchery contribution to natural spawning are key uncertainties for these populations. The modest improvements in natural-origin returns in recent years are primarily the result of several years of relatively good survival in the ocean and tributary habitats. For the Wenatchee steelhead population, there is an increase in the proportion of natural-origin fish on the spawning grounds from 1991 to 2014, and natural-origin fish now make up over fifty percent of the spawners in this basin (Table 6). Based on the combined ratings for abundance/productivity and spatial structure/diversity, three of the four extant populations and the DPS remain at high risk of extinction. Hatchery-origin steelhead included in the action area are the Wenatchee River and Entiat River populations.

Table 6. Estimates of the percent natural-origin spawners for UCR steelhead populations (NWFSC 2015).

Population	% Natural-origin (5-year average)			
	1995 to 1999	2000 to 2004	2005 to 2009	2010-2014
Wenatchee River	41	34	38	58
Entiat River	21	24	24	31
Methow River	14	11	15	24
Okanogan River	5	6	9	13

The ESA Recovery Plan (UCSRB 2007) for UCR steelhead calls for each of the four extant steelhead populations to reach viability (no more than a 5 percent risk of extinction in 100 years) and for a level of spatial structure and diversity that restores the distribution of natural populations to previously occupied areas and allows natural patterns of genetic and phenotypic diversity to be expressed. Three of the four natural populations are currently at “high risk” of extinction within 100 years, and the Wenatchee River population is at “maintained risk” of extinction within 100 years (Figure 7).

Although increases in steelhead total abundance (natural and hatchery fish; Table 5) relative to the extremely low levels observed during the mid-1990s are encouraging, overall productivity has decreased to extremely low levels for the natural-origin steelhead population; however, the recent increase of productivity of the Wenatchee population to greater than 1 is encouraging. The predominance of hatchery fish on the spawning grounds, particularly for the Methow and Okanogan River populations, is a continuing risk. Based on the combined ratings for abundance/productivity and spatial structure/diversity, three extant populations (not including the Wenatchee population), have a high risk of extinction in the next 100 years (Figure 7).

Risk for Abundance / Productivity	Risk for Spatial Structure / Diversity: Very Low	Low	Moderate	High
Very Low (<1%)	Highly Viable	Highly Viable	Viable	Maintained
Low (1-5%)	Viable	Viable	Viable	Maintained: Wenatchee
Moderate (6-25%)	Maintained	Maintained	Maintained	High
High (>25%)	High	High	High	High: Entiat Methow Okanogan

Figure 7. Matrix used to assess population status across VSP parameters for UCR steelhead. Percentages for abundance and productivity scores represent the probability of extinction in a 100-year time period (NWFSC 2015) (ICTRT 2007b).

Limiting factors for both species

Both the UCR spring-run Chinook salmon and steelhead populations continue to experience many problems that limit their abundance, productivity, spatial structure, and diversity. The primary factors limiting these species' persistence include (Ford 2011; UCSRB 2007):

(1) Degradation and loss of estuarine areas that help the fish survive the transition between fresh and marine waters;

(2) Altered flood plain connectivity and function;

(3) Spawning and rearing areas that have riparian degradation and altered channel structure and complexity[25];

(4) Reduced stream flow;

(5) Predation by native and non-native species;

(6) Harvest; and

(7) Interbreeding and competition between hatchery fish and fish from natural populations.

Recovery Criteria for UCR Spring-run Chinook and UCR Steelhead

The ICTRT (2007) developed specific biological viability criteria based on the VSP concept (McElhany et al. 2000) at the natural population, MPG, and at the ESU/DPS scales. At the population scale, the ICTRT recommended specific biological criteria based on the four viability components of VSP: abundance, productivity, spatial structure, and diversity (Table 3 and Table 5). These criteria are integrated to develop a total population viability rating and de-listing

[25] This includes deep pools, cover, large wood recruitment, side-channel refuge areas, and high-quality spawning gravels.

criteria (Table 7 and Table 9). The population viability ratings, in order of descending risk, are highly viable, viable, maintained, and high risk (Figure 5 and Figure 7).

In 2007, NMFS adopted a recovery plan for UCR spring-run Chinook salmon and UCR steelhead developed by the Upper Columbia Salmon Recovery Board (UCSRB 2007). The Upper Columbia Salmon Recovery Plan's overall goal is "to achieve recovery and delisting of spring Chinook salmon and steelhead by ensuring the long-term persistence and viable populations of naturally produced fish distributed across their native range." This plan incorporated the ICTRT viability goals as biological delisting criteria (UCSRB 2007). The recovery strategies outlined in the recovery plan are targeted to achieve, at a minimum, the biological criteria for each ESU/DPS.

The UCR Spring-run Chinook Salmon Biological Recovery Criteria (Table 7):

- Criterion 1: The 12-year geometric mean for abundance and productivity of naturally produced spring-run Chinook salmon within the Wenatchee, Entiat, and Methow populations must reach a level that would have no more than a 5 percent extinction-risk (viability) over a 100-year period.

- Criterion 2: At a minimum, the UCR Spring-run Chinook Salmon ESU will maintain at least 4,500 naturally produced spawners and a spawner-to-spawner ratio greater than 1.0 distributed among the three populations[26].

- Criterion 3: Over a 12-year period, naturally produced spring Chinook salmon will use currently occupied major spawning areas (minor spawning areas are addressed primarily under Criteria 4 and 5) throughout the ESU according to population-specific criteria outlined in the Recovery Plan[27].

- Criterion 4: The mean score for the three metrics of natural rates and levels of spatially mediated processes (Goal A) will result in a moderate or lower risk assessment for naturally produced spring Chinook salmon within the Wenatchee, Entiat, and Methow natural populations and all threats for "high" risk have been addressed.

- Criterion 5: The score for the eight metrics of natural levels of variation (Goal B) will result in a moderate or lower risk assessment for naturally produced spring Chinook salmon within the Wenatchee, Entiat, and Methow natural populations and all threats for "high" risk have been addressed.

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[26] For the UCR Wenatchee spring Chinook salmon population, it is a minimum 12-year geometric mean of 2,000 spawners with a minimum 1.2 spawner to spawner ratio (the minimum growth rates associated with the minimum number of spawners of a viable population) (UCSRB. 2007. Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan. 352p.).

[27] For the UCR Wenatchee spring Chinook salmon population, the use of spawning areas is measured by at least 4 of the 5 major spawning areas having either 5 percent of the total redds in the Wenatchee River Basin or 20 redds within each major spawning area, whichever is greater (ibid.).

Table 7. UCR spring-run Chinook salmon criterion 1 and 2 recovery criteria (UCSRB 2007).

Population	Minimum 12-year geometric mean for spawners	Minimum 12-year geometric mean spawner to spawner ratio
Wenatchee	2,000	1.2
Entiat	500	1.4
Methow	2,000	1.2
Total for ESU	**4,500**	**>1.0**

Table 8. Actions called for in the UCR recovery plan (UCSRB 2007) for the LNFH spring Chinook salmon program.

Action	Status
Short-term actions	
Continue to release spring Chinook into Icicle Creek to provide treaty and non-treaty harvest opportunities	On-going
Reduce the amount of in-basin straying from current hatchery program; reduce or eliminate presence of out-of-basin stock (Carson spring Chinook) on spawning grounds; and employ mechanisms to manage hatchery returns on spawning grounds in balance with naturally produced fish, e.g., tribal and sport fisheries, removal at Tumwater Dam, and other methods may be used to remove hatchery fish in excess of management objectives	On-going
Provide fish passage at Dam 5 on Icicle Creek	Completed
Change to local spring Chinook stock since there is suitable spawning and rearing habitat upstream of the hatchery	Not under consideration at this time
Size hatchery programs appropriately for available habitat given survival trends	On-going
Long-term actions	
Release spring Chinook into Icicle Creek to provide for treaty and non-treaty harvest opportunities	On-going
Modify hatchery programs to minimize adverse impacts of hatchery fish on naturally produced fish while maintaining production levels identified in various agreements	On-going

For UCR steelhead, at the population scale, the ICTRT recommended specific biological criteria based on the four viability components of VSP: abundance, productivity, spatial structure, and diversity (Table 5). The population viability ratings, in order of descending risk, are highly viable, viable, maintained, and high risk (Figure 7).

These criteria are integrated to develop a total population viability rating and delisting criteria (Table 9).

The UCR Steelhead Biological Recovery Criteria (Table 9):

- Criterion 1: The 12-year geometric mean for abundance and productivity of naturally produced steelhead within the Wenatchee, Entiat, Methow, and Okanogan natural populations must reach a level that would have no more than a 5 percent extinction-risk (viability) over a 100-year period.

- Criterion 2: At a minimum, the UCR steelhead DPS will maintain at least 3,000 spawners and a spawner-to-spawner ratio greater than 1.0 distributed among the four populations[28].

- Criterion 3: Over a 12-year period, naturally produced steelhead will use currently occupied major spawning areas (minor spawning areas are addressed primarily under Criteria 4 and 5) throughout the DPS according to natural population-specific criteria outlined in the Recovery Plan[29].

- Criterion 4: The mean score for the three metrics of natural rates and levels of spatially mediated processes (Goal A) will result in a moderate or lower risk assessment for naturally produced steelhead within the Wenatchee, Entiat, Methow, and Okanogan populations and all threats for "high" risk have been addressed.

- Criterion 5: The score for the eight metrics of natural levels of variation (Goal B) will result in a moderate or lower risk assessment for naturally produced steelhead within the Wenatchee, Entiat, Methow, and Okanogan populations and all threats for "high" risk have been addressed.

Table 9. UCR steelhead criterion 1 and 2 recovery criteria (UCSRB 2007).

Population	**Minimum 12-year geometric mean for spawners**	**Minimum 12-year geometric mean spawner to spawner ratio**
Wenatchee	1,000	1.1
Entiat	500	1.2
Methow	1,000	1.1
Okanogan	500	1.2
Total for DPS	**3,000**	**>1.0**

Although the abundance of both spring-run Chinook salmon and steelhead in the UCR has increased, the populations do not yet meet the recovery criteria in the recovery plan. In addition, all populations for both species, except for the Wenatchee River steelhead population, remain at high risk in their overall viability ratings.

[28] For the UCR Wenatchee steelhead population, the minimum 12-year geometric mean would be 1,000 spawners with a 1.1 spawner to spawner ratio (the minimum number of spawners of a viable population) (ibid.).

[29] For the UCR Wenatchee steelhead population, the use of spawning areas is measured by having the greater of at least 5 percent of the total redds in the Wenatchee River Basin or 20 redds within each of at least 4 of the 5 major spawning areas (ibid.).

2.2.2. Status of Critical Habitat

In this section, we examine the range-wide status of designated critical habitat affected by the proposed action by examining the condition and trends of essential physical and biological features throughout the designated areas. For UCR spring Chinook salmon and UCR steelhead, critical habitat was designated in 70 FR 52630 (September 2, 2005).

Both species have overlapping ranges, similar life history characteristics, and designated critical habitat. Except for reaches in the uppermost areas of their geographical range and the Wenatchee River Basin, most areas of critical habitat for these species are coextensive. Each species has a number of watersheds identified as comprising its designated critical habitat. The status of critical habitat is based primarily on a watershed-level analysis of conservation values that focused on the presence of ESA-listed species and physical features that are essential to their conservation (NMFS 2005a).

The NMFS organized information at the 5th field hydrologic unit code (HUC) watershed scale because it corresponds to the spatial distribution and site fidelity scales of salmon and steelhead populations (McElhany et al. 2000). The analysis for the 2005 designations of salmon and steelhead species was completed by Critical Habitat Analytical Review Teams (CHARTs) that focused on large geographical areas corresponding approximately to recovery domains (NMFS 2005c). Each watershed was ranked using a conservation value attributed to the quantity of stream habitat with “primary constituent elements” (PCE)[30], the present condition of those PCEs, the likelihood of achieving PCE potential (either naturally or through active restoration), support for rare or important genetic or life history characteristics, support for abundant populations, and support for spawning and rearing populations. In some cases, our understanding of these interim conservation values has been further refined by the work of technical recovery teams and other recovery planning efforts that have better explained the habitat attributes, ecological interactions, and population characteristics important to each species.

NMFS reviews the status of designated critical habitat affected by the Proposed Action by examining the condition and trends of PCEs throughout the designated area. These PCEs vary slightly for some species, due to biological and administrative reasons, but all consist of site types and site attributes associated with life history events (Table 10).

[30] As previously discussed, we use the term PCE to mean PBF or essential feature, as appropriate for the specific critical habitat in this biological opinion.

Table 10. PCEs of critical habitat designated for ESA-listed salmon and steelhead considered in this opinion.

Primary Constituent Elements		Species Life History Event
Site Type	Site Attribute	
Freshwater spawning	Substrate Water quality Water quantity	Adult spawning Embryo incubation Alevin growth and development
Freshwater rearing	Floodplain connectivity Forage Natural cover Water quality Water quantity	Fry emergence from gravel Fry/parr/smolt growth and development
Freshwater migration	Free of artificial obstruction Natural cover Water quality Water quantity	Adult sexual maturation Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration
Estuarine areas	Forage Free of artificial obstruction Natural cover Salinity Water quality Water quantity	Adult sexual maturation and “reverse smoltification” Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration
Nearshore marine areas	Forage Free of artificial obstruction Natural cover Water quantity Water quality	Adult growth and sexual maturation Adult spawning migration Nearshore juvenile rearing
Offshore marine areas	Forage Water quality	Adult growth and sexual maturation Adult spawning migration Subadult rearing

The physical or biological features of freshwater spawning and incubation sites include water flow, quality and temperature conditions and suitable substrate for spawning and incubation, as well as migratory access for adults and juveniles (Table 10). These features are essential to conservation because without them the species cannot successfully spawn and produce offspring. The physical or biological features of freshwater migration corridors associated with spawning and incubation sites include water flow, quality and temperature conditions supporting larval and adult mobility, abundant prey items supporting larval feeding after yolk sac depletion, and free passage (no obstructions) for adults and juveniles. These features are essential to conservation because they allow adult fish to swim upstream to reach spawning areas and they allow larval fish to proceed downstream and reach the ocean or to migrate upstream to access suitable rearing habitats.

Interior Columbia Recovery Domain

Habitat quality in tributary streams in the Interior Columbia Recovery Domain, including the UCR, range from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (NMFS 2009b; Wissmar et al. 1994). Critical habitat throughout much of the Interior Columbia Recovery Domain has been degraded by intense 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 developed areas.

Currently, many stream reaches designated as critical habitat in the Interior Columbia Recovery Domain, including many stream reaches in the UCR basin, are over-allocated, with more allocated water rights than existing stream-flow conditions can support. 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 stream flow has been identified as a major limiting factor for all listed salmon and steelhead species in this area (NMFS 2011b)

Despite these degraded habitat conditions, the HUCs that have been identified as critical habitat for these species are largely ranked as having high conservation value (NMFS 2005d). Conservation value reflects several factors: (1) how important the area is for various life history stages, (2) how necessary the area is to access other vital areas of habitat, and (3) the relative importance of the populations the area supports relative to the overall viability of the ESU or DPS.

2.2.2.1. Critical Habitat for Upper Columbia River Spring Chinook Salmon

UCR spring Chinook salmon critical habitat includes river reaches proceeding upstream to Chief Joseph Dam, as well as specific stream reaches in the following subbasins: Moses Coulee, Upper Columbia/Priest Rapids, Chief Joseph, Methow, Upper Columbia/Entiat, and Wenatchee (NMFS 2005a or b, Appendix D).

The CHART assessment for this ESU addressed four subbasins containing 15 occupied watersheds, as well as the Columbia River rearing/migration corridor (NMFS 2005d; Appendix D). The Interior Columbia Basin Technical Recovery Team did not identify separate major groupings/strata for this ESU due to the relatively small size of the area. NMFS ranked watersheds within designated critical habitat at the scale of the fifth-field HUC (i.e., HUC 5) in terms of the conservation value they provide to each listed species they support; the conservation rankings are high, medium or low. Thus, the CHART considered the conservation value of each HUC 5 in the context of a single population group.

For the Wenatchee Subbasin (HUC4#17020011), all five watersheds identified were occupied by spring Chinook salmon and considered to be of high or medium conservation value to the ESU. The Upper Wenatchee River, Chiwawa River, and Nason/Tumwater watersheds received a high conservation value rating (NMFS 2005a, Appendix D). The Icicle/Chumstick and Lower Wenatchee[31] watersheds received a medium conservation value rating (NMFS 2005b, Appendix D).

[31] The lower Wenatchee River contains 39.9 miles of designated critical habitat PCEs for UCR spring Chinook salmon in the action area.

With the exception of the area bordered by the mainstem Wenatchee River, tributaries such as Icicle Creek in the lower Wenatchee River were excluded from the critical habitat listing (NMFS 2005a). Although some spawning occurs in the lower Icicle Creek mainstem and in the Icicle Creek historical channel, the recovery plan identified this as a minor spawning area with medium intrinsic potential for UCR spring Chinook salmon (UCSRB 2007; Figure 8).

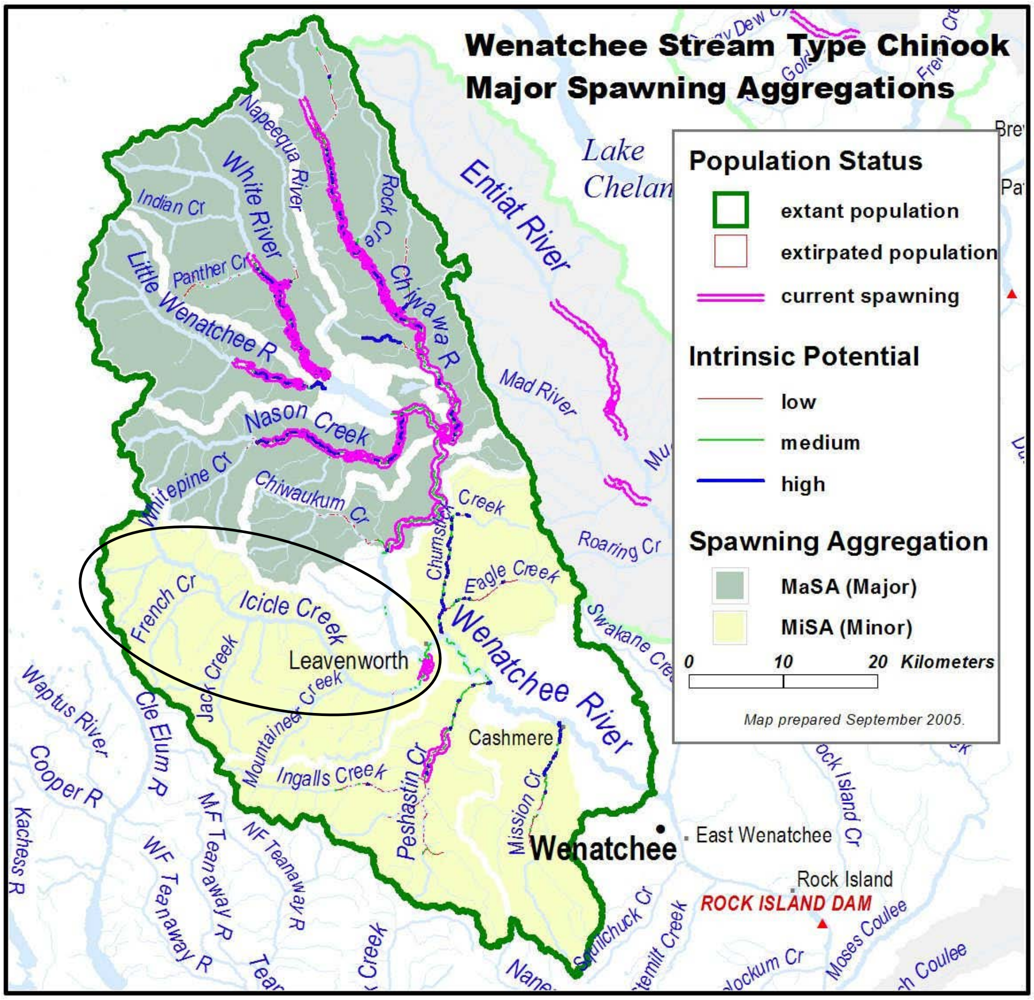

Figure 8. Distribution of major and minor spawning areas for spring Chinook salmon in the Wenatchee Basin (UCSRB 2007).

While Icicle Creek was occupied and contained PCEs[32] supporting UCR spring Chinook salmon, Icicle Creek/Chumstick HUC 5 (#1702001104) was excluded from being listed as part of the UCR spring Chinook salmon critical habitat because NMFS applied the "Tributaries only" exclusion and determined that the economic benefits of exclusion outweighed the benefits of

[32] Icicle Creek contains 39.9 miles of critical habitat PCEs for UCR spring Chinook salmon, of which 5.7 miles are in the action area but were excluded from the critical habitat designation due to economic reasons NMFS. 2005a. Endangered and Threatened Species: Designation of Critical Habitat for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead in Washington, Oregon, and Idaho. Pages 52630-52858 *in*. Federal Register, Volume 70 No. 170.

designation (70 FR 52676, August 12, 2005)(NMFS 2005d). ESA-listed Wenatchee spring Chinook adult salmon (natural-origin and hatchery-origin) may be present in Icicle Creek from May until September. The majority of spawners are likely hatchery-derived (e.g., Carson stock) (ICTRT 2007). CPUD and WDFW have conducted spawning surveys for spring Chinook salmon in Icicle Creek since 1989. From 1989 to 2013, the average number of spring Chinook salmon redds is 62 (range 6 – 245) (Hillman et al. 2014). In 2013, Icicle Creek contained 9.2% of all the spring Chinook salmon redds in the Wenatchee Basin (107 redds) (Hillman et al. 2014). The redd counts were 211 in 2014, 132 in 2015 (Hillman et al. 2016), and 72 in 2016 (Kondo 2017o). Between 2006 and 2013, an average of 18 (range 0 to 34) spring Chinook salmon redds have also been reported in Icicle Creek above LNFH (Hall 2014). However, the majority of natural-origin spring Chinook salmon spawning habitat of high intrinsic potential occurs in the Upper Wenatchee Basin above Tumwater Dam. The Icicle Creek historical channel contains approximately 6% of the weighted total intrinsic potential in the Icicle Basin and 25% of the intrinsic potential total weighted area downstream of the boulder field (Bambrick 2015) where access to spring Chinook salmon spawning sites is more likely to occur. Maintaining Icicle Creek upstream passage and rearing habitat for ESA-listed adult and juvenile spring Chinook salmon through the LNFH instream structures and above the primary intake could concomitantly increase abundance, productivity, and spatial structure, and, thus, help to some degree the recovery of the Wenatchee spring Chinook salmon population and the UCR Spring-run Chinook Salmon ESU as a whole.

2.2.2.2. Critical Habitat for Upper Columbia River Steelhead

UCR steelhead critical habitat includes river reaches proceeding upstream to Chief Joseph Dam, as well as specific stream reaches in the following subbasins: Columbia River/Lynch Coulee, Chief Joseph, Okanogan, Salmon, Methow, Similkameen, Chewuch, Twisp, Entiat, Wenatchee, Chiwawa, Nason, and Icicle.

The CHART assessment for this ESU addressed four subbasins containing 15 occupied watersheds, as well as the Columbia River rearing/migration corridor (NMFS 2005b, Appendix H). The Interior Columbia Basin Technical Recovery Team (ICTRT 2003; McClure et al. 2005) did not identify separate major groupings/strata for this ESU due to the relatively small size of the area. NMFS ranked watersheds within designated critical habitat at the scale of the fifth-field HUC (i.e., HUC 5) in terms of the conservation value they provide to each listed species they support; the conservation rankings are high, medium or low. Thus, the CHART considered the conservation value of each HUC5 in the context of a single population group. For the Wenatchee Subbasin (HUC4#17020011), all five watersheds identified were occupied by steelhead and considered to be of high or medium conservation value to the DPS. The Upper Wenatchee River, Chiwawa River, and Nason/Tumwater watersheds received a high conservation value rating (NMFS 2005a, Appendix H). The Icicle/Chumstick[33] and Lower Wenatchee[34] received a medium conservation value rating (NMFS 2005b, Appendix H); it was unclear whether access to areas above the Icicle Creek boulder field was naturally limited. Subsequent to culvert

[33] Icicle Creek/Chumstick contains 45 miles of designated critical habitat PCEs for UCR steelhead. Icicle Creek contains 31.8 miles of critical habitat, of which 5.7 miles are in the action area.

[34] The lower Wenatchee River contains 55.5 miles of designated critical habitat PCEs for UCR steelhead in the action area.

replacements, the Chumstick Creek is experiencing a resurgence of steelhead with increased spawning (Bambrick 2015). Spawning ground survey data has demonstrated that the lower Wenatchee River, and Peshastin and Icicle Creeks, which includes Mission Creek, support many naturally spawning steelhead (Hillman et al. 2014).

Critical habitat for steelhead in Icicle Creek (e.g., Icicle/Chumstick watershed) was designated for the entire watershed; no other areas (i.e., tributaries) in Icicle Creek were excluded from the critical habitat listing (NMFS 2005a). Icicle Creek supports a major spawning aggregation for UCR steelhead (Figure 9). The lower Icicle Creek mainstem was identified as containing habitat of medium intrinsic potential for steelhead (i.e., the mouth up to the Icicle Creek historical channel). The upper mainstem and tributaries above LNFH (i.e., from Structure 2 at RM 2.8 to the boulder field at RM 5.7 in the action area) are identified as containing habitat with high intrinsic potential that supports PCEs necessary for the conservation of steelhead. Icicle Creek contains spawning, rearing, and migration PCEs where Icicle Creek is expected to support increased natural spawning since access to the area was recently restored and as the area restores itself following decades of limited instream flows.

The USFWS Columbia River Basin Hatchery Review Team acknowledged that ESA-listed steelhead inhabit all major tributaries of the Wenatchee River. Surveyed spawning areas in order of importance were the Wenatchee River between the Chiwawa River and Lake Wenatchee, Nason Creek, Chiwawa River, and Icicle Creek (USFWS 2007). Icicle Creek contains important habitat for ESA-listed UCR steelhead. In 2013, Icicle Creek contained 10.2% of all the steelhead redds in the Wenatchee River basin (Hillman et al. 2014). No estimates of steelhead redds for 2014 in Icicle Creek are available. In 2015, 78 redds were predicted to be in Icicle Creek (Kondo 2017o), compared to 262 redds surveyed elsewhere in the Wenatchee River basin (Hillman et al. 2016); the 2013 and 2015 redd estimates, however, cannot be compared to each other because the methods of estimation are different. In 2013, less than 1% of the total redds in the Wenatchee River basin were located in the Icicle Creek historical channel (Hillman et al. 2014). These data support a finding that almost all of steelhead spawning in Icicle Creek occurs below RM 2.8. This is not completely surprising as during much of the period of record, habitat conditions due to operation of the LNFH Structures 2 and 5 were not conducive to steelhead passage.

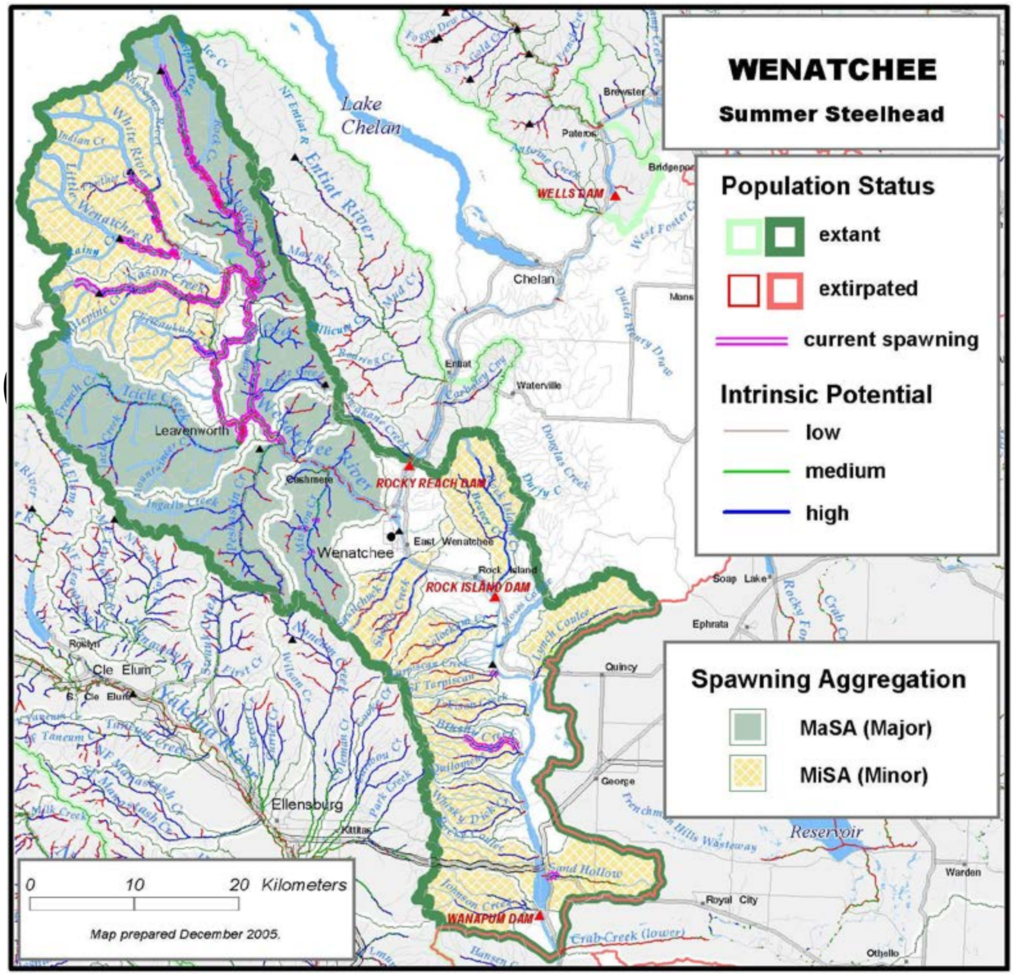

Figure 9. Distribution of major and minor spawning areas of steelhead in the Wenatchee Basin (UCSRB 2007).

The primary purpose for functional upstream fish passage for anadromous fish in Icicle Creek is to allow access to spawning and rearing habitat (Anglin et al. 2013). Spring Chinook salmon and steelhead have migrated 500 miles upstream from the ocean to arrive at the Icicle Creek drainage (Anglin et al. 2013). These salmonid species stop feeding when they enter fresh water, and their energy reserves need to be sufficient to reach the spawning grounds if successful reproduction is expected (Anglin et al. 2013). Spring Chinook salmon and steelhead swimming ability decreases as distance-traveled increases (Tillinger and Stein 1996), reducing the fitness of returning adults. Anglin et al. (2013) reported, “the deteriorating condition of anadromous fish as they move upstream from the ocean towards their spawning tributary, may be the most important reason to optimize passage conditions” in Icicle Creek. Passage and stream flow conditions are also important for rearing juvenile steelhead in Icicle Creek. This life stage generally requires shallower depths and slower velocities than adult salmonids. Steelhead juveniles are present in Icicle Creek for the entire year, thus experiencing the full range of flow conditions (Anglin et al. 2013).

Dominguez et al. (2013) reported that the Icicle Creek boulder field provides some indication that the area contains natural elements that contribute to impeding fish passage. The complexity of the Icicle Creek boulder field could provide for multiple fish passage routes with some areas exhibiting higher velocities and constricted flow and other areas with lower velocities (Dominguez et al. 2013). All Lower, Middle, and Upper Reaches of Icicle Creek studied were found to be passable at various instream flows, with the exception of the Anchor Boulder Area (RM 5.6) in the Middle Reach that exhibited higher velocities and constricted flow that would make steelhead passage difficult or impassable (Dominguez et al. 2013). It is not known presently if steelhead are able to ascend the boulder field at RM 5.6, but recent genetic analysis of *O. mykiss* in Icicle Creek (Winans et al. 2014) suggests a connection between the resident rainbow trout and steelhead populations; fish above the boulder field and the Wenatchee River steelhead population shared a few similar genetic alleles. The observed relationship could be a result of, but not limited to, the following: (1) the two populations shared a common ancestry prior to isolation; (2) the resident population may be generating anadromous adults at some level that interbreed with steelhead; (3) resident adults may be moving downstream and interbreeding with steelhead; or (4) anadromous steelhead may be successfully ascending the falls and spawning with resident fish. The Upper Columbia Regional Technical Team (RTT) has designated boulder field passage assessment and fish passage improvement in Icicle Creek as priorities (RTT 2013).

2.2.3. Climate Change

Climate change has negative implications for designated critical habitats in the Pacific Northwest (ISAB 2007; Scheuerell and Williams 2005; Zabel et al. 2006). During the last century, average regional air temperatures increased by 1.5°F, and increased up to 4°F in some areas. As the climate changes, air temperatures in the Pacific Northwest are expected to increase <1°C in the Columbia Basin by the 2020s and 2°C to 8°C by the 2080s (Mantua et al. 2010). Overall, about one-third of the current cold-water fish habitat in the Pacific Northwest is likely to exceed key water temperature thresholds by the end of this century (USGCRP 2009). While total precipitation changes are uncertain, increasing air temperature will result in more precipitation falling as rain rather than snow in watersheds across the basin (NMFS 2015b). Effects are likely to include:

- Warmer air temperatures will result in diminished snowpacks and a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.
- With a smaller snowpack, seasonal hydrology in Pacific Northwest watersheds will shift to more frequent and severe early large storms, changing stream flow timing, which may limit salmon survival (Mantua et al. 2009).
- Water temperatures are expected to rise, especially during the summer months when lower streamflows co-occur with warmer air temperatures.

These changes will not be spatially homogeneous across the entire Pacific Northwest. Our analysis under the ESA includes consideration of ongoing and projected changes in climate. The term “climate” refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2014). The term “climate change” refers to a change in the mean or variability of one or more measures of climate (e.g., temperature, precipitation, snowpack, etc.) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2014). Climate change modeling spanning several decades demonstrates that changes in climate are occurring, and the rate of change since the 1950s is unprecedented (IPCC 2014). Analyses presented by the Intergovernmental Panel on Climate Change (IPCC) indicate that most of the observed increase in global average temperatures since the mid-20th century cannot be explained by natural variability in climate, and it is extremely likely[35] warming is due to the observed greenhouse gas (GHG) concentrations in the atmosphere caused by human activities, particularly carbon dioxide emissions from the use of fossil fuels (IPCC 2014). Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions (e.g., Ganguly et al. 2000; Van Vuren et al. 2001; Meehl et al. 2007; Prinn et al. 2011).

Though there are differences in vulnerability to climate effects among species (e.g., sensitivity is determined by a combination of such factors as the duration and timing of freshwater vs. marine residency, and thermal tolerance), the types of exposure factors that are relevant are similar across species; they all need cool freshwater (ample but not excessive amounts) and a productive marine environment. For the purpose of the present analysis, important effects include direct effects of temperature such as mortality from heat stress, changes in growth and development rates, and disease resistance. Changes in the flow regime (especially flooding and low flow events) also affect survival and behavior by, for example, impeding adult and juvenile migration, or drying out or scouring redds. Expected behavioral responses include shifts in seasonal timing of important life history events, such as the adult migration, spawn timing, fry emergence timing, and the juvenile migration. UCR spring Chinook salmon are expected to have a high vulnerability to climate change because both the adult and juvenile fish in freshwater would be highly vulnerable to increases in stream temperature and very highly vulnerable to a change in precipitation from snow-dominated to rain-dominated system (Crozier 2017); UCR steelhead is also expected to have a high vulnerability to climate change, though the vulnerability is likely to be less than that of UCR spring Chinook salmon because only the adults in freshwater are moderately sensitive to high stream temperature (Crozier 2017). This finding for UCR steelhead is also consistent with Wade et al. (2017), who found that climate exposure is not as big of a vulnerability for UCR steelhead as vulnerability stemming from habitat and demographics.

There are various difficulties in predicting future climate, and climate change modeling predictions should be viewed with caution. Cowtan et al. (2015) explained that the vast majority of comparisons between climate model projections and observations of the earth's surface temperature are not precisely "apples-to-apples" for two reasons: (1) observed temperature compilations include regions of missing data (i.e., incomplete geographic data coverage) while climate models include the entire surface, and (2) observed compilations combine air temperature measurements over the land with sea surface temperatures into a global average, while climate model compilations use air temperatures over both land and oceans. The combination of these factors is shown to lead to a slight warming bias in the models when compared to actual observations that can be exaggerated over time.

[35] "Extremely likely" is defined by the IPCC as 95% or higher probability.

Approximately one year after completion of the 2015 Opinion, NMFS released its Guidance for Treatment of Climate Change in NMFS Endangered Species Act Decisions (Weiting 2016), which recommended use of the most current reports from the Intergovernmental Panel on Climate Change (IPCC) in evaluating effects of climate change in section 7(a)(2) biological opinions under the ESA. This guidance states that "NMFS will use climate indicator values projected under the Intergovernmental Panel on Climate Change (IPCC)'s Representative Concentration Pathway 8.5 when data are available. When data specific to that pathway are not available, we will use the best available science that is as consistent as possible with RCP 8.5" (Weiting 2016). Global climate projections provided in the most recent IPCC reports (IPCC 2014)(IPCC 2013) are informative and, in some cases, the only or the best scientific information available for use. Overall, these climate and hydrology models project a decrease in cold temperature extremes, an increase in warm temperature extremes, an increase in extreme high sea levels and an increase in the number of heavy precipitation events in a number of regions, including substantial reductions in both total snow pack and low-elevation snow pack in the Pacific Northwest over the next 50 years (IPCC 2014; Mote and Eric P. Salathé Jr. 2010)(Mote and Salathé 2009; IPCC 2013). The result of such changes is that the extent of the snowmelt-dominated habitat available to salmon and steelhead is expected to decline. Effects of the proposed action on UCR spring Chinook salmon and steelhead, taking into account current and projected future climate change, are described in Section 2.4.2.8.

2.3. Environmental Baseline

In the Environmental Baseline section, NMFS describes what is affecting ESA-listed species and designated critical habitat in the action area before including any effects resulting from 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 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02).

Wide varieties of human activities have affected UCR spring Chinook salmon, steelhead, and PCEs in the action area. These activities, more recently, include reclamation actions that are having beneficial effects.

In order to understand what is affecting a species, it is first necessary to understand the biological requirements of the species. Each stage in a species’ life history has its own biological requirements (Groot and Margolis 1991; NRC 1996; Spence et al. 1996). Generally speaking, anadromous fish require clean water with cool temperatures and access to thermal refugia, dissolved oxygen near 100 percent saturation, low turbidity, adequate flows and depths to allow passage over barriers to reach spawning sites, and sufficient holding and resting sites. Anadromous fish select spawning areas based on species-specific requirements of flow, water quality, substrate size, and groundwater upwelling. Embryo survival and fry emergence depend on substrate conditions (e.g., gravel size, porosity, permeability, and oxygen concentrations), substrate stability during high flows, and, for most species, water temperatures of 13 °C (55.4 ºF) or less. Habitat requirements for juvenile rearing include seasonally suitable microhabitats for holding, feeding, and resting. Migration of juveniles to rearing areas, whether the ocean, lakes, or other stream reaches, requires free access to these habitats.

Information relevant to the environmental baseline is also discussed in detail in Chapter 5 of the Supplemental Comprehensive Analysis (SCA)(NMFS 2008d), which cross-references back to the related 2008 FCRPS biological opinion (NMFS 2008c). Chapter 5 of the SCA (NMFS 2008d) provides an analysis of the effects of past and ongoing human and natural factors on the current status of the species, their habitats and ecosystems, within the entire Columbia River Basin, including the UCR. In addition, chapter 5 of the SCA evaluates the effects of those ongoing actions on designated critical habitat with that same area. Chapter 5 of the SCA is hereby incorporated here by reference. Additional information on the historical and current condition of Icicle Creek (e.g., pre-action condition) was provided in the USFWS SBA and is also incorporated by reference (USFWS 2014). Activities and their effects of particular importance to the current proposed action are summarized below.

2.3.1. Land Ownership

The Wenatchee basin consists of five sub-watersheds (the Chiwawa, White, Little Wenatchee, and Wenatchee Rivers and Nason Creek), which drain a combined total of approximately 1,300 square miles (NPCC 2004). The Wenatchee River enters the Columbia River at RM 468 between Rocky Reach and Rock Island dams.

Icicle Creek enters the Wenatchee River at approximately RM 25. The Icicle Creek watershed contributes 20 percent of the annual average low season flows to the Wenatchee River (WSCC 2001). Icicle Creek originates high in the Cascade Mountains and drains an area of 214 square miles (136,960 acres; USFS 1995) in North Central Washington. Icicle Creek runs 31.8 river miles before emptying into the Wenatchee River at the City of Leavenworth.

Land uses in the Wenatchee basin consist of commercial forest (86 percent areal coverage), commercial agriculture (1 percent), rural (12 percent), urban (0.5 percent), and open water (0.3 percent). Approximately 76 percent of the lands in the basin are managed by the U.S. Forest Service (USFS 1994). Approximately 18.5 percent of the basin is privately owned and almost two-thirds contain lower-gradient streams that support anadromous fish such as salmon and steelhead (USFS 1994). Agriculture consists primarily of orchards (93 percent) with some production of hay, grains, and row crops (6.5 percent) (NPCC 2004).

2.3.2. Resource Development

Wide varieties of human activities have affected UCR spring Chinook salmon and UCR steelhead, and their important habitat PCEs in the action area. Although land and water management activities have improved, factors such as hydroelectric and hatchery diversions and dams, agricultural activities, stream channelization and diking, roads and railways, historical forest management and timber harvest, and urban development still affect UCR spring Chinook salmon and steelhead and their designated habitat (UCSRB 2007).

Many stream reaches in the UCR have more allocated water rights than existing stream flow conditions can support. Reduced tributary stream flow has been identified as a major limiting factor for all listed UCR salmon and steelhead (NMFS 2007c; NMFS 2011c). Critical habitat is designated in the upper and lower mainstem Wenatchee River and upper tributaries (above Tumwater Dam) only for ESA-listed spring Chinook salmon, not including Icicle Creek. Critical habitat is designated in the mainstem Wenatchee River and tributaries in the sub-basin, including Icicle Creek, for ESA-listed steelhead (Section 2.2.1.1 and Section 2.2.1.2). Migration routes for UCR spring Chinook salmon and steelhead are still disrupted by water diversions without proper adult and juvenile passage routes, unscreened diversions that trap or divert adults and juveniles, instream structures that impede adult and juvenile passage, hydroelectric passage mortality that reduces abundance of migrants, and sedimentation from land and water management that causes loss of habitat complexity, off-channel habitat, and deep pools and/or loss of pool-forming structures such as boulders and large woody debris (UCSRB 2007).

Habitat quality in the lower Icicle Creek (within the action area, below RM 5.5) is considered impaired by forestry practices, private land development in floodplain and riparian areas, roads, and agriculture. The USFS reports that about 4.5% of the drainage has been harvested (USFS 1994). Private land development occurs in the lower reach of the watershed within the floodplain and riparian areas. This is primarily single-family residences and roads (USFS 1994). There have been numerous land use/land management related habitat impacts in the channel migration zone of lower Icicle Creek (NMFS 2002a). Based upon analysis of aerial photographs, Chapman et al. (1994) found that 11.2% of Icicle Creek between RM 0.2 and 1.8 had no riparian vegetation. Portions of Icicle Creek Road and some USFS campgrounds affect the floodplain (NMFS 2002a). Additionally, a substantial quantity of stream bank along Icicle Creek Road has been altered with riprap (NMFS 2002a).

Water use is a high demand resource in the watershed, with multiple small irrigators, two irrigation districts, the city of Leavenworth, and the LNFH all drawing water from the watershed (NMFS 2002a). Low flow conditions and associated high instream temperatures in the lower reaches of Icicle Creek from RM 5.7 at the Icicle Peshastin Irrigation District's (IPID's) water diversion downstream to the mouth negatively affect salmonid fish passage and decrease habitat quantity. Reduced stream flow and increased water temperatures in the lower 3.8 miles of Icicle Creek may affect ESA-listed spring Chinook salmon and steelhead and reduce habitat in the Icicle Creek watershed in the Wenatchee Basin.

The following sections describe conditions in Icicle Creek relevant to the proposed action from 1937 (development of the LNFH) to the present.

a) 1937 to 2003

Development of the LNFH began in 1937 when three river miles of Icicle Creek below the boulder falls were fenced off for experimental salmon production (USFWS 2014). Salmon were captured at Rock Island Dam and held in the fenced area of Icicle Creek through the spawning period (Brennan 1938). Upstream fish passage was blocked during the spawning season, and blockage was likely extended until construction of the LNFH began in 1938 (USFWS 2014). From 1938 through 2000, upstream fish passage was blocked year round at approximately RM 2.8 due to instream structure 5 (USFWS 2014). In 1942, the LNFH obtained water rights to Icicle Creek surface water and Snow and Nada Lakes and began exercising those rights soon thereafter (USFWS 2014). The LNFH diversion dam at RM 4.5 prevented fish access upstream to 24.5 miles of mainstem Icicle Creek habitat (Mullan et al. 1992a; USFS 1994). The hatchery's intake at RM 4.5 blocked fish passage at low flows (USFWS 2001). During several months of the year, fish passage in Icicle Creek was blocked by structures in the mainstem (i.e., Structure 1 and Structure 5) and in the Icicle Creek historical channel (i.e., Structure 2) with little to no flow in the Icicle Creek historical channel (NMFS 2002a). Two of the LNFH structures (i.e., Structures 3 and 4) effectively blocked upstream fish passage (at RM 2.8) and were no longer needed for hatchery operations (NMFS 2002a).

Spring Chinook salmon spawning ground surveys were conducted by WDFW in Icicle Creek since 1989 (Hillman et al. 2014). From 1989 to 2003, an average of 47 (range 6 to 245) spring Chinook salmon redds were encountered in Icicle Creek (Hillman et al. 2014). The origin of Icicle Creek spring Chinook salmon was unknown. NMFS (1999b) reported that spring Chinook spawning in Icicle, Peshastin, and Ingalls Creeks were likely from hatchery-derived populations.

Evidence suggests that historically Icicle Creek produced native steelhead (Brennan 1938; Fulton 1970; Mullan et al. 1992b). In 1997, NMFS completed a status review of West Coast steelhead that resulted in NMFS listing UCR steelhead as endangered (Busby et al. 1996; 62 FR 43937, August 18, 1997). The status of UCR steelhead in the lower Icicle Creek was unknown at this time but it is unlikely that migrating steelhead passed RM 2.8. It is also likely steelhead were subject to competition and genetic introgression from interactions with hatchery steelhead and rainbow trout and habitat effects related to low flow conditions in Icicle Creek (USFWS 2014).

In the Icicle Creek watershed, natural conditions[36] may also limit fish access to tributaries. However, the remaining upstream habitat has significant production potential (WSCC 2001). The Icicle Creek watershed contributes to additional spawning and migration habitat to ESA-listed spring Chinook salmon and steelhead in the Wenatchee basin (WSCC 2001). With improvements in the watershed, Icicle Creek could contribute to the increased spatial structure, abundance, and productivity of the Wenatchee spring Chinook salmon and steelhead populations. Although, none of the water diversions have been proven to be year round barriers (USFWS 2001), they limit passage of ESA-listed species for all life stages (i.e., spawning, migration, and rearing).

b) 2004 to 2010

In the winter of 2006, the LNFH began to document operations of instream structures 2 and 5 (USFWS 2014). The original design of the LNFH involved diverting 42 cfs out of the creek and into a hatchery channel with an energy control dam at the base and construction of holding dams and weirs in the Icicle Creek mainstem and historical channel (USFWS 2014). In 2007, the USFWS Columbia River Basin Hatchery Review Team stated, "Upstream fish passage is a significant issue in Icicle Creek. At the present time, hatchery structures impeded upstream fish passage at three locations: (1) Structure 5 immediately upstream of the hatchery fish ladder and bypass canal spillway (RM 2.8); (2) Structure 2 and associated headgate for diverting Icicle Creek water into the bypass canal (i.e., Hatchery Channel); and (3) a low-head dam (i.e., Structure 1) for diverting Icicle Creek water into the intake pipe for the hatchery (RM 4.5)" (USFWS 2007). The USFWS also stated that, "NOAA Fisheries, the USFWS Ecological Services office in Wenatchee, and the Wild Fish Conservancy (formerly Washington Trout) are very concerned about passage issues for ESA-listed bull trout and summer steelhead at the lower-most structure in Icicle Creek (Structure 5) and at the water intake structure" (Structure 1)

[36] Natural conditions include steep gradients, waterfalls, and stream flow.

(USFWS 2007). In 2007, the USFWS Columbia River Basin Hatchery Review Team identified recommendations for the LNFH. The review team stated that the LNFH posed a demographic risk to ESA-listed steelhead because the water intake screening did not comply with NOAA Fisheries fish exclusion guidelines (USFWS 2007). In addition, passage facilities for upstream migrating fish around the hatchery instream structures were "inadequate" and instream flows in Icicle Creek did not meet minimum requirements between the hatchery intake (RM 4.5) and the hatchery outflow (RM 2.4) (USFWS 2007). The USFWS Columbia River Basin Hatchery Review Team report stated, "[i]n some years, this latter section of Icicle Creek has gone completely dry during the summer [in the historical channel], although the majority of water is withdrawn by irrigation companies during months of lowest flows" (USFWS 2007).

WDFW spring Chinook salmon spawning grounds surveys continued. From 2004 to 2010, an average of 58 (range 8 to 155) spring Chinook salmon redds were encountered in Icicle Creek (Hillman et al. 2014).

Steelhead spawning ground surveys[37] have been conducted since 2004 in Icicle Creek (Hillman et al. 2014). From 2004 to 2010, an average of 48 (range 8 to 120) steelhead redds were encountered (Hillman et al. 2014). In 2005, NMFS designated critical habitat for UCR steelhead (70 FR 52630, September 2, 2005). Upstream fish passage opportunities were expanded but due to the LNFH's operation of structures 2 and 5 during spring Chinook salmon broodstock collection, adult steelhead migration was still blocked at the end of the normal run period (USFWS 2014).

In 2005, a group of regional experts[38] convened to assess potential steelhead spawning habitat in the Icicle Creek historical channel and the reach above the LNFH (up to RM 5.7) (Hall 2014). The group estimated (visually) 1,822 square meters of suitable spawning habitat[39] in the former reach and about 26 square meters in the latter reach. The group noted that, following the Icicle Creek Restoration Project[40], the Icicle Creek historical channel was in a state of transition from wetland to riverine habitat such that the condition of spawning habitat may further improve (Hall 2014).

c) 2011 to the Present

Beginning in 2011, the LNFH has made a number of changes to improve the quantity and complexity of habitat in the historical channel, allowing greater frequency of adult steelhead passage, and improved efficiency of ground water usage. From 2011 through 2014, structures 2 and 5 have remained open during the hatchery's spring Chinook salmon broodstock collection period to allow for upstream fish passage and higher instream flows in the Icicle Creek historical channel(USFWS 2014). In 2015 and 2016, the limit for the number of LNFH adult spring

[37] Icicle Creek steelhead surveys were conducted by WDFW using consistent methodologies below RM 2.4 since 2004 and in the historical channel since 2006.
[38] Regional experts consisted of biologists representing NMFS, USFWS, WDFW, USFS, and the YN.
[39] The group also noted that high levels of sedimentation could potentially affect spawning success.
[40] Removal of the LNFH instream structures 3 and 4.

Chinook salmon[41] was reached; Structure 2 was operated to allow installation of pickets at Structure 5 to close natural upstream migration for adult salmonid species beyond Structure 5 (June 1-June 24 for 2015; May 9-June 23 for 2016), with trapping procedures in place to release natural-origin migrating spring Chinook salmon and steelhead upstream or downstream of Structure 5[42]. Structure 2 was operated in 2012 and 2013 for aquifer recharge (February 15-29, September 6-19, and October 17-28 for 2012, and February 6-20 and September 4-19 for 2013), (Kondo 2017p) though LNFH proposes to operate Structure 2 for 15 consecutive days or less for up to 5 times each year for aquifer well recharge.

Consistent with past operations, the LNFH continues to divert up to 42 cfs of surface flow (at RM 4.5) from Icicle Creek year round and to target the discharge of up to 50 cfs of surface water (at RM 5.7) from Snow/Nada Lake Reservoirs into Icicle Creek during the months of August and September (USFWS 2014). Up until 2015, IPID has not used water from Snow/Nada Lake and Snow Creek; thus, there have been no additional adverse effects of low flows in August and September on ESA-listed species in Icicle Creek because supplemental flows offset the LNFH's diversion. The USBR's contract with IPID, which was later reassigned from the USBR to the USFWS in 1949, allows IPID to divert up to 30 cfs from Upper Snow Lake until their annual allowance of 750 AF is exhausted[43]. However, IPID will withdraw water from other water sources first and use water from Snow/Nada Lake and Snow Creek as a last resort (T. Jantzer, IPID, personal communication, May 10, 2017), as required by the contract (Kondo 2017e), and it is not likely that IPID would withdraw at its maximum diversion rate (e.g., IPID used 5 cfs of supplemental flow during the 2015 irrigation season[44], which was considered to be a drought year (T. Jantzer, IPID, personal communication, May 10, 2017)). In addition, USBR and USFWS have plans to upgrade the water delivery system (Kondo 2017s) (by replacing the valve to allow up to 80 cfs of water to be released) in the reservoirs in a manner that would allow a larger amount of water to be released from the reservoirs, which could accommodate both IPID and hatchery water use. The water users in this watershed are also determining the feasibility of installing an automation system that would allow an optimized release of water from the reservoirs that could fine-tune the amount of release based on user needs (Aspect Consulting and Anchor QEA 2015).

In 2011, a minimum instream flow goal of 20 cfs was proposed for the Icicle Creek historical channel, particularly during operation of Structure 2 when re-routing of water from the Icicle Creek historical channel would occur to the hatchery channel to recharge aquifers. In the spring of 2014, the LNFH made additional improvements to the radial gates at Structure 2. In November 2014, the USFWS again proposed a minimum instream flow goal of 20 cfs in the Icicle Creek historical channel (USFWS 2014).

[41] Starting in 2011, structures 2 and 5 remain in the open position all year except if the following conditions arise: (1) 50 returning adult spring Chinook salmon pass upstream of structure 5 during broodstock collection (May through July); (2) stream flow through the hatchery channel is not sufficient to promote smolt emigration during release in mid-April; (3) stream flow in the hatchery channel has not been sufficient enough to recharge the shallow aquifer; (4) high stream flows from spring runoff and rain-on-snow events are endangering downstream infrastructure; or (5) during maintenance of structure 5.

[42] Steelhead are released upstream or downstream depending on spawning status.

[43] IPID could only draw water at 30 cfs for 12.6 days before reaching their annual allowance of 750 AF.

[44] Irrigation season is from May – October.

The minimum collective (all water users) instream flow goal under the current proposed action is for 100 cfs to provide roughly 80% of potential steelhead rearing habitat (Irving 2015a). For 2016, the LNFH provided supplemental flows from Snow/Nada Lake Reservoirs from July 13th to October 7th. Between January 6 and September 30, 2016, the flows in the historical channel were below 100 cfs from August 18th to 24th (average of 86.6 cfs), September 7th to 17th (average of 71.3 cfs), and September 19th to 30th (average of 75.2 cfs), though Structure 2 was not operated during this time (Kondo 2017a).

CPUD spring Chinook salmon spawning surveys continue (assisted by USFWS staff since 2015). From 2011 to 2013, an average of 143 redds (range 107 to 199) were encountered in Icicle Creek (Hillman et al. 2014). The redd counts were 211 in 2014, 132 in 2015 (Hillman et al. 2016), and 72 in 2016 (Kondo 2017o). Icicle Creek is a minor spawning area for UCR spring Chinook salmon (Section 2.2.2.1) and most likely influenced by LNFH-origin spring Chinook that spawn in Icicle Creek (NMFS 1999b).

WDFW steelhead spawning surveys also continue. From 2011 to 2013, an average of 92 redds (range 47 to 180) were encountered in Icicle Creek (Hillman et al. 2014). Redd surveys were not performed for steelhead in 2014 (Hillman et al. 2016); instead, WDFW changed their method of estimating redds to use PIT-tag based spawner escapement estimates and performed labor intensive surveys (to establish observer efficiency) that excluded some tributaries, such as Icicle Creek, in 2014 (Kondo 2017o). Starting in 2015, WDFW used PIT-tag-based spawner escapements to estimate the number of redds in Icicle Creek. Using this new methodology, WDFW estimated 78 redds in 2015 and 56 redds in 2016 (Kondo 2017o). Icicle Creek is a major spawning area for UCR steelhead (Section 2.2.2.2). No hatchery releases of steelhead in Icicle Creek have occurred since 1997. The last return of LNFH-produced steelhead to Icicle Creek occurred in 2000 (Hall 2014).

2.3.3. Restoration

The USFWS completed the Icicle Creek Restoration Project EIS and Record of Decision in 2002. The goal of the project was to improve the migration of ESA-listed and non-ESA-listed species through Icicle Creek because of the past LNFH in-river structures that had the potential to entrain fish and block passage. Phase I involved removal of Structures 3 and 4 and was completed in 2003, which included removal of any diffusion dams, racks, abutments, flumes, and concrete foundations. These structures were legacy features of early hatchery operations when adult fish were corralled in the historical channel. The project also included flushing sediments and restoring streamflow to the historical Icicle Creek channel to improve passage conditions for listed salmonids, particularly steelhead and bull trout. Any native spring Chinook salmon attempting to migrate through the hatchery grounds was also provided access in order to migrate upstream of the hatchery. In-channel structures were installed to reduce bank erosion and provide cover and pool habitat for rearing salmonids. The purpose of Phase II was to restore long-term, year-round sustainable passage and riverine fish habitat through LNFH instream structures by reconditioning all parts of Structure 2. A vertical slot fishway would be constructed at the headgate to provide fish passage. The fishway would be designed to allow passage of all life stages of salmonids (NMFS 2002a).

Phase II has not been implemented, as proposed, because of legal action, citizen and agency concerns, insufficient funding, and delays in receiving needed permits and approvals. When project-specific details are determined, LNFH will undergo a new, updated NEPA process and a separate ESA consultation as necessary. As mentioned above, the upstream habitat in Icicle Creek has important production potential, particularly for ESA-listed steelhead. Icicle Creek has consistently had steelhead redds in the lower 2 miles and spawning surveys are limited to downstream areas. Designated critical habitat for ESA-listed steelhead has a medium conservation value (see Section 2.2.2.2) with the majority of spawning limited to the lower Icicle Creek mainstem (with even less spawning currently occurring in the Icicle Creek historical channel). In NMFS' recovery planning analysis for evaluating potential habitat condition improvements for salmon and steelhead in the Columbia River Basin (NWFSC 2004), the Icicle Creek watershed was considered a major spawning area containing habitat with medium intrinsic potential that supports important physical or biological features that are essential to the conservation of the species, for steelhead in the lower mainstem (mouth up to historical channel) (NWFSC 2004). Habitat with high intrinsic potential was identified as being located above the LNFH (NWFSC 2004) (Section 2.2.2.2) but is likely limited by natural passage impediments present at most flows.

Due to implementation of Phase I of the Icicle Creek Restoration Project, habitat in the Icicle Creek historical channel has improved. From 2010 to 2013, an average of 95 (range 43 to 175) steelhead redds were documented in Icicle Creek below RM 2.8 and an average of 3.8 (range 2 to 5) steelhead redds were documented in the Icicle Creek historical channel (Hall 2014). Icicle Creek also contains important rearing and migration PCEs in habitat above the LNFH to RM 5.7 (NMFS 2005c). The Icicle Creek historical channel is the only corridor that provides access to this upstream habitat. Currently, spawning data show that the majority of steelhead present are in the lower portion of Icicle Creek (from RM 2.8 to RM 0.0), which contains degraded habitat due to the land use activities described above.

The Pacific Coastal Salmon Recovery Fund (PCSRF) was established by Congress to help protect and recover salmon and steelhead populations and their habitats (NMFS 2007c). The states of Washington, Oregon, California, Idaho, and Alaska, and the Pacific Coastal and Columbia River tribes, receive PCSRF appropriations from NMFS each year. The fund supplements existing state, tribal and local programs to foster development of Federal-state-tribal-local partnerships in salmon and steelhead recovery. The PCSRF has made substantial progress in achieving program goals, as indicated in annual Reports to Congress, workshops, and independent reviews.

The UCR recovery plan for UCR spring Chinook salmon and steelhead (UCSRB 2007) describes recovery actions intended to reduce threats associated with land and water management. The following short-term and long-terms actions are intended to reduce the primary threats to improve aquatic and riparian conditions where feasible and practical:

Short-term Protection Actions

Use administrative and institutional rules and regulations to protect and restore stream and riparian habitats on public lands within the following assessment units:

- Middle Wenatchee
- Upper Wenatchee
- Upper Icicle Creek
- Chiwaukum
- Chiwawa River
- Lake Wenatchee
- Little Wenatchee
- White River

Short-term Restoration Actions

Implement the following actions throughout the entire Wenatchee Basin:

- Address passage barriers
- Address diversion screens
- Reduce the abundance and distribution of brook trout through feasible means (e.g., increased harvest).

Lower Icicle Creek Assessment Unit (Category 2; Appendix G.1):

- Increase connectivity by improving fish passage over Dam 5 (i.e., Structure 5) in the lower Icicle Creek
- Reduce sediment recruitment by restoring riparian vegetation between the mouth of the Icicle and the boulder field (RM 0.0 - 5.4)
- Improve road maintenance to reduce fine sediment recruitment in the upper watershed
- Increase habitat diversity and quantity by restoring riparian vegetation, reconnecting side channels, and reconnecting the floodplain with the channel in lower Icicle Creek
- Use practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) in Icicle Creek

Long-term Actions

- Protect and maintain stream and riparian habitats within Category 1 assessment units
- Protect, maintain, or enhance beneficial stream and riparian habitat conditions established by implementing Short-term Actions within assessment units
- Where feasible and practical, maintain connectivity throughout the historical distribution of the species

NMFS has completed ESA consultation on the activities of the NOAA Restoration Center in the Pacific Northwest (NMFS 2004b). These include participation in the Damage Assessment and Restoration Program, Community-based Restoration Program (CRP), and the Restoration Research Program. The CRP is a financial and technical assistance program, which helps communities to implement habitat restoration projects. Projects are selected for funding based on their ecological benefits, technical merit, level of community involvement, and cost-effectiveness. National and regional partners and local organizations contribute matching funds, technical assistance, land, volunteer support or other in-kind services to help citizens carry out restoration.

In 2012, the IWG was formed to develop a comprehensive water resources management strategy for the Icicle Creek Watershed (http://www.co.chelan.wa.us/natural-resources/pages/icicle-work-group). The group's broad membership includes two Native American tribes, environmental groups, county and city government, irrigation districts, recreational interests, and State and Federal agencies, including the LNFH. The group adopted nine guiding principles, including operating LNFH in a sustainable manner and improving stream flow to support healthy habitat. The group also formed an instream flow subcommittee that recommended minimum flows in the Icicle Creek historical channel of 100 cubic feet per second (cfs), except in drought years, when they recommend a minimum flow of 60 cfs. The IWG also recommended a goal of 250 cfs in the Icicle Creek historical channel during wet water years.

In summary, human activities have impaired habitat quality in the Icicle Creek watershed, including low flow conditions and associated high instream temperatures due to water withdrawals and man-made passage barriers in the lower reaches of Icicle Creek that reduce salmonid fish passage, connectivity between Icicle Creek and the rest of the Wenatchee Basin, and habitat quality and quantity. Some improvements in fish passage and instream flows in lower Icicle Creek, including the historical channel, have occurred. Fish passage in the Icicle Creek historical channel is limited by reduced flows and by the physical characteristics of the LNFH instream structures, and such passage limitations can prevent access to habitat with high intrinsic potential upstream of the hatchery. The instream structures also reduce water quality and quantity of UCR steelhead designated critical habitat in the Icicle Creek historical channel and downstream areas. Improvements to address some of these impediments are part of the proposed action.

2.3.4. Hatchery Propagation

Early attempts to establish hatcheries on the Columbia River above the confluence of the Yakima River were generally unsuccessful. Beginning in 1899, with the construction of a fish hatchery on the Wenatchee River by the Washington Department of Fish and Game, hatcheries were constructed and subsequently abandoned on the Colville, Little Spokane, and Methow Rivers. Hatchery records indicate that relatively few Chinook salmon were spawned (Craig and Suomela 1941). Attempts to improve the spring Chinook salmon run with imported eggs (most notably from the upper Willamette River) were also unsuccessful (Craig and Suomela 1941).

The spring Chinook salmon hatchery program included in the proposed action is the Leavenworth National Fish Hatchery (LNFH) spring Chinook salmon program. In the past, out-of-basin transfers and a stock with mixed ancestry served as a source for LNFH broodstock; this has resulted in a heightened threat or risk to the diversity of spring Chinook salmon in the ESU, and particularly in the Upper Wenatchee and Entiat Basins. The LNFH began releasing juvenile spring Chinook salmon in 1941. For the first two decades, there was an attempt to focus on local-origin broodstock. From 1941-1944, broodstock was primarily from fish collected at Rock Island Dam as part of the Grand Coulee Fish-Maintenance Project. In 1942, approximately 200,000 fish from the McKenzie River (a Willamette River tributary) were also released. Between 1944 and 1971, releases only occurred sporadically. In 1948, approximately 800,000 sub-yearling progeny of fish returning to Icicle Creek were released. In 1967 and 1968, approximately 300,000 yearlings of Clackamas River-origin (Eagle Creek NFH) were released. From 1971 to 1993, production consisted of large-scale releases (1 million or more yearlings annually) of spring

Chinook salmon transferred primarily from Carson and Wind River NFHs (Carson derivative), combined with returns from Icicle Creek. Mixed-origin Carson stock was developed beginning in 1958 of spring Chinook salmon intercepted at Bonneville Dam. Since 1994, the broodstock has been composed entirely of returns to Icicle Creek (Mullan et al. 1992a; NRC 1996; Utter et al. 1995).

Returning LNFH adults (brood years 1999 – 2009), during which the production was 1.625 million smolts, are marked at a 100% adipose fin-clip rate (beginning brood year 2000), and an average coded-wire-tag (CWT) rate of 33% (range 11% – 59%) (Hall 2014). The current production level is 1.2 million spring Chinook salmon smolts annually. Straying of LNFH-origin hatchery spring Chinook salmon into the natural spawning areas for Wenatchee spring Chinook salmon has been a concern. In 2007, the USFWS Columbia River Basin Hatchery Review Team made a recommendation to "move promptly to unique marks or tags for LNFH and Upper Wenatchee River hatchery programs" and to "establish a system for differentially marking or tagging LNFH spring Chinook and Chiwawa River hatchery spring Chinook" (USFWS 2007). Prior to 2011, the proportion of LNFH origin spring Chinook salmon spawning naturally in areas upstream of Tumwater Canyon contributed to a high risk rating for diversity. From 2001 to 2003, 34.6% of all naturally spawning spring Chinook salmon in the Upper Wenatchee River, upstream of Tumwater Dam, were composed of adults from the LNFH based on estimates derived from expanded coded-wire-tag (CWT) recoveries (USFWS 2007). In 2007, LNFH adult spring Chinook salmon composed a combined average of 9% of the natural spawners (i.e., carcass recoveries) in the Chiwawa River, Chickamin Creek, and Rock Creek, 53% of the natural spawners in the Little Wenatchee River, 18% of the natural spawners in Nason Creek, 3% of the natural spawners in the Little Wenatchee River, Napeequa Creek, and Panther Creek, and 89% of the natural spawners in the Upper Wenatchee mainstem (USFWS 2007). By the early 2000s, only 2.6% of LNFH spring Chinook salmon strayed outside of Icicle Creek, but they represented a relatively high proportion of the natural spawners in some areas upstream of Tumwater Dam because of the very low abundance of natural-origin spring Chinook salmon adults in the Wenatchee Basin (USFWS 2007). To address this concern, LNFH reduced the coded-wire-tag (CWT) rate on hatchery spring Chinook salmon to 18% with 100% of the fish adipose fin-clipped to provide a differential mark for removal of LNFH-origin fish at Tumwater Dam (NMFS 2011a). This reduction in LNFH CWT rate and 100% adipose fin clip corresponded with an increase in CWT rate and the presence of an adipose fin for the Nason Creek spring Chinook salmon hatchery supplementation program. Prior to 2013, the Nason Creek mitigation obligation was fulfilled through the Chiwawa River safety net program, which had a mark identical to the LNFH program fish. Beginning in 2013, the GPUD was able to fulfill their mitigation obligation through a Nason Creek spring Chinook salmon conservation component of the Wenatchee River hatchery supplementation program so that the number of CWT fish with an adipose fin increased, thus allowing for better identification and removal of LNFH fish at Tumwater Dam. Since 2009, 82% of potential LNFH-origin stray hatchery fish are identifiable for removal during standard adult management and broodstock collection efforts at Tumwater Dam while working collaboratively with CPUD and WDFW (NMFS 2011a). From 2004-2012, the mean LNFH-origin component of the Upper Wenatchee River spring Chinook salmon escapement was 0.8% (range 0% to 3.2%) (Hall 2014). Increased marking efforts have facilitated greater removal of these fish before they can spawn naturally. Currently, the LNFH program has a pHOS of less than 1% in the Wenatchee Basin (Hall 2014) and approximately 2% in the Entiat Basin (Cooper 2012) (Section 2.4.2.2).

From 2008 to 2016, natural-origin adult spring Chinook salmon encounters at LNFH remained roughly the same at one wild adult or less per year. However, broodstock collection from 2011 to 2013 has shown an increase in the handling of ESA-listed hatchery-origin spring Chinook salmon, ranging from 28 to 88 fish per year (Kondo 2017t). These strays were predominantly from the Chiwawa Spring Chinook Salmon Hatchery Program (Gale 2012a). A proportion of spring Chinook salmon are also adipose-fin-clipped from the Wenatchee spring Chinook salmon hatchery programs[45] safety-net component. Since it is difficult to positively identify one ad-clipped adult spring Chinook salmon in the Wenatchee Basin from another (i.e., those without a CWT or other identifying tag or mark), these fish are sometimes incidentally incorporated into the LNFH broodstock. From 2008 to 2016, up to 1 natural-origin and an average of 21 (range 2 to 88) hatchery-origin spring Chinook salmon volunteered into the LNFH ladder during annual broodstock collection (Kondo 2017t).

In addition to the LNFH spring Chinook salmon hatchery program, there are seven other hatchery programs in the action area. The CPUD, GPUD, WDFW, YN, and BPA fund and operate three spring Chinook salmon, two summer Chinook salmon, one steelhead, and one coho salmon hatchery programs. The Wenatchee hatchery programs originated with the Habitat Conservation Plan (HCP) settlement agreements[46].

The first of three spring Chinook salmon programs in the Wenatchee Basin is the Chiwawa River spring Chinook salmon hatchery program. Fish from this program are intended to spawn naturally in the Chiwawa River for recovery of the endangered UCR Spring-Run Chinook salmon ESU. The program began with collection of wild broodstock in 1989. Under the terms of the Rock Island and Rocky Reach HCPs, the program originally was to produce 672,000 smolts annually until 2013, when the release numbers would be adjusted based on NNI recalculations.

[45] Wenatchee spring Chinook salmon supplementation includes the Chiwawa River and Nason Creek hatchery programs.

[46] Anadromous Fish Agreement and Habitat Conservation Plan (HCP) Rocky Reach (RR) Hydroelectric Project Federal Energy Regulatory Commission (FERC) License No. 2145 Chelan County Public Utility District. 2002b. Anadromous Fish Agreement and Habitat Conservation Plan. Rocky Reach Hydroelectric Project. FERC License No. 2145. March 26, 2002. Public Utility District No. 1 of Chelan County, Wenatchee, Washington. 64p. and the Anadromous Fish Agreement and HCP Rock Island (RI) Hydroelectric Project FERC License No. 943 Chelan County Public Utility District. 2002a. Anadromous Fish Agreement and Habitat Conservation Plan. Rocky Island Hydroelectric Project. March 26, 2002. FERC License No. 943. Public Utility District No. 1 of Chelan County, U.S. Fish and Wildlife Service, National Marine Fisheries Service, Washington Department of Fish and Wildlife, Confederated Tribes of the Colville Reservation, Yakama Nation, Confederated Tribes of the Umatilla Indian Reservation.. CPUD is responsible for funding elements of the hatchery programs related to ESA conservation and recovery goals of their HCPs ibid., Chelan County Public Utility District. 2002b. Anadromous Fish Agreement and Habitat Conservation Plan. Rocky Reach Hydroelectric Project. FERC License No. 2145. March 26, 2002. Public Utility District No. 1 of Chelan County, Wenatchee, Washington. 64p.. GPUD is responsible for funding elements of the hatchery programs related to ESA conservation and recovery goals as a requirement of GPUD's license to operate the Priest Rapids Project issued by FERC FERC. 2010. Order on Remand and on offer of settlement, amending license, authorizing new powerhouse, and lifting stay. July 15, 2010. Project No. 460-033, 040, and -021. City of Tacoma, Washington. 200p.. WDFW is the funding source for elements of the hatchery programs that are not CPUD and GPUDs' obligations under the HCPs or respective hydroelectric licenses.

The program size was adjusted downward to 298,000 by the HCP Hatchery Committee, and further adjusted to 144,026 in 2013. Actual numbers released have differed considerably from the production goal due to variations in survival and the availability of broodstock. From 1989 to 1999, the program released an average of 95,610 fish (range 0 – 266 148); from 2000 to 2009 the program released an average of 375,135 fish (range 47,104-612,482)(Hillman et al. 2012). From 2001-2011, the program released an average of 393,847 fish (range 149,668 – 612,482) (Hillman et al. 2014)(Table 11).

Although the Chiwawa program has undoubtedly reduced extinction risk for the Wenatchee spring Chinook salmon natural population (abundance declined to record low numbers during the 1990s), the continued preponderance of hatchery-origin spawners is a risk to spatial structure and diversity and productivity. Additionally, the large number of hatchery fish in the basin may have reduced productivity through competition at the adult or juvenile levels. A final concern about the Chiwawa program is the extent to which Chiwawa adults spawn naturally outside the Chiwawa River but within the action area. This has likely reduced the amount of diversity among spawning aggregates, a loss of within-population diversity.

Table 11. Numbers of spring Chinook smolts tagged and released from the Chiwawa hatchery program, brood years 2001-2015 (Hillman et al. 2014; Kondo 2017o).

Brood Year	Release Year	Total smolts released
2001	2003	377,544
2002	2004	148,668
2003	2005	222,131
2004	2006	494,517
2005	2007	494,012
2006	2007/2008	612,482
2007	2008/2009	305,542
2008	2010	609,789
2009	2011	438,561
2010	2012	346,248
2011	2013	281,821
2012	2014	222,504
2013	2015	147,480
2014	2016	341,226
2015	2017	163,411
Mean	**2003-2017**	**347,062**

There was also a spring Chinook salmon hatchery program in the White River (captive-broodstock program), but it was terminated after a final smolt release in 2015. The program was designed and operated to rescue, at least temporarily, spring Chinook salmon in the White River. Because of concerns about the loss of genetic diversity represented by the White River spawning aggregate, White River spring Chinook salmon were cultured in a captive broodstock program as a conservation measure beginning in 1997. Lauver et al. (2012) provides a complete history and summary of results of the program. Overall, the White River program was beneficial in reducing extinction risk for the White River subpopulation. Although the last release of hatchery fish was in 2015, monitoring and evaluation of White River hatchery adult returns will continue through 2026.

The third hatchery program is the Nason Creek spring Chinook salmon program. Fish from this hatchery program are intended to spawn naturally in Nason Creek. It began with the collection of wild broodstock, from Nason Creek, in 2013. The first juvenile releases occurred in 2015 (Hillman et al. 2014). It is anticipated that the Nason Creek program will reduce extinction risk for the Wenatchee spring Chinook salmon population. The Nason Creek hatchery program will be monitored carefully, similar to the Chiwawa River program, to reduce negative impacts on productivity and to reduce adverse genetic and ecological effects from adults or juveniles in the natural environment. Construction of the Nason Creek Acclimation Facility has been evaluated in a separate section 7(a)(2) consultation and NMFS found that implementation of the project would not jeopardize listed spring Chinook salmon or steelhead in the UCR, nor would it destroy or adversely modify designated critical habitat (NMFS 2013b).

The Chiwawa, White River, and Nason Creek spring Chinook salmon hatchery programs have been previously evaluated and authorized under separate ESA consultations, which are incorporated in the baseline by reference. Operation of the Chiwawa spring Chinook hatchery program has been evaluated and authorized in separate section 7(a)(2) consultation and section 10(a)(1)(A) Permit No. 1196 and Permit No. 18121 (NMFS 2004a; NMFS 2013c) (NMFS 2013e). Operation of the White River spring Chinook hatchery program has been evaluated and authorized in a separate section 7(a)(2) consultation and section 10(a)(1)(A) Permit No. 1592 and Permit No. 18120 (NMFS 2007a; NMFS 2013c). In addition, the spring Chinook hatchery program for Nason Creek has been evaluated and authorized in a separate section 7(a)(2) consultation and section 10(a)(1)(A) Permit No. 18118 (NMFS 2013c). The Chiwawa River and Nason Creek spring Chinook salmon hatchery programs pose both benefits and risks to the Wenatchee River spring Chinook salmon natural population. They have benefited the natural population by reducing short-term extinction risk (during record low adult returns in the 1990s). However, a high proportion of hatchery-origin spawners (pHOS) in the natural population poses risk (Ford 2011). To balance benefits to natural spawning abundance against risks to diversity and productivity, the Chiwawa spring Chinook salmon program must meet or exceed a proportionate natural influence (PNI) of 0.67, measured as a 5-year running average. Because the above permits require a reduction in pHOS, which coincides with large reductions in hatchery releases (beginning in 2013) due to NNI recalculations, negative effects on diversity and productivity from the programs are anticipated to decline to desired levels within the next five years (NMFS 2013a).

Summer Chinook salmon programs exist in the Wenatchee and Entiat Basins. The Entiat hatchery program is part of the National Fish Hatcheries complex in the UCR operated by the USFWS. Annual production is 400,000 summer Chinook salmon smolts; the first full release was in 2013, with partial releases occurring in 2011 and 2012 (Table 12). The Entiat summer Chinook salmon hatchery program was evaluated under a separate section 7(a)(2) consultation and NMFS found that implementation of the project would not jeopardize listed spring Chinook salmon or steelhead in the UCR, nor would it destroy or adversely modify designated critical habitat (NMFS 2012b). This program replaces a spring Chinook salmon hatchery program that was a risk to the spring Chinook salmon population in the Entiat River and to the UCR Spring-run Chinook Salmon ESU. Spring Chinook salmon production ceased in 2007 and the last adult hatchery spring Chinook salmon returned to the Entiat River in 2010.

Table 12. Release of summer Chinook salmon from the Entiat summer Chinook salmon hatchery program (Kondo 2017k).

Brood Year	Release Year	Number of smolts released
2009	2011	150,181
2010	2012	174,661
2011	2013	356,098
2012	2014	386,569
2013	2015	417,995
2014	2016	421,783

The Wenatchee River and Chelan Falls summer Chinook salmon hatchery programs have been evaluated and authorized under a separate section 7(a)(2) consultation operated under Section 10 Permit No. 1347 (NMFS 2003a). From 1989 to 2000 (brood year), releases of juveniles from the Wenatchee River summer Chinook salmon program have averaged approximately 639,265 smolts annually (Hillman et al. 2014). From 2001 to 2011 (brood year), releases of summer Chinook salmon have averaged approximately 762,899 smolts annually (Table 13). Permit coverage was extended in September 2013 (Jones 2013), and new section 10(a)(1)(B) consultations for the UCR summer/fall Chinook salmon programs are currently underway.

The subyearling Turtle Rock summer Chinook salmon program was discontinued in 2010. The release target for Turtle Rock summer Chinook subyearlings was 810,000 fish annually; the release target for Turtle Rock summer Chinook accelerated subyearlings was also 810,000 fish annually (Hillman et al. 2014). Production from the Turtle Rock summer Chinook subyearling programs were converted to the Chelan Falls yearling program. The release target for Turtle Rock summer Chinook salmon was 200,000 smolts for the period before brood year 2010. The current release target is 600,000 summer Chinook smolts. From 1995 to 2009 (brood year), the average annual summer Chinook salmon yearling smolt releases from Turtle Rock and Chelan hatchery programs were 137,625 and 233,429, respectively. From 2010 to 2014, the average annual summer Chinook salmon smolt releases from the Chelan Falls hatchery program were 573,142 (Hillman et al. 2014). The 2011 yearling summer Chinook salmon program achieved 96% (e.g., 827,709 fish released) of their 864,000-target goal.

Table 13. Releases of summer Chinook salmon from the Wenatchee summer Chinook salmon hatchery program (Hillman et al. 2014; Kondo 2017o).

Brood Year	Release Year	Number of smolts released
2001	2003	604,668

2002	2004	835,645
2003	2005	653,764
2004	2006	892,926
2005	2007	644,182
2006	2008	950,657
2007	2009	456,805
2008	2010	888,811
2009	2011	843,866
2010	2012	792,746
2011	2013	827,709
2012	2014	550,877
2013	2015	470,570
2014	2016	535,255
2015	2017	525,366
Mean	**2003-2017**	**698,256**

From 1939 to 1951, steelhead of unknown origin were trapped at Rock Island Dam, as well as from the Wells Fish Hatchery from 1977 to 1997, and delivered to the LNFH for spawning, progeny rearing, and release into Icicle Creek (Hall 2014). As mentioned in Section 2.3.2, the last adult returns from the LNFH occurred in 2000. From the 1960s through the early 1990s, WDFW and Chelan PUD released hundreds of thousands of hatchery steelhead in Icicle Creek as well as several million hatchery steelhead in the Wenatchee River (Hall 2014c). In addition, as early as 1933 and into the mid-1990s, rainbow trout from various origins[47] were planted extensively in Icicle Creek as well as upper Icicle Creek lakes (Hall 2014).

There is a steelhead hatchery program in the action area funded and operated by CPUD and WDFW. Until 1998, steelhead broodstock for this program were collected at Wells Dam and at Priest Rapids Dam. This changed with creation of the Wenatchee program at Eastbank Hatchery, which was authorized to release up to 400,000 fish annually, and was resized by the HCP HC to 247,300 fish in 2011. The Wenatchee steelhead hatchery program is intended to supplement the natural-origin steelhead population in the Wenatchee River and these fish are included in the ESA-listed UCR Steelhead DPS. In 2012, the release of Wenatchee steelhead achieved 101% of the 247,300 target goal (~249,004 smolts released into the Wenatchee and Chiwawa rivers and Nason Creek) (Table 13). Juvenile steelhead releases in each of the three subbasins were determined by the mean proportion of steelhead redds in each basin with about 28.9% and 19.0% of the steelhead released in Nason Creek and the Chiwawa River, respectively (Hillman et al. 2014). The balance of program releases was split between the Wenatchee River downstream from Tumwater Dam (21.3%) and the Wenatchee River upstream from the dam (30.8%) (Hillman et al. 2014).

[47] Rainbow trout releases included both within-basin and out-of-basin stocks.

Table 14. Releases of summer steelhead smolts in the Wenatchee from 1998-2015 (brood year) (Hillman et al. 2014; Kondo 2017o).

Brood Year	Release Year	Number of smolts released
1998[a]	1999	172,078
1999	2000	175,701
2000	2001	184,639
2001	2002	335,933
2002	2003	302,060
2003	2004	374,867
2004	2005	294,114
2005	2006	452,184
2006	2007	299,937
2007	2008	306,690
2008	2009	327,143
2009	2010	484,772
2010	2011	354,314
2011[b]	2012	206,397
2012	2013	249,004
2013	2014	264,758
2014	2015	198,913
2015	2016	269,868
Mean	**1998-2010**	**312,649**
Mean	**2011 to present**	**257,209**

To balance benefits to natural spawning abundance against the risks posed to diversity and productivity, the steelhead hatchery program must meet or exceed a proportionate natural influence (PNI) of 0.67, measured as a 5 year running average. PNI has also varied over the years. From 2001-2010, the pHOS was high and averaged 67 percent, while the proportion of natural-origin fish in the broodstock (pNOB) averaged 33 percent, yielding an average PNI of 35 percent (Hillman et al. 2012). For all brood years combined (2001-2013), the average PNI for the Wenatchee steelhead program was 50 percent (Hillman et al. 2014). Although the Wenatchee steelhead program undoubtedly reduced extinction risk, particularly during the mid-1990s, pHOS may have had a negative effect. Additionally, the large number of hatchery fish in the basin may have reduced productivity through competition at the adult or juvenile level. Operation of the Wenatchee River steelhead hatchery program was evaluated under a separate section 7(a)(2) consultation and section 10(a)(1)(A) Permit No. 1395 (NMFS 2003a; NMFS 2003b). NMFS found that implementation of the project would not jeopardize listed spring Chinook salmon or steelhead in the UCR, nor would it destroy or adversely modify designated critical habitat. Permit coverage was extended in September 2013 (Jones 2013) and new section 7(a)(2) and section 10(a)(1)(A) consultations for the Wenatchee steelhead program are nearing completion. Because the new permit requires a reduction in pHOS, along with a large reduction in hatchery releases (beginning in 2013), this risk is anticipated to decline to desired levels within the next five years.

The YN's coho reintroduction project is part of the Mid-Columbia Coho Restoration Project (MCCRP) that involves ongoing studies, research, and artificial production of coho salmon in the Wenatchee and Methow river basins. The LNFH supports this project by providing hatchery facilities for part of the YN's expanded coho salmon production program. This ongoing effort has undergone separate ESA section 7(a)(2) consultation (NMFS 2014a). NMFS found that implementation of the project would not jeopardize listed spring Chinook salmon or steelhead in the UCR, nor would it destroy or adversely modify designated critical habitat.

Beginning in 1999, the YN has released coho salmon into the Wenatchee Basin as part of the MCCRP. An average of 793,703 coho salmon smolts has been released annually from 1995 to 2011 (Hillman et al. 2014; Kamphaus 2013) into Icicle, Beaver, and Nason Creeks, many of them reared at the LNFH (Table 14). In recent years, an average of 61% of the Wenatchee coho salmon have been direct-released from the LNFH, with up to 500,000 juveniles having been transferred to LNFH in February for acclimation through April (Kamphaus 2015; Kondo 2017h).

Table 15. Releases of coho salmon smolts in the Wenatchee Basin from 1997-2014 (brood year) (Hillman et al. 2014; Kamphaus 2013; Kondo 2017d; Kondo 2017o).

Brood Year	Release Year	Number of smolts released
1997	1999	525,000
1998	2000	968,738
1999	2001	997,458
2000	2002	1,004,291
2001	2003	912,506
2002	2004	1,129,319
2003	2005	947,401
2004	2006	1,070,539
2005	2007	1,084,080
2006	2008	989,508
2007	2009	974,378
2008	2010	1,025,622
2009	2011	872,006
2010	2012	992,109
2011	2013	899,245
2012	2014	971,645
2013	2015	582,090
2014	2016	709,107
Mean	**1999-2016**	**925,280**

In summary, spring Chinook salmon and steelhead hatchery propagation in the action area have both positive and negative effects on ESA-listed Wenatchee spring Chinook salmon and steelhead. All of the hatcheries in the action area have undergone section 7(a)(2) consultation and in some cases, section 10(a)(1)(A) or section 10(a)(1)(B) permitting and were found to meet the ESA standards for avoiding jeopardy. The Wenatchee spring Chinook salmon supplementation programs have contributed to the survival and recovery of UCR spring Chinook salmon. LNFH and Chiwawa River spring Chinook salmon hatchery strays likely had a negative effect (NMFS 2003a; NMFS 2003b) but those effects were reduced to low levels as reflected in the current pHOS levels. Hatchery influence on natural populations due to LNFH production, as well as steelhead and coho and summer Chinook salmon production from other hatcheries in the basin, may have reduced productivity for both ESA-listed adults and juveniles.

2.3.5. Fisheries

Another factor that NMFS considers in the environmental baseline is the effect on ESA-listed species from harvest. Regulations continue to apply to limit the number of ESA-listed UCR spring Chinook and steelhead that can be taken in fisheries. The Upper Columbia Salmon Recovery Board (UCSRB) has a firm commitment to pursue and support all possible fishing opportunities (sport and tribal) in the Upper Columbia consistent with meeting ESA obligations for ESA-listed populations (UCSRB 2007).

In the action area, fisheries are managed to selectively remove LNFH spring Chinook salmon and other hatchery salmon and steelhead that are surplus to natural spawning needs. Too many hatchery fish on the spawning grounds means the risks to natural population diversity and productivity can outweigh benefits from an increase in natural spawners. Because hatchery fish can occur together with fish from natural populations, fisheries encounter and catch-and-release natural-origin fish at some cost to the natural population (that is, take can occur incidental to the operation of the fisheries, and can result in catch-and-release mortality or other debilitation, as discussed below). This incidental take can affect the abundance, productivity, diversity, and spatial structure of natural populations. These effects are balanced against the beneficial effects of removing hatchery fish in excess of natural spawning needs and the viability status of the affected natural population (i.e., risk factors for abundance and productivity and for spatial structure and diversity; Figure 6 and **Figure 8**). The effects of fisheries targeting LNFH spring Chinook salmon have been evaluated under a separate ESA consultation (NMFS 2008b)**.**

The linking of harvest with hatchery operations in a single plan (i.e., HGMP) is a relatively new approach to hatchery implementation (UCSRB 2007). In 2013, NMFS approved a new spring Chinook salmon fishery below Tumwater Dam in the lower Wenatchee River for the purpose of removing hatchery fish that were excess to natural spawning needs while achieving criteria for protecting spring Chinook salmon diversity (pHOS criteria) (NMFS 2013a; NMFS 2013c; NMFS 2013e). The take of ESA-listed natural-origin spring Chinook salmon in the fishery is strictly limited based on the abundance of natural-origin spring Chinook salmon returning to the Wenatchee River to spawn with a cap or maximum incidental mortality (i.e., catch-and-release mortality) of 2% (i.e., 2% of the natural-origin spring Chinook salmon returning to spawn that year). In recent years, Wenatchee River spring Chinook salmon abundance has averaged between 500 and 600 fish, meaning fisheries targeting hatchery fish could commence annually until the incidental take (i.e., catch-and-release mortality) of natural-origin spring Chinook salmon has reached 10 to 12 fish. For UCR steelhead, spring Chinook salmon fisheries are also strictly regulated and limited to no more than 1 percent incidental mortality (natural-origin and hatchery-origin combined). Current estimates based upon observed steelhead encounters during the Icicle Creek recreational spring Chinook salmon fishery and expanded for lower Wenatchee River fishery indicate an annual estimated encounter rate of 53 percent (using a 10-year geometric mean of encounters). This would provide a range of adult encounters from zero to ten steelhead during the proposed fishery (hatchery- and natural-origin combined). With a 10 percent incidental catch and release (hooking) mortality rate, this would result in the maximum incidental mortality of 0.8 fish or approximately one ESA-listed steelhead annually (NMFS 2013a). Annual monitoring and reporting is required to ensure that these performance standards are met.

The harvest of UCR unlisted hatchery spring Chinook salmon within the action area varies from year-to-year depending on an abundance-based harvest rate schedule. Harvest will depend on the total abundance of upriver unlisted spring Chinook produced by the LNFH. It may be further limited by the availability of hatchery spring Chinook salmon produced by the Chiwawa and Nason safety-net programs, and the presence of ESA-listed natural-origin spring Chinook with an allowable harvest range from 5.5% to 17% for unlisted hatchery spring Chinook salmon[48] in the Wenatchee Basin. Mainstem Columbia River fisheries (outside of the Wenatchee Basin) and Icicle Creek fisheries (within the Wenatchee Basin action area) targeting Chinook salmon and steelhead produced by these programs have been evaluated and authorized under a separate opinion under the *U.S. v. Oregon* Management Agreement (NMFS 2008b).

During return years 1996 to 2006, LNFH contributed an average of 78,000 hatchery adults to the ocean, mainstem Columbia River, and tributary fisheries in the lower mainstem Wenatchee River and Icicle Creek (Table 10 in USFWS 2011c). The Icicle Creek fishery represents one of the few opportunities for tribal harvest of spring Chinook salmon in the UCR (Irving 2015a). As mentioned above, the effects of fisheries targeting LNFH spring Chinook salmon have been evaluated under a separate ESA consultation (NMFS 2008b)**.**

Fisheries on hatchery-origin steelhead also occur in the Upper Columbia and Wenatchee River Basins. Due to the timing differences in runs between species, encounters with spring Chinook salmon during steelhead fisheries in the Wenatchee River action area are rare (NMFS 2013a). However, if, in the implementation of future steelhead fisheries, adult spring Chinook salmon are encountered, incidental mortality is restricted to no more than one spring Chinook salmon handled and released. Effects of steelhead fisheries have been authorized under a separate ESA consultation (NMFS 2003b; NMFS 2003d; NMFS 2013e).

In summary, harvest in the action area results in some incidental take of ESA-listed spring Chinook and steelhead but the numbers are very small and are likely to have negligible effects on Wenatchee River spring Chinook salmon and steelhead. All of the fisheries in the action area have undergone section 7(a)(2) consultation, and in some cases section 10(a)(1)(A) permitting, and were found to meet the ESA standards for avoiding jeopardy.

[48] Out-of-basin, Carson-stock spring Chinook salmon from the LNFH.

2.3.6. Research, Monitoring, and Evaluation (RM&E)

LNFH RM&E activities are coordinated through the USFWS Mid-Columbia Fish and Wildlife Conservation Office (FWCO) and include information on hatchery returns, straying rates, biological characteristics of the hatchery stock, fish marking, tag recovery, and other aspects of the hatchery program. RM&E programs are designed and coordinated with other research and monitoring projects in the Wenatchee Basin to maximize data collection while minimizing take of listed species. Related salmon and steelhead RM&E for Wenatchee Basin hatchery programs has been previously evaluated and authorized under the Rocky Reach Habitat Conservation Plan (NMFS's section 6(c)(1) Permit No. 6007.2100); WDFW and USFWS scientific research monitoring (NMFS 2002a); and section 10(a)(1)(A) Permit No. 1196, 18118, 18120, and 18121 for UCR spring Chinook salmon (NMFS 1999a; NMFS 2004a; NMFS 2013a; NMFS 2013c; NMFS 2013d; NMFS 2013e) and Permit No. 1395 for UCR steelhead (NMFS 2003d). Impacts of related RM&E activities for the LNFH program on listed bull trout is authorized under a separate scientific permit through the USFWS (USFWS TE-702631, MFR. 0-13; USFWS 2011b).

In summary, RM&E activities in the action may increase risk to the ESA-listed spring Chinook and steelhead populations through incidental effects such as temporary disturbance or displacement during observational monitoring. The proposed action does not include research but only sampling, and marking of LNFH fish in the hatchery or observational surveys at the spillway pool that includes no incidental take of listed species. All other RM&E activities listed above that include direct and incidental take have undergone section 7(a)(2) consultations and were found to not jeopardize the species.

2.3.7. Climate Change

Climate change is expected to change salmonid habitat, with negative implications for designated critical habitats in the Pacific Northwest (ISAB 2007; Scheuerell and Williams 2005; Zabel et al. 2006). Such change is likely to include warmer air temperatures, earlier snow melt, lower summer streamflow, shift of the dominating form of precipitation from snow to rain, and warmer water temperatures (ISAB 2007)(see Section 2.2.3). The effects of climate change are likely already occurring, though it is difficult to distinguish from effects of climate variability in the near term.

Within the action area, climate change is likely to have effects similar to those expected more generally in the region, though effects on water temperature and flow may be slightly ameliorated because the Icicle Creek watershed is fed predominantly by high-elevation mountain crests, alpine lakes, and glaciers (Section 1.4). Generally, water temperature is expected to rise from 1 to 4.7°C within the Columbia Basin by 2040(ISAB 2007; Wade et al. 2013), with one model predicting a 2°C rise in water temperature for Icicle Creek (Kondo 2017x). Similarly, by 2040 in the Columbia Basin, winter precipitation is expected to increase up to 13% (ISAB 2007), and summer stream flow is expected to decrease (ISAB 2007). Specifically for Icicle Creek, the mean summer flow is expected to decrease by 332 cfs by 2040 (Kondo 2017x). See Section 2.4.2 for a detailed discussion of change in environment as a result of climate change.

2.4. Effects of the Action on ESA Protected Species and on Designated Critical Habitat

This section describes the effects of the Proposed Action, independent of the environmental baseline and cumulative effects. The methodology and best scientific information NMFS utilizes for analyzing hatchery effects is summarized first in Section 2.4.1, and application of the methodology and analysis of the Proposed Action itself follows in Section 2.4.2. Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur. Effects of the Proposed Action that are expected to occur later in time are included in the analysis in this opinion to the extent they can be meaningfully evaluated. This effects analysis is used later in this document (section 2.6) to consider the effects of the Proposed Action in the context of the status of the species, the environmental baseline, and cumulative effects to determine whether implementing the Proposed Action is likely to appreciably reduce the likelihood of survival and recovery of ESA-protected species or result in the destruction or adverse modification of their designated critical habitat.

2.4.1. Factors Considered When Analyzing Hatchery Effects

NMFS has substantial experience with hatchery programs and has developed and published a series of guidance documents for designing and evaluating hatchery programs following best available science(Hard et al. 1992; Jones Jr. 2006; McElhany et al. 2000; NMFS 2004d; NMFS 2005e; NMFS 2008a; NMFS 2011d). A key factor in analyzing a hatchery program for its effects, positive and negative, on the status of salmon and steelhead is to consider the genetic resources that reside in the program. Such genetic resources can represent the ecological and genetic diversity of a species. "Hatchery programs with a level of genetic divergence relative to the local natural population(s) that is no more than what occurs within the ESU are considered part of the ESU and will be included in any listing of the ESU"(NMFS 2005e). NMFS monitors hatchery practices for whether they promote the conservation of genetic resources included in a salmon ESU or steelhead DPS and updates the status of genetic resources residing in hatchery programs every five years. (Jones Jr. 2015) provides the most recent update of the relatedness of Pacific Northwest hatchery programs to 18 salmon ESUs and steelhead DPSs listed under the ESA. Generally speaking, hatchery programs that are reproductively connected or "integrated" with a natural population, if one still exists, contain genetic resources that represent the ecological and genetic diversity of a species and are included in an ESU or steelhead DPS.

When a hatchery program actively maintains distinctions or promotes differentiation between hatchery fish and fish from a native population, NMFS refers to the program as "isolated" (also sometimes referred to as a "segregated" program). Generally speaking, isolated hatchery programs have a level of genetic divergence, relative to the local natural population(s), that is more than what occurs within the ESU and are not considered part of an ESU or steelhead DPS. They promote domestication or selection in the hatchery over selection in the wild and select for and culture a stock of fish with different phenotypes (e.g., different ocean migrations and spatial and temporal spawning distribution) compared to the native population (extant in the wild, in a hatchery, or both). For Pacific salmon, NMFS evaluates extinction processes and effects of the Proposed Action beginning at the population scale (McElhany et al. 2000). NMFS defines population performance measures in terms of natural-origin fish and four key parameters or attributes (abundance, productivity, spatial structure, and diversity), then relates effects of the Proposed Action at the population scale to the MPG level, and ultimately to the survival and recovery of an entire ESU or DPS.

A Proposed Action is analyzed for effects, positive and negative, on the attributes that define population viability, including abundance, productivity, spatial structure, and diversity. "Because of the potential for circumventing the high rates of early mortality typically experienced in the wild, artificial propagation may be useful in the recovery of listed salmon species. However, artificial propagation entails risks as well as opportunities for salmon conservation" (Hard et al. 1992). The effects of a hatchery program on the status of an ESU or steelhead DPS "will depend on which of the four key attributes are currently limiting the ESU, and how the hatchery fish within the ESU affect each of the attributes" (NMFS 2005e). The presence of hatchery fish within the ESU can positively affect the overall status of the ESU by increasing the number of natural spawners, by serving as a source population for repopulating unoccupied habitat and increasing spatial distribution, and by conserving genetic resources. "Conversely, a hatchery program managed without adequate consideration can affect a listing determination by reducing adaptive genetic diversity of the ESU, and by reducing the reproductive fitness and productivity of the ESU" (NMFS 2005e). NMFS also analyzes and takes into account the effects of hatchery facilities (e.g., weirs and water diversions) on each VSP attribute and on designated critical habitat.

NMFS analyzes the effects of the Proposed Action on ESA-listed species and on designated critical habitat, based on the best scientific information available. This analysis allows for quantification (wherever possible) of the various factors of hatchery operation to be applied to each applicable life-stage of the listed species at the population level (described in Section 2.4.2), which in turn allows the combination of all such effects with other effects accruing to the species to determine the likelihood of posing jeopardy to the species as a whole (described in Section 2.6).

The effects, positive and negative, for the two categories of hatchery programs are summarized in Table 16. Generally speaking, effects range from beneficial to negative when programs use local fish[49] for hatchery broodstock, and from negligible to negative when programs do not use local fish for broodstock[50]. Hatchery programs can benefit population viability, but only if they use genetic resources that represent the ecological and genetic diversity of the target or affected natural population(s). When hatchery programs use genetic resources that do not represent the ecological and genetic diversity of the target or affected natural population(s), NMFS is particularly interested in how effective the program will be at isolating hatchery fish and at avoiding co-occurrence and effects that potentially disadvantage fish from natural populations.

Analysis of an HGMP or Proposed Action for its effects on ESA-listed species and on designated critical habitat depends on seven factors. These factors are:

[49] The term "local fish" is defined to mean fish with a level of genetic divergence relative to the local natural population(s) that is no more than what occurs within the ESU or steelhead DPS (70 FR 37215, June 28, 2005).
[50] Exceptions include restoring extirpated populations and gene banks.

(1) the hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock,
(2) hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities,
(3) hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas,
(4) hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor, estuary, and ocean,
(5) RM&E that exists because of the hatchery program,
(6) operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program, and
(7) fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds.

The analysis assigns an effect for each factor from the following categories:

(1) positive or beneficial effect on population viability,
(2) negligible effect on population viability, and
(3) negative effect on population viability.

The effects of hatchery fish on ESU/DPS status will depend on which of the four VSP criteria are currently limiting the ESU/DPS and how the hatchery program affects each of the criteria (NMFS 2005e). The category of effect assigned to a factor is based on an analysis of each factor weighed against each affected population's current risk level for abundance, productivity, spatial structure, and diversity, the role or importance of the affected natural population(s) in ESU or steelhead DPS recovery, the target viability for the affected natural population(s), and the environmental baseline including the factors currently limiting population viability.

Table 16. An overview of the range of effects on natural population viability parameters from the two categories of hatchery programs.

Natural population viability parameter	Hatchery broodstock originate from the local population and are included in the ESU or DPS	Hatchery broodstock originate from a non-local population or from fish that are not included in the same ESU or DPS
Productivity	**Positive to negative effect** Hatcheries are unlikely to benefit productivity except in cases where the natural population's small size is, in itself, a predominant factor limiting population growth (i.e., productivity) (NMFS 2004c).	**Negligible to negative effect** Productivity is dependent on differences between hatchery fish and the local natural population (i.e., the more distant the origin of the hatchery fish, the greater the threat), the duration and strength of selection in the hatchery, and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect).
Diversity	**Positive to negative effect** Hatcheries can temporarily support natural populations that might otherwise be extirpated or suffer severe bottlenecks and have the potential to increase the effective size of small natural populations. On the other hand, broodstock collection that homogenizes population structure is a threat to population diversity.	**Negligible to negative effect** Diversity is dependent on the differences between hatchery fish and the local natural population (i.e., the more distant the origin of the hatchery fish, the greater the threat) and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect).
Abundance	**Positive to negative effect** Hatchery-origin fish can positively affect the status of an ESU by contributing to the abundance of the natural populations in the ESU (70 FR 37204, June 28, 2005, at 37215). Increased abundance can also increase density dependent effects.	**Negligible to negative effect** Abundance is dependent on the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect), handling, RM&E, and facility operation, maintenance and construction effects.
Spatial Structure	**Positive to negative effect** Hatcheries can accelerate re-colonization and increase population spatial structure, but only in conjunction with remediation of the factor(s) that limited spatial structure in the first place. "Any benefits to spatial structure over the long term depend on the degree to which the hatchery stock(s) add to (rather than replace) natural populations" (70 FR 37204, June 28, 2005 at 37213).	**Negligible to negative effect** Spatial structure is dependent on facility operation, maintenance, and construction effects and the level of isolation achieved by the hatchery program (i.e., the greater the isolation, the closer to a negligible effect).

2.4.1.1. Factor 1. The hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock

This factor considers the risk to a natural population from the removal of natural-origin fish for hatchery broodstock. The level of effect for this factor ranges from neutral or negligible to negative.

A primary consideration in analyzing and assigning effects for broodstock collection is the origin and number of fish collected. The analysis considers whether broodstock are of local origin and the biological pros and cons of using ESA-listed fish (natural or hatchery-origin) for hatchery broodstock. It considers the maximum number of fish proposed for collection and the proportion of the donor population tapped to provide hatchery broodstock. "Mining" a natural population to supply hatchery broodstock can reduce population abundance and spatial structure. Also considered here is whether the program "backfills" with fish from outside the local or immediate area. The physical process of collecting hatchery broodstock and the effect of the process on ESA-listed species are considered under Factor 2.

2.4.1.2. Factor 2. Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities

NMFS also analyzes the effects of hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds. The level of effect for this factor ranges from positive to negative.

There are two aspects to this part of the analysis: genetic effects and ecological effects. NMFS generally views genetic effects as detrimental because we believe that artificial breeding and rearing is likely to result in some degree of genetic change and fitness reduction in hatchery fish and in the progeny of naturally spawning hatchery fish relative to desired levels of diversity and productivity for natural populations based on the weight of available scientific information at this time. Hatchery fish can thus pose a risk to diversity and to natural population rebuilding and recovery when they interbreed with fish from natural populations.

However, NMFS recognizes that beneficial effects exist as well, and that the risks just mentioned may be outweighed under circumstances where demographic or short-term extinction risk to the population is greater than risks to population diversity and productivity. Conservation hatchery programs may accelerate recovery of a target population by increasing abundance faster than may occur naturally (Waples 1999). Hatchery programs can also be used to create genetic reserves for a population to prevent the loss of its unique traits due to catastrophes (Ford 2011).

NMFS also recognizes there is considerable debate regarding genetic risk. The extent and duration of genetic change and fitness loss and the short- and long-term implications and consequences for different species (i.e., for species with multiple life-history types and species subjected to different hatchery practices and protocols) remain unclear and should be the subject of further scientific investigation. As a result, NMFS believes that hatchery intervention is a legitimate and useful tool to alleviate short-term extinction risk, but otherwise managers should seek to limit interactions between hatchery and natural-origin fish and implement hatchery practices that harmonize conservation with the implementation of treaty Indian fishing rights and other applicable laws and policies (NMFS 2011d).

2.4.1.2.1. Genetic effects

Hatchery fish can have a variety of genetic effects on natural population productivity and diversity when they interbreed with natural-origin fish. Although there is biological interdependence between them, NMFS considers three major areas of genetic effects of hatchery programs: within-population diversity, outbreeding effects, and hatchery-induced selection. As we have stated above, in most cases, the effects are viewed as risks, but in small populations these effects can sometimes be beneficial, reducing extinction risks.

First, within-population genetic diversity is a general term for the quantity, variety, and combinations of genetic material in a population (Busack and Currens 1995). Within-population diversity is gained through mutations or gene flow from other populations (described below under outbreeding effects) and is lost primarily due to genetic drift, a random loss of diversity due to population size. The rate of loss is determined by the population's effective population size (N_e), which can be considerably smaller than its census size. For a population to maintain genetic diversity reasonably well, the effective size should be in the hundreds (e.g., Lande 1987), and diversity loss can be severe if N_e drops to a few dozen.

Hatchery programs, simply by virtue of creating more fish, can increase N_e. In very small populations, this increase can be a benefit, making selection more effective and reducing other small-population risks (e.g., Lacy 1987; Whitlock 2000; Willi et al. 2006). Conservation hatchery programs can thus serve to protect genetic diversity; several programs, such as the Snake River sockeye salmon program, are important genetic reserves. However, hatchery programs can also directly depress N_e by two principal methods. One is by the simple removal of fish from the population so that they can be used in the hatchery broodstock. If a substantial portion of the population is taken into a hatchery, the hatchery becomes responsible for that portion of the effective size, and if the operation fails, the effective size of the population will be reduced (Waples and Do 1994). Two is when N_e is reduced considerably below the census number of broodstock by using a skewed sex ratio, spawning males multiple times (Busack 2007), and by pooling gametes. Pooling semen is especially problematic because when semen of several males is mixed and applied to eggs, a large portion of the eggs may be fertilized by a single male (Gharrett and Shirley 1985; Withler 1988). An extreme form of N_e reduction is the Ryman-Laikre effect (Ryman et al. 1995; Ryman and Laikre 1991), when N_e is reduced through the return to the spawning grounds of large numbers of hatchery fish from very few parents. On the other hand, factorial mating schemes, in which fish are systematically mated multiple times, can be used to increase N_e (Busack and Knudsen 2007; Fiumera et al. 2004).

Inbreeding depression, another N_e-related phenomenon, is caused by the mating of closely related individuals (e.g., siblings, half-siblings, cousins). The smaller the population, the more likely spawners will be related. Related individuals are likely to contain similar genetic material, and the resulting offspring may then have reduced survival because they are less variable genetically or have double doses of deleterious mutations. The lowered fitness of fish due to inbreeding depression accentuates the genetic risk problem, helping to push a small population toward extinction.

Outbreeding effects, the second major area of genetic effects of hatchery programs, are caused by gene flow from other populations. Gene flow occurs naturally among salmon and steelhead populations, a process referred to as straying (Quinn 1993; Quinn 1997). Natural straying serves a valuable function in preserving diversity that would otherwise be lost through genetic drift and in re-colonizing vacant habitat, and straying is considered a risk only when it occurs at unnatural levels or from unnatural sources. Hatchery programs can result in straying outside natural patterns for two reasons. First, hatchery fish may exhibit reduced homing fidelity relative to natural-origin fish (Goodman 2005; Grant 1997; Jonsson et al. 2003; Quinn 1997), resulting in unnatural levels of gene flow into recipient populations, either in terms of sources or rates. Second, even if hatchery fish home at the same level of fidelity as natural-origin fish, their higher abundance can cause unnatural straying levels into recipient populations. One goal for hatchery programs should be to ensure that hatchery practices do not lead to higher rates of genetic exchange with fish from natural populations than would occur naturally (Ryman 1991). Rearing and release practices and ancestral origin of the hatchery fish can all play a role in straying (Quinn 1997).

Gene flow from other populations can have two effects. It can increase genetic diversity (e.g., Ayllon et al. 2006), which can be a benefit in small populations, but it can also alter established allele frequencies (and co-adapted gene complexes) and reduce the population’s level of adaptation, a phenomenon called outbreeding depression (Edmands 2007; McClelland and Naish 2007). In general, the greater the geographic separation between the source or origin of hatchery fish and the recipient natural population, the greater the genetic difference between the two populations (ICTRT 2007), and the greater potential for outbreeding depression. For this reason, NMFS advises hatchery action agencies to develop locally derived hatchery broodstock. Additionally, unusual rates of straying into other populations within or beyond the population’s MPG, salmon ESU, or a steelhead DPS can have an homogenizing effect, decreasing intra-population genetic variability (e.g.(Vasemagi et al. 2005)), and increasing risk to population diversity, one of the four attributes measured to determine population viability. Reduction of within-population and among-population diversity can reduce adaptive potential.

The pHOS[51] among natural spawners is often used as a surrogate measure of gene flow. Appropriate cautions and qualifications should be considered when using this proportion to analyze outbreeding effects. Adult salmon may wander on their return migration, entering and then leaving tributary streams before spawning (Pastor 2004). These “dip-in” fish may be detected and counted as strays, but may eventually spawn in other areas, resulting in an overestimate of the number of strays that potentially interbreed with the natural population (Keefer et al. 2008). Caution must also be taken in assuming that strays contribute genetically in proportion to their abundance. Several studies demonstrate little genetic impact from straying despite a considerable presence of strays in the spawning population (Blankenship et al. 2007; Saisa et al. 2003). The causative factors for poorer breeding success of strays are likely similar to those identified as responsible for reduced productivity of hatchery-origin fish in general, e.g.,

[51] It is important to reiterate that, as NMFS analyzes them, outbreeding effects are a risk only when the hatchery fish are from a different population than the naturally produced fish. If they are from the same population, then the risk is from hatchery-influenced selection.

differences in run and spawn timing, spawning in less productive habitats, and reduced survival of their progeny (Leider et al. 1990; Reisenbichler and McIntyre 1977; Williamson et al. 2010).

Hatchery-influenced selection (often called domestication), the third major area of genetic effects of hatchery programs, occurs when selection pressures imposed by hatchery spawning and rearing differ greatly from those imposed by the natural environment and causes genetic change that is passed on to natural populations through interbreeding with hatchery-origin fish. These differing selection pressures can be a result of differences in environments or a consequence of protocols and practices used by a hatchery program. Hatchery-influenced selection can range from relaxation of selection that would normally occur in nature, to selection for different characteristics in the hatchery and natural environments, to intentional selection for desired characteristics (Waples 1999).

Genetic change and fitness reduction resulting from hatchery-influenced selection depends on: (1) the difference in selection pressures; (2) the exposure or amount of time the fish spends in the hatchery environment; and (3) the duration of hatchery program operation (i.e., the number of generations that fish are propagated by the program). For an individual, the amount of time a fish spend in the hatchery mostly equates to fish culture. For a population, exposure is determined by the proportion of natural-origin fish in the hatchery broodstock, the proportion of natural spawners consisting of hatchery-origin fish (Ford 2002; Lynch and O'Hely 2001), and the number of years the exposure takes place. In assessing risk or determining impact, all three factors must be considered. Strong selective fish culture with low hatchery-wild interbreeding can pose less risk than relatively weaker selective fish culture with high levels of interbreeding.

Most of the empirical evidence of fitness depression due to hatchery-influenced selection comes from studies of species that are reared in the hatchery environment for an extended period – one to two years – prior to release (Berejikian and Ford 2004). Exposure time in the hatchery for fall and summer Chinook salmon and Chum salmon is much shorter, just a few months. One especially well-publicized steelhead study (Araki et al. 2007; Araki et al. 2008), showed dramatic fitness declines in the progeny of naturally spawning Hood River hatchery steelhead. Researchers and managers alike have wondered if these results could be considered a potential outcome applicable to all salmonid species, life-history types, and hatchery rearing strategies, but researchers have not reached a definitive conclusion.

Besides the Hood River steelhead work, a number of studies are available on the relative reproductive success (RRS) of hatchery- and natural-origin fish (e.g., Berntson et al. 2011; Ford et al. 2012; Hess et al. 2012; Theriault et al. 2011). All have shown that, generally, hatchery-origin fish have lower reproductive success; however, the differences have not always been statistically significant and, in some years in some studies, the opposite was true. Lowered reproductive success of hatchery-origin fish in these studies is typically considered evidence of hatchery-influenced selection. Although RRS may be a result of hatchery-influenced selection, studies must be carried out for multiple generations to unambiguously detect a genetic effect. To date, only the Hood River steelhead (Araki et al. 2007; Christie et al. 2011) and Wenatchee spring Chinook salmon (Ford et al. 2012) RRS studies have reported multiple-generation effects.

Critical information for analysis of hatchery-induced selection includes the number, location, and timing of naturally spawning hatchery fish, the estimated level of gene flow between hatchery-origin and natural-origin fish, the origin of the hatchery stock (the more distant the origin compared to the affected natural population, the greater the threat), the level and intensity of hatchery selection, and the number of years the operation has been run in this way. Efforts to control and evaluate the risk of hatchery-influenced selection are currently largely focused on gene flow between natural-origin and hatchery-origin fish[52]. The Interior Columbia Technical Recovery Team (ICTRT) developed guidelines based on the pHOS (Figure 10).

More recently, the Hatchery Scientific Review Group (HSRG) developed gene-flow guidelines based on mathematical models developed by (Ford 2002) and by (Lynch and O'Hely 2001). Guidelines for isolated programs are based on pHOS, but guidelines for integrated programs are based also on a metric called proportionate natural influence (PNI), which is a function of pHOS and the proportion of natural-origin fish in the broodstock (pNOB)[53]. PNI is, in theory, a reflection of the relative strength of selection in the hatchery and natural environments; a PNI value greater than 0.5 indicates dominance of natural selective forces. The HSRG guidelines vary according to type of program and conservation importance of the population. When the underlying natural population is of high conservation importance, the guidelines are a pHOS of no greater than 5 percent for isolated programs. For integrated programs, the guidelines are a pHOS no greater than 30 percent and PNI of at least 67 percent for integrated programs (HSRG 2009b). Higher levels of hatchery influence are acceptable, however, when a population is at high risk or very high risk of extinction due to low abundance and the hatchery program is being used to conserve the population and reduce extinction risk in the short-term. (HSRG 2004) offered additional guidance regarding isolated programs, stating that risk increases dramatically as the level of divergence increases, especially if the hatchery stock has been selected directly or indirectly for characteristics that differ from the natural population. The HSRG recently produced an update report (HSRG 2014) that stated that the guidelines for isolated programs may not provide as much protection from fitness loss as the corresponding guidelines for integrated programs.

[52] Gene flow between natural-origin and hatchery-origin fish is often interpreted as meaning actual matings between natural-origin and hatchery-origin fish. In some contexts, it can mean that. However, in this document, unless otherwise specified, gene flow means contributing to the same progeny population. For example, hatchery-origin spawners in the wild will either spawn with other hatchery-origin fish or with natural-origin fish. Natural-origin spawners in the wild will either spawn with other natural-origin fish or with hatchery-origin fish. But all these matings, to the extent they are successful, will generate the next generation of natural-origin fish. In other words, all will contribute to the natural-origin gene pool.

[53] PNI is computed as pNOB/(pNOB+pHOS). This statistic is really an approximation of the true proportionate natural influence (HSRG. 2009b. Columbia River Hatchery Reform System-Wide Report. February 2009. Prepared by Hatchery Scientific Review Group. 278p.) but operationally the distinction is unimportant.

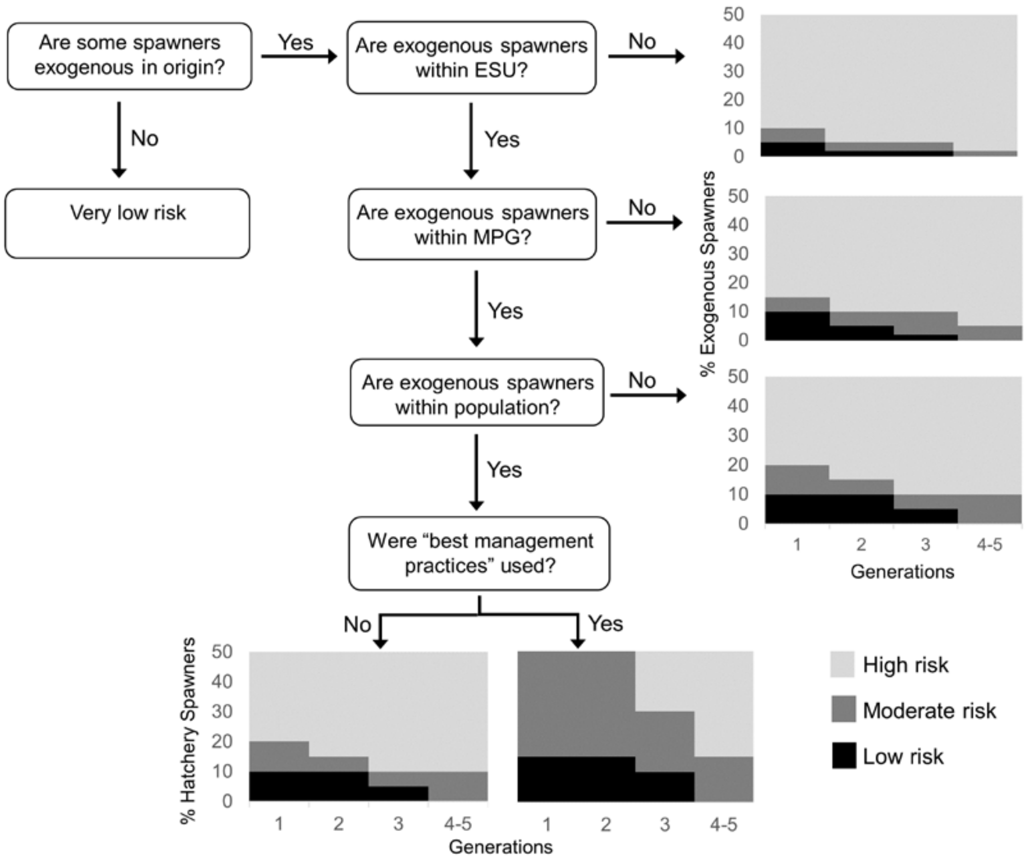

Figure 10. ICTRT (2007b) risk criteria associated with spawner composition for viability assessment of exogenous spawners on maintaining natural patterns of gene flow. Exogenous fish are considered to be all fish-hatchery-origin, and non-normative strays of natural origin.

Another HSRG team recently reviewed California hatchery programs and developed guidelines that differed considerably from those developed by the earlier group (California HSRG 2012). The California HSRG felt that truly isolated programs in which no hatchery-origin returnees interact genetically with natural populations were impossible in California, and was "generally unsupportive" of the concept. However, if programs were to be managed as isolated, they recommend a pHOS of less than 5 percent. They rejected development of overall pHOS guidelines for integrated programs because the optimal pHOS will depend upon multiple factors, such as "the amount of spawning by natural-origin fish in areas integrated with the hatchery, the value of pNOB, the importance of the integrated population to the larger stock, the fitness differences between hatchery- and natural-origin fish, and societal values, such as angling opportunity." They recommended that program-specific plans be developed with corresponding population-specific targets and thresholds for pHOS, pNOB, and PNI that reflect these factors. However, they did state that PNI should exceed 50 percent in most cases, although in supplementation or reintroduction programs the acceptable pHOS could be much higher than 5 percent, even approaching 100 percent at times. They also recommended for conservation programs that pNOB approach 100 percent, but pNOB levels should not be so high they pose demographic risk to the natural population.

Discussions involving pHOS can be problematic due to variation in its definition. Most commonly, the term pHOS refers to the proportion of the total natural spawning population consisting of hatchery fish, and the term has been used in this way in all NMFS documents. However, the HSRG has defined pHOS inconsistently in its Columbia Basin system report, equating it with "the proportion of the natural spawning population that is made up of hatchery fish" in the Conclusion, Principles and Recommendations section (HSRG 2009b), but with "the proportion of *effective* hatchery-origin spawners" in their gene-flow criteria. In addition, in their Analytical Methods and Information Sources section (appendix C in HSRG 2009b) they introduce a new term, *effective pHOS* ($pHOS_{eff)}$ defined as the effective proportion of hatchery fish in the naturally spawning population. This confusion was cleared up in the 2014 update document, where it is clearly stated that the metric of interest is effective pHOS (HSRG 2014).

The HSRG recognized that hatchery fish spawning naturally may on average produce fewer adult progeny than natural-origin spawners, as described above. To account for this difference the HSRG defined *effective* pHOS as:

$$pHOS_{eff} = RRS * pHOS_{census}$$

where $pHOS_{census}$ is the proportion of the naturally spawning population that is composed of hatchery-origin adults (HSRG 2014). In the 2014 report, the HSRG explicitly addressed the differences between *census* pHOS and *effective* pHOS, by defining PNI as:

$$PNI = \frac{pNOB}{(pNOB + pHOS_{eff})}$$

NMFS feels that adjustment of census pHOS by RRS should be done very cautiously, not nearly as freely as the HSRG document would suggest because the Ford (2002) model, which is the foundation of the HSRG gene-flow guidelines, implicitly includes a genetic component of RRS. In that model, hatchery fish are expected to have RRS < 1 (compared to natural fish) due to selection in the hatchery. A component of reduced RRS of hatchery fish is therefore already incorporated in the model and by extension the calculation of PNI. Therefore, reducing pHOS values by multiplying by RRS will result in underestimating the relevant pHOS and therefore overestimating PNI. Such adjustments would be particularly inappropriate for hatchery programs with low pNOB, as these programs may well have a substantial reduction in RRS due to genetic factors already incorporated in the model.

In some cases, adjusting pHOS downward may be appropriate, however, particularly if there is strong evidence of a non-genetic component to RRS. Wenatchee spring Chinook salmon (Williamson et al. 2010) is an example case with potentially justified adjustment by RRS, where the spatial distribution of natural-origin and hatchery-origin spawners differs, and the hatchery-origin fish tend to spawn in poorer habitat. However, even in a situation like the Wenatchee spring Chinook salmon, it is unclear how much of an adjustment would be appropriate. By the same logic, it might also be appropriate to adjust pNOB in some circumstances. For example, if hatchery juveniles produced from natural-origin broodstock tend to mature early and residualize (due to non-genetic effects of rearing), as has been documented in some spring Chinook salmon and steelhead programs, the "effective" pNOB might be much lower than the census pNOB.

It is also important to recognize that PNI is only an approximation of relative trait value, based on a model that is itself very simplistic. To the degree that PNI fails to capture important biological information, it would be better to work to include this biological information in the underlying models rather than make ad hoc adjustments to a statistic that was only intended to be rough guideline to managers. We look forward to seeing this issue further clarified in the near future. In the meantime, except for cases in which an adjustment for RRS has strong justification, NMFS feels that census pHOS, rather than effective pHOS, is the appropriate metric to use for genetic risk evaluation.

Additional perspective on pHOS that is independent of HSRG modelling is provided by a simple analysis of the expected proportions of mating types. Figure 11 shows the expected proportion of mating types in a mixed population of natural-origin (N) and hatchery-origin (H) fish as a function of the census pHOS, assuming that N and H adults mate randomly[54]. For example, at a census pHOS level of 10 percent, 81 percent of the matings will be NxN (natural-origin fish crossed with another natural-origin fish), 18 percent will be NxH (natural-origin fish crossed with hatchery-origin fish), and 1 percent will be HxH (hatchery-origin fish crossed with another hatchery-origin fish). This diagram can also be interpreted as probability of parentage of naturally produced progeny, assuming random mating and equal reproductive success of all mating types. Under this interpretation, progeny produced by a parental group with a pHOS level of 10 percent will have an 81 percent chance of having two natural-origin parents, etc.

Random mating assumes that the natural-origin and hatchery-origin spawners overlap completely spatially and temporally. As overlap decreases, the proportion of NxH matings decreases; with no overlap, the proportion of NxN matings is 1 minus pHOS and the proportion of HxH matings equals pHOS. RRS does not affect the mating type proportions directly but changes their effective proportions. Overlap and RRS can be related. For example, in the Wenatchee River, hatchery spring Chinook salmon tend to spawn lower in the system than natural-origin fish, and this accounts for a considerable amount of their lowered reproductive success (Williamson et al. 2010). In that particular situation the hatchery-origin fish were spawning in inferior habitat.

[54] These computations are purely theoretical, based on a simple mathematical binomial expansion ($(a+b)^2=a^2 + 2ab + b^2$).

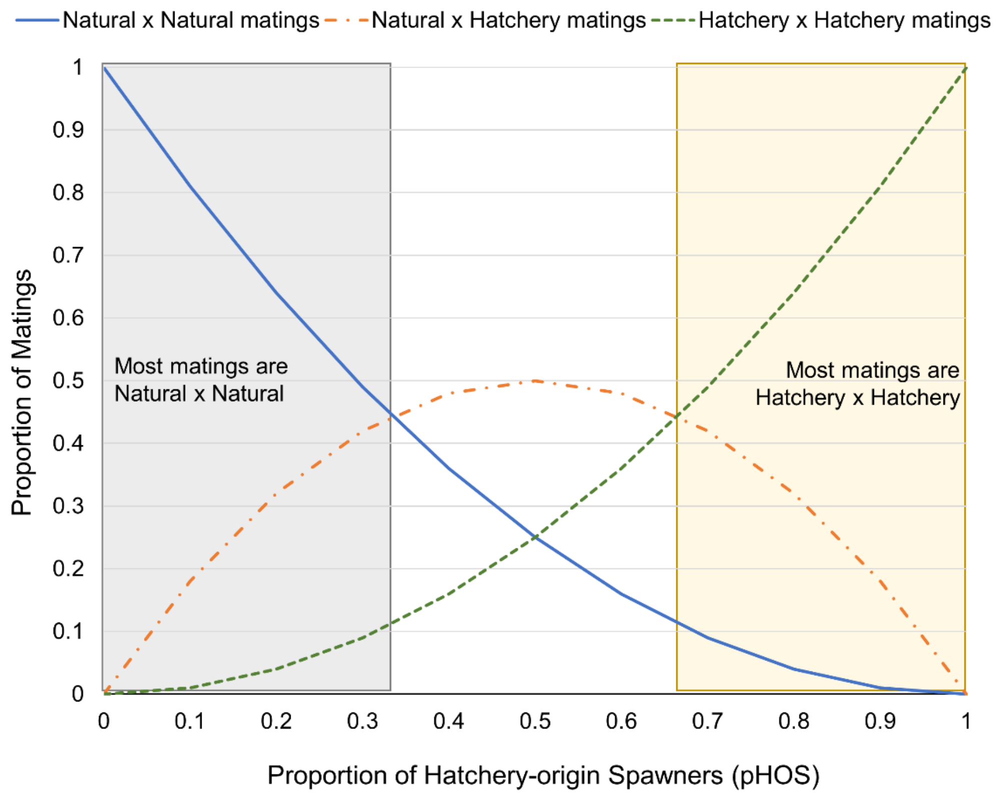

Figure 11. Relative proportions of types of matings as a function of pHOS.

2.4.1.2.2. Ecological effects

Ecological effects for this factor (i.e., hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds) refer to effects from competition for spawning sites and redd superimposition, contributions to marine-derived nutrients, and the removal of fine sediments from spawning gravels. Ecological effects on the spawning grounds may be positive or negative. To the extent that hatcheries contribute added fish to the ecosystem, there can be positive effects. For example, when anadromous salmonids return to spawn, hatchery-origin and natural-origin alike, they transport marine-derived nutrients stored in their bodies to freshwater and terrestrial ecosystems. Their carcasses provide a direct food source for juvenile salmonids and other fish, aquatic invertebrates, and terrestrial animals, and their decomposition supplies nutrients that may increase primary and secondary production (Gresh et al. 2000; Kline et al. 1990; Larkin and Slaney 1996; Murota 2003; Piorkowski 1995; Quamme and Slaney 2003; Wipfli et al. 2003). As a result, the growth and survival of juvenile salmonids may increase (Bell 2001; Bilton et al. 1982; Bradford et al. 2000; Brakensiek 2002; Hager and Noble 1976; Hartman and Scrivener 1990; Holtby 1988; Johnston et al. 1990; Larkin and Slaney 1996; Quinn and Peterson 1996; Ward and Slaney 1988).

Additionally, studies have demonstrated that perturbation of spawning gravels by spawning salmonids loosens cemented (compacted) gravel areas used by spawning salmon (e.g., (Montgomery et al. 1996). The act of spawning also coarsens gravel in spawning reaches, removing fine material that blocks interstitial gravel flow and reduces the survival of incubating eggs in egg pockets of redds.

The added spawner density resulting from hatchery-origin fish spawning in the wild can have negative consequences at times. In particular, the potential exists for hatchery-derived fish to superimpose or destroy the eggs and embryos of ESA-listed species when there is spatial overlap between hatchery and natural spawners. Redd superimposition has been shown to be a cause of egg loss in pink salmon and other species (e.g., Fukushima et al. 1998).

2.4.1.2.3. Adult Collection Facilities

The analysis also considers the effects from encounters with natural-origin fish that are incidental to broodstock collection. Here, NMFS analyzes effects from sorting, holding, and handling natural-origin fish in the course of broodstock collection. Some programs collect their broodstock from fish voluntarily entering the hatchery, typically into a ladder and holding pond, while others sort through the run at large, usually at a weir, ladder, or sampling facility. Generally speaking, the more a hatchery program accesses the run at large for hatchery broodstock – that is, the more fish that are handled or delayed during migration – the greater the negative effect on natural-origin and hatchery-origin fish that are intended to spawn naturally and on ESA-listed species. The information NMFS uses for this analysis includes a description of the facilities, practices, and protocols for collecting broodstock, the environmental conditions under which broodstock collection is conducted, and the encounter rate for ESA-listed fish.

NMFS also analyzes the effects of structures, either temporary or permanent, that are used to collect hatchery broodstock, and remove hatchery fish from the river or stream and prevent them from spawning naturally on juvenile and adult fish from encounters with these structures. NMFS determines through the analysis, for example, whether the spatial structure, productivity, or abundance of a natural population is affected when fish encounter a structure used for broodstock collection, usually a weir or ladder.

2.4.1.3. Factor 3. Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas

NMFS also analyzes the potential for competition and predation when the progeny of naturally spawning hatchery fish and hatchery releases share juvenile rearing areas. The level of effect for this factor ranges from neutral or negligible to negative.

2.4.1.3.1. Competition

Generally speaking, competition and a corresponding reduction in productivity and survival may result from direct or indirect interactions. Direct interactions occur when hatchery-origin fish interfere with the accessibility to limited resources by natural-origin fish, and indirect interactions occur when the utilization of a limited resource by hatchery fish reduces the amount available for fish from the natural population (Rensel et al. 1984). Natural-origin fish may be competitively displaced by hatchery fish early in life, especially when hatchery fish are more numerous, are of equal or greater size, take up residency before naturally produced fry emerge from redds, and residualize. Hatchery fish might alter natural-origin salmon behavioral patterns and habitat use, making natural-origin fish more susceptible to predators (Hillman and Mullan 1989; Steward and Bjornn 1990). Hatchery-origin fish may also alter natural-origin salmonid migratory responses or movement patterns, leading to a decrease in foraging success by the natural-origin fish (Hillman and Mullan 1989; Steward and Bjornn 1990). Actual impacts on natural-origin fish would thus depend on the degree of dietary overlap, food availability, size-related differences in prey selection, foraging tactics, and differences in microhabitat use (Steward and Bjornn 1990).

Specific hazards associated with competitive impacts of hatchery salmonids on listed natural-origin salmonids may include competition for food and rearing sites (NMFS 2012a). In an assessment of the potential ecological impacts of hatchery fish production on naturally produced salmonids, the Species Interaction Work Group (Rensel et al. 1984) concluded that naturally produced coho and Chinook salmon and steelhead are all potentially at "high risk" due to competition (both interspecific and intraspecific) from hatchery fish of any of these three species. In contrast, the risk to naturally produced pink, chum, and sockeye salmon due to competition from hatchery salmon and steelhead was judged to be low.

Several factors influence the risk of competition posed by hatchery releases: whether competition is intra- or interspecific; the duration of freshwater co-occurrence of hatchery and natural-origin fish; relative body sizes of the two groups; prior residence of shared habitat; environmentally induced developmental differences; and density in shared habitat (Tatara and Berejikian 2012). Intraspecific competition would be expected to be greater than interspecific, and competition would be expected to increase with prolonged freshwater co-occurrence. Hatchery smolts are commonly larger than natural-origin fish, and larger fish usually are superior competitors. However, natural-origin fish have the competitive advantage of prior residence when defending territories and resources in shared natural freshwater habitat. Tatara and Berejikian (2012) further reported that hatchery-influenced developmental differences from co-occurring natural-origin fish are variable and can favor both hatchery- and natural-origin fish. They concluded that, of all factors, fish density of the composite population in relation to habitat carrying capacity likely exerts the greatest influence.

En masse hatchery salmon smolt releases may cause displacement of rearing natural-origin juvenile salmonids from occupied stream areas, leading to abandonment of advantageous feeding stations, or premature out-migration by natural-origin juvenile salmonids. Pearsons et al. (1994) reported small-scale displacement of juvenile naturally produced rainbow trout from stream sections by hatchery steelhead. Small-scale displacements and agonistic interactions observed between hatchery steelhead and natural-origin juvenile trout were most likely a result of size differences and not something inherently different about hatchery fish.

A proportion of the smolts released from a hatchery may not migrate to the ocean but rather reside for a period of time in the vicinity of the release point. These non-migratory smolts (residuals) may directly compete for food and space with natural-origin juvenile salmonids of similar age. Although this behavior has been studied and observed, most frequently in the case of hatchery steelhead, residualism has been reported as a potential issue for hatchery coho and Chinook salmon as well. Adverse impacts of residual hatchery Chinook and coho salmon on natural-origin salmonids can occur, especially given that the number of smolts per release is generally higher; however, the issue of residualism for these species has not been as widely investigated compared to steelhead. Therefore, for all species, monitoring of natural stream areas in the vicinity of hatchery release points may be necessary to determine the potential effects of hatchery smolt residualism on natural-origin juvenile salmonids.

The risk of adverse competitive interactions between hatchery- and natural-origin fish can be minimized by:

- Releasing hatchery smolts that are physiologically ready to migrate. Hatchery fish released as smolts emigrate seaward soon after liberation, minimizing the potential for competition with juvenile naturally produced fish in freshwater (California HSRG 2012; Steward and Bjornn 1990)
- Operating hatcheries such that hatchery fish are reared to a size sufficient to ensure that smoltification occurs in nearly the entire population
- Releasing hatchery smolts in areas below those used for stream-rearing by naturally produced juveniles
- Monitoring the incidence of non-migratory smolts (residuals) after release and adjusting rearing strategies, release location, and release timing if substantial competition with naturally rearing juveniles is determined likely

Critical to analyzing competition risk is information on the quality and quantity of spawning and rearing habitat in the action area,[55] including the distribution of spawning and rearing habitat by quality and best estimates for spawning and rearing habitat capacity. Additional important information includes the abundance, distribution, and timing for naturally spawning hatchery fish and natural-origin fish; the timing of emergence; the distribution and estimated abundance for progeny from both hatchery and natural-origin natural spawners; the abundance, size, distribution, and timing for juvenile hatchery fish in the action area; and the size of hatchery fish relative to co-occurring natural-origin fish.

2.4.1.3.2. Predation

Another potential ecological effect of hatchery releases is predation. Salmon and steelhead are piscivorous and can prey on other salmon and steelhead. Predation, either direct (consumption by hatchery fish) or indirect (increases in predation by other predator species due to enhanced attraction), can result from hatchery fish released into the wild. Considered here is predation by hatchery-origin fish, the progeny of naturally spawning hatchery fish, and avian and other predators attracted to the area by an abundance of hatchery fish. Hatchery fish originating from egg boxes and fish planted as non-migrant fry or fingerlings can prey upon fish from the local natural population during juvenile rearing. Hatchery fish released at a later stage, so they are more likely to emigrate quickly to the ocean, can prey on fry and fingerlings that are encountered during the downstream migration. Some of these hatchery fish do not emigrate and instead take up residence in the stream (residuals) where they can prey on stream-rearing juveniles over a more prolonged period, as discussed above. The progeny of naturally spawning hatchery fish also can prey on fish from a natural population and pose a threat. In general, the threat from predation is greatest when natural populations of salmon and steelhead are at low abundance,

[55] "Action area" means all areas to be affected directly or indirectly by the action, and typically only those areas in which the effects of the action can be meaningfully detected and evaluated.

when spatial structure is already reduced, when habitat, particularly refuge habitat, is limited, and when environmental conditions favor high visibility.

Rensel et al. (1984) rated most risks associated with predation as unknown because there was relatively little documentation in the literature of predation interactions in either freshwater or marine areas at the time. More studies are now available, but they are still too sparse to allow many generalizations to be made about risk. Newly released hatchery-origin yearling salmon and steelhead may prey on juvenile fall Chinook and steelhead and other juvenile salmon in the freshwater and marine environments (Hargreaves and LeBrasseur 1986; Hawkins and Tipping 1999; Pearsons and Fritts 1999). Low predation rates have been reported for released steelhead juveniles (Hawkins and Tipping 1999; Naman and Sharpe 2012). Hatchery steelhead release timing and protocols used widely in the Pacific Northwest were shown to be associated with negligible predation by migrating hatchery steelhead on fall Chinook fry, which had already emigrated or had grown large enough to reduce or eliminate their susceptibility to predation when hatchery steelhead entered the rivers (Sharpe et al. 2008). Hawkins (1998) documented hatchery spring Chinook salmon yearling predation on naturally produced fall Chinook salmon juveniles in the Lewis River. Predation on smaller Chinook salmon was found to be much higher in naturally produced smolts (coho salmon and cutthroat, predominantly) than their hatchery counterparts.

Predation may be greatest when large numbers of hatchery smolts encounter newly emerged fry or fingerlings, or when hatchery fish are large relative to naturally produced fish (Rensel et al. 1984). Due to their location in the stream or river, size, and time of emergence, newly emerged salmonid fry are likely to be the most vulnerable to predation. Their vulnerability is believed to be greatest immediately upon emergence from the gravel and then their vulnerability decreases as they move into shallow, shoreline areas (USFWS 1994). Emigration out of important rearing areas and foraging inefficiency of newly released hatchery smolts may reduce the degree of predation on salmonid fry (USFWS 1994).

Some reports suggest that hatchery fish can prey on fish that are up to 1/2 their length (HSRG 2004; Pearsons and Fritts 1999), but other studies have concluded that salmonid predators prey on fish 1/3 or less their length (Beauchamp 1990; Cannamela 1992; CBFWA 1996; Hillman and Mullan 1989; Horner 1978). Hatchery fish may also be less efficient predators as compared to their natural-origin conspecifics, reducing the potential for predation impacts (Bachman 1984; Olla et al. 1998; Sosiak et al. 1979).

There are several steps that hatchery programs can implement to reduce or avoid the threat of predation:

- Releasing all hatchery fish as actively migrating smolts through volitional release practices so that the fish migrate quickly seaward, limiting the duration of interaction with any co-occurring natural-origin fish downstream of the release site.
- Ensuring that a high proportion of the population have physiologically achieved full smolt status. Juvenile salmon tend to migrate seaward rapidly when fully smolted, limiting the duration of interaction between hatchery fish and naturally produced fish present within, and downstream of, release areas.

- Releasing hatchery smolts in lower river areas near river mouths and below upstream areas used for stream-rearing young-of-the-year naturally produced salmon fry, thereby reducing the likelihood for interaction between the hatchery and naturally produced fish.
- Operating hatchery programs and releases to minimize the potential for residualism.

2.4.1.3.3. Disease

The release of hatchery fish and hatchery effluent into juvenile rearing areas can lead to transmission of pathogens, contact with chemicals, or altering of environmental parameters (e.g., dissolved oxygen) that can result in disease outbreaks. Fish diseases can be subdivided into two main categories: infectious and non-infectious. Infectious diseases are those caused by pathogens such as viruses, bacteria, and parasites. Noninfectious diseases are those that cannot be transmitted between fish and are typically caused by genetic or environmental factors (e.g., low dissolved oxygen). Pathogens can also be categorized as exotic or endemic. For our purposes, exotic pathogens are those that have no history of occurrence within state boundaries. For example, *Oncorhynchus masou* virus (OMV) would be considered an exotic pathogen if identified anywhere in Washington state. Endemic pathogens are native to a state, but may not be present in all watersheds.

In natural fish populations, the risk of disease associated with hatchery programs may increase through a variety of mechanisms (Naish et al. 2008), including:

- Introduction of exotic pathogens
- Introduction of endemic pathogens to a new watershed
- Intentional release of infected fish or fish carcasses
- Continual pathogen reservoir
- Pathogen amplification

The transmission of pathogens between hatchery and natural fish can occur indirectly through hatchery water influent/effluent or directly via contact with infected fish. Within a hatchery, the likelihood of transmission leading to an epizootic (i.e., disease outbreak) is increased compared to the natural environment because hatchery fish are reared at higher densities and closer proximity than would naturally occur. During an epizootic, hatchery fish can shed relatively large amounts of pathogen into the hatchery effluent and ultimately, the environment, amplifying pathogen numbers. However, few, if any, examples of hatcheries contributing to an increase in disease in natural populations have been reported (Naish et al. 2008; Steward and Bjornn 1990). This lack of reporting may be because both hatchery and natural-origin salmon and trout are susceptible to the same pathogens (Noakes et al. 2000), which are often endemic and ubiquitous (e.g., *Renibacterium salmoninarum,* the cause of Bacterial Kidney Disease (BKD)).

Adherence to a number of state, Federal, and/or tribal fish health policies limits the disease risks associated with hatchery programs (IHOT 1995; NWIFC and WDFW 2006; ODFW 2003; USFWS 2004b). Specifically, the policies govern the transfer of fish, eggs, carcasses, and water to prevent the spread of exotic and endemic reportable pathogens. For all pathogens, both reportable and non-reportable, pathogen spread and amplification are minimized through regular monitoring (typically monthly), removing mortalities, and disinfecting all eggs. Vaccines may provide additional protection from certain pathogens when available (e.g., *Vibrio anguillarum*).

If a pathogen is determined to be the cause of fish mortality, treatments (e.g., antibiotics) will be used to limit further pathogen transmission and amplification. Some pathogens, such as *infectious hematopoietic necrosis virus* (IHNV), have no known treatment. Thus, if an epizootic occurs for those pathogens, the only way to control pathogen amplification is to cull infected individuals or terminate all susceptible fish. In addition, current hatchery operations often rear hatchery fish on a timeline that mimics their natural life history, which limits the presence of fish susceptible to pathogen infection and prevents hatchery fish from becoming a pathogen reservoir when no natural fish hosts are present.

In addition to the state, federal, and tribal fish health policies, disease risks can be further minimized by preventing pathogens from entering the hatchery facility through the treatment of incoming water (e.g., by using ozone) or by leaving the hatchery through hatchery effluent (Naish et al. 2008). Although preventing the exposure of fish to any pathogens prior to their release into the natural environment may make the hatchery fish more susceptible to infection after release into the natural environment, reduced fish densities in the natural environment compared to hatcheries likely reduces the risk of fish encountering pathogens at infectious levels (Naish et al. 2008). Treating the hatchery effluent would also minimize amplification, but would not reduce disease outbreaks within the hatchery itself caused by pathogens present in the incoming water supply. Another challenge with treating hatchery effluent is the lack of reliable, standardized guidelines for testing or a consistent practice of controlling pathogens in effluent (LaPatra 2003). However, hatchery facilities located near marine waters likely limit freshwater pathogen amplification downstream of the hatchery without human intervention because the pathogens are killed before transmission to fish when the effluent mixes with saltwater.

Noninfectious diseases are those that cannot be transmitted between fish and are typically caused by genetic or environmental factors (e.g., low dissolved oxygen). Hatchery facilities routinely use a variety of chemicals for treatment and sanitation purposes. Hatchery effluent, such as chlorine and phosphorus levels, is monitored in conjunction with with an NPDES permit administered by the EPA. Other chemicals are discharged in accordance with manufacturer instructions. The NPDES permit also requires monitoring of settleable and suspended solids, temperature, and dissolved oxygen in the hatchery effluent on a regular basis to ensure compliance with environmental standards and to prevent fish mortality. In contrast to infectious diseases, which typically are manifest by a limited number of life stages and over a protracted time period, non-infectious diseases caused by environmental factors typically affect all life stages of fish indiscriminately and over a relatively short period of time. One group of non-infectious diseases that are expected to occur rarely in current hatchery operations are those caused by nutritional deficiencies because of the vast literature available on successful rearing of salmon and trout in aquaculture.

2.4.1.3.4. Acclimation

One factor that can affect hatchery fish distribution and the potential to spatially overlap with natural-origin spawners, and thus the potential for genetic and ecological impacts, is the acclimation of hatchery juveniles before release. “Acclimation” is the process of allowing fish to adjust to the environment in which they will be released. Acclimation of hatchery juveniles before release increases the probability that hatchery adults will home back to the release location, reducing their potential to stray into natural spawning areas. Acclimating fish for a period of time also allows them to recover from the stress caused by the transportation of the fish to the release location and by handling. (Dittman and Quinn 2008) provide an extensive literature review and introduction to homing of Pacific salmon. They note that, as early as the 19th century, marking studies had shown that salmonids would home to the stream, or even the specific reach, where they originated. The ability to home to their home or "natal" stream is thought to be due to odors to which the juvenile salmonids were exposed while living in the stream (olfactory imprinting) and migrating from it years earlier (Dittman and Quinn 2008; Keefer and Caudill 2013). Fisheries managers use this innate ability of salmon and steelhead to home to specific streams by using acclimation ponds to support the reintroduction of species into newly accessible habitat or into areas where they have been extirpated (Dunnigan 1999; Quinn 1997; YKFP 2008).

(Dittman and Quinn 2008) reference numerous experiments that indicated that a critical period for olfactory imprinting is during the parr-smolt transformation, which is the period when the salmonids go through changes in physiology, morphology, and behavior in preparation for transitioning from fresh water to the ocean (Beckman et al. 2000; Hoar 1976). Salmon species with more complex life histories (e.g., sockeye salmon) may imprint at multiple times from emergence to early migration (Dittman et al. 2010). Imprinting to a particular location, be it the hatchery, or an acclimation pond, through the acclimation and release of hatchery salmon and steelhead is employed by fisheries managers with the goal that the hatchery fish released from these locations will return to that particular site and not stray into other areas (Bentzen et al. 2001; Fulton and Pearson 1981; Hard and Heard 1999; Kostow 2009; Quinn 1997; Westley et al. 2013). However, this strategy may result in varying levels of success in regards to the proportion of the returning fish that stray outside of their natal stream. (e.g., (Clarke et al. 2011; Kenaston et al. 2001).

Having hatchery salmon and steelhead home to a particular location is one measure that can be taken to reduce the proportion of hatchery fish in the naturally spawning population. By having the hatchery fish home to a particular location, those fish can be removed (e.g., through fisheries, use of a weir) or they can be isolated from primary spawning areas. Factors that can affect the success of homing include:

- The timing of the acclimation, such that a majority of the hatchery juveniles are going through the parr-smolt transformation during acclimation
- A water source unique enough to attract returning adults
- Whether or not the hatchery fish can access the stream reach where they were released
- Whether or not the water quantity and quality is such that returning hatchery fish will hold in that area before removal and/or their harvest in fisheries.

2.4.1.4. Factor 4. Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor, in the estuary, and in the ocean

Migrating hatchery fish can also potentially affect natural-origin fish through competition, predation, and pathogen transmission resulting in disease. Based on a review of the scientific literature, NMFS' conclusion is that the influence of density-dependent interactions, such as competition, predation, and disease discussed in Factor 3, on the growth and survival of salmon and steelhead is likely small compared with the effects of large-scale and regional environmental conditions. While there is evidence that large-scale hatchery production can effect salmon survival at sea, the degree of effect or level of influence is not yet well understood or predictable. The same is true for mainstem rivers and estuaries. NMFS will watch for new research to discern and to measure the frequency, the intensity, and any effects resulting from density-dependent interactions between hatchery and natural-origin fish. In the meantime, NMFS will monitor emerging science and information and will consider re-initiation of section 7 consultation in the event that new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this consultation (50 CFR 402.16).

2.4.1.5. Factor 5. Research, monitoring, and evaluation that exists because of the hatchery program

NMFS also analyzes proposed RM&E for its effects on listed species and on designated critical habitat. The level of effect for this factor ranges from positive to negative.

Generally speaking, negative effects on the fish from RM&E are weighed against the value or benefit of new information, particularly information that tests key assumptions and that reduces uncertainty. RM&E actions can cause harmful changes in behavior and reduced survival; such actions include, but are not limited to:

- Observation during surveying
- Collecting and handling (purposeful or inadvertent)
- Holding the fish in captivity, sampling (e.g., the removal of scales and tissues)
- Tagging and fin-clipping, and observing the fish (in-water or from the bank)

2.4.1.5.1. Observing/disturbing

For some parts of the proposed studies, listed fish would be observed in-water (e.g., by snorkel surveys, wading surveys, or observation from the banks). Direct observation is the least disruptive method for determining a species' presence/absence and estimating their relative numbers. Its effects are also generally the shortest-lived and least harmful of the research activities discussed in this section because a cautious observer can effectively obtain data while only slightly disrupting fishes' behavior. Fry and juveniles frightened by the turbulence and sound created by observers are likely to seek temporary refuge in deeper water, or behind/under rocks or vegetation. In extreme cases, some individuals may leave a particular pool or habitat type and then return when observers leave the area. At times, the research involves observing adult fish, which are more sensitive to disturbance. These avoidance behaviors can be expected to be in the range of normal predator and disturbance behaviors. Redds may be visually inspected, but would not be walked on.

2.4.1.5.2. Capturing/handling

Any physical handling or psychological disturbance is known to be stressful to fish (Sharpe et al. 1998). Primary contributing factors to stress and death from handling are excessive doses of anesthetic, differences in water temperatures (between the river and holding vessel), dissolved oxygen conditions, the amount of time fish are held out of the water, and physical trauma. Stress increases rapidly if the water temperature exceeds 18 °C or dissolved oxygen is below saturation. Fish transferred to holding tanks can experience trauma if care is not taken in the transfer process, and fish can experience stress and injury from overcrowding in traps if the traps are not emptied regularly. Decreased survival can result from high stress levels because stress can be immediately debilitating, and may also increase the potential for vulnerability to subsequent challenges (Sharpe et al. 1998). Debris buildup at traps can also kill or injure fish if the traps are not monitored and cleared regularly.

2.4.1.5.3. Fin clipping and tagging

Though fin clipping and tagging fish are part of the proposed action, and can have adverse effects, these activities are performed only on non-ESA-listed Carson-stock spring Chinook salmon. Accordingly, there will be no adverse effects on ESA-listed fish as a result of these activities.

2.4.1.6. Factor 6. Construction, operation, and maintenance, of facilities that exist because of the hatchery program

The construction/installation, operation, and maintenance of hatchery facilities can alter fish behavior and can injure or kill eggs, juveniles, and adults. These actions can also degrade habitat function and reduce or block access to spawning and rearing habitats altogether. Here, NMFS analyzes changes to: riparian habitat, channel morphology, habitat complexity, in-stream substrates, and water quantity and quality attributable to operation, maintenance, and construction activities. NMFS also confirms whether water diversions and fish passage facilities are constructed and operated consistent with NMFS criteria. The level of effect for this factor ranges from neutral or negligible to negative.

2.4.1.7. Factor 7. Fisheries that exist because of the hatchery program

There are two aspects of fisheries that are potentially relevant to NMFS' analysis of the Proposed Action in a section 7 consultation. One is where there are fisheries that exist because of the Proposed Action (i.e., the fishery is an interrelated and interdependent action), and listed species are inadvertently and incidentally taken in those fisheries. The other is when fisheries are used as a tool to prevent the hatchery fish associated with the HGMP, including hatchery fish included in an ESA-listed salmon ESU or steelhead DPS, from spawning naturally. The level of effect for this factor ranges from neutral or negligible to negative.

"Many hatchery programs are capable of producing more fish than are immediately useful in the conservation and recovery of an ESU and can play an important role in fulfilling trust and treaty obligations with regard to harvest of some Pacific salmon and steelhead populations. For ESUs listed as threatened, NMFS will, where appropriate, exercise its authority under section 4(d) of the ESA to allow the harvest of listed hatchery fish that are surplus to the conservation and recovery needs of the ESU, in accordance with approved harvest plans" (NMFS 2005e). In any event, fisheries must be strictly regulated based on the take, including catch and release effects, of ESA-listed species.

2.4.2. Effects of the Proposed Action

Analysis of the Proposed Action identified that within the action area, ESA-listed species are likely to be negatively affected, and take will occur as part of two of the seven factors described in Section 2.4.1: hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities; and operation and maintenance of the hatchery facilities. Analysis of the proposed action additionally identified that one factor that is likely to have no effect, three factors that are likely to have negligible effects, and one factor that does not apply to ESA-listed spring Chinook salmon. Critical habitat is not designated for spring Chinook salmon in Icicle Creek; it is designated within the mainstem Wenatchee River and the Entiat River (within the action area). For UCR steelhead, analysis of the proposed action identified one factor that is likely to have a negative effect, four factors that are likely to have negligible effects, and two factors that do not apply to ESA-listed summer steelhead or its designated critical habitat in Icicle Creek and the Wenatchee and Entiat Rivers. An overview of the analyses is provided in Table 17.

Table 17. A summary of potential effects* of the LNFH program on UCR spring Chinook salmon and steelhead and on their designated critical habitat.

Factor[1]	Range in potential effects for this factor	Effects on UCR spring Chinook salmon	Effects on UCR steelhead
1) The hatchery program does or does not remove fish from the natural population and use them for broodstock	Negligible to negative effect	**No effect** – Spring Chinook salmon broodstock used in the program are not included in an ESA-listed ESU. Little natural production from the native spring Chinook population is thought to occur in Icicle Creek (UCSRB 2007).	**N/A[2]** – Program does not propagate steelhead.

2) Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities	Negligible to negative effect	**The net effect is Negative** – *Genetic effects* LNFH spring Chinook salmon are not intended to spawn naturally. LNFH strays in the Upper Wenatchee and Entiat Basins are likely to have a negative effect, especially considering that LNFH spring Chinook salmon are diverged from natural populations in the ESU. However, based on actual LNFH stray rates in the Upper Wenatchee and Entiat Basins this negative effect is small because the LNFH stray rate is currently $\leq$ 2%. Hatchery releases are 100 percent externally marked; a recent marking strategy will make them more identifiable from ESA-listed spring Chinook salmon and easier to remove at Tumwater Dam before they can reach upstream primary spawning and rearing locations. This results in a beneficial effect on natural-origin spring Chinook salmon. LNFH spring Chinook salmon that voluntarily enter the LNFH collection ponds will not be returned to the river resulting in a beneficial effect. *Ecological effects* The LNFH program is not likely to result in increased local competition for spawning sites, redd superimposition, and removal of fine sediments from spawning gravels because little natural production from the native spring Chinook population is thought to occur in Icicle Creek (UCSRB 2007). Remaining hatchery fish that are not collected at the fish ladder are harvested through fisheries in Icicle Creek and the lower Wenatchee River. Fisheries in Icicle Creek are particularly effective at harvesting hatchery fish resulting in beneficial and negligible effects on ESA-listed natural-origin fish. Hatchery fish that voluntarily enter the LNFH collection ponds would not be returned to the river reducing the number of LNFH fish that can stray into and spawn in other areas of the Upper Wenatchee Basin resulting in beneficial effects on natural-origin spring Chinook salmon. LNFH implements disease prevention measures and coordinates with the USFWS OFHC to reduce the possibility of disease transmission through broodstock resulting in negligible effects.	**The net effect is Negligible** – *Genetic effects* N/A – spring Chinook salmon and steelhead do not interbreed. *Ecological effects* The LNFH program is not likely to result in increased local competition for spawning sites, redd superimposition, and removal of fine sediments from spawning gravels due to differences in spawn timing between UCR spring Chinook salmon and summer steelhead, resulting in no effect. Hatchery-origin spring Chinook salmon are removed at the fish collection ladder and are not allowed to spawn naturally. LNFH surveys below the hatchery barrier to determine if any adults are present after the collection ladder is closed. Remaining hatchery fish that are not collected at the fish ladder are harvested through fisheries in Icicle Creek and the lower Wenatchee River. Fisheries in Icicle Creek are particularly effective at harvesting hatchery fish resulting in beneficial and negligible effects on ESA-listed natural-origin fish. LNFH implements disease prevention measures and coordinates with the USFWS OFHC to reduce the possibility of disease transmission through broodstock resulting in negligible effects. *Structure effects* Encounters with adult steelhead at broodstock collection facilities are < 10 fish annually. Natural-origin adult steelhead that enter the facility would be quickly returned to Icicle Creek (pre-spawn steelhead are released upstream of hatchery barriers; post spawn steelhead (i.e., kelts) are released downstream of the hatchery ladder) resulting in negligible effects (USFWS 2011c). Up to 50 juvenile *O. mykiss* may be encountered in the broodstock collection facilities and would volitionally return to or be released in Icicle Creek. If Structure 5 (S5) is closed during spring Chinook salmon broodstock collection, fish traps may entrain ESA-listed steelhead resulting in negative effects. Traps are checked twice daily to release entrained ESA-listed steelhead upstream or downstream of the structure (depending on spawning condition). If crowding is occurring or more than five steelhead are encountered in one day, the traps will be checked

		Structure effects An average of one natural-origin adult spring Chinook salmon voluntarily entered LNFH during annual broodstock collection activities resulting in negligible effects. Natural-origin spring Chinook salmon that enter the facility are tagged for future identification and returned to the lower Icicle Creek near the confluence of the Wenatchee River to spawn naturally. LNFH has seen an increase in ESA-listed hatchery-origin spring Chinook salmon at the collection ladder with average annual encounter of 21 fish from 2008 to 2016; the number of encounters may be higher than that seen in the past for future years with good returns. These hatchery-origin fish are strays from other programs and are not meant to spawn in Icicle Creek resulting in a negligible effect. If S5 is closed during spring Chinook salmon broodstock collection, fish traps may entrain ESA-listed spring Chinook salmon resulting in negative effects. Traps are checked twice daily to release entrained fish. If crowding is occurring, the traps will be checked on weekends to reduce negative effects such as passage delay, injury or mortality.	on weekends to reduce negative effects such as passage delay, injury or mortality.

3) Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas	Negligible to negative effect	**The effects are Negligible –** *Icicle Creek* – Little competition for food and space or possible premature emigration are likely to occur due to little natural production in Icicle Creek (UCSRB 2007). Although, LNFH has seen an increase in ESA-listed hatchery-origin spring Chinook salmon at the collection ladder with average annual encounter of 21 fish (range 2 to 88) from 2008 to 2016, these effects are considered negligible due to low productivity of these hatchery fish (Williamson et al. 2010; Ford et al. 2012). *Lower Wenatchee River* - Competition for food and space and predation are likely to occur at a low level because few natural spawning areas exist in the lower Wenatchee River basin below the confluence of Icicle Creek to the confluence of the Columbia River and few juvenile spring chinook salmon, of hatchery or natural-origin, use this area for rearing. NMFS analysis indicates a maximum of 21 adult equivalent mortality (effects of competition + predation) may occur on ESA-listed spring Chinook salmon. LNFH implements disease prevention measures and coordinates with the USFWS OFHC to reduce the possibility of disease transmission through hatchery juvenile releases resulting in negligible effects.	**The effects are Negligible –** *Icicle Creek & Lower Wenatchee River* - Effects due to competition for food and space or possible premature emigration are likely to be negligible because after release, hatchery fish leave for the ocean immediately and are only in the same vicinity as natural-origin steelhead fry and fingerlings for a very short duration, perhaps hours. Competition for food and space is likely to occur at a low level, though no predation is expected. NMFS analysis indicates a maximum of 6 adult equivalent mortality (from completion effects only), resulting in negligible effects on ESA-listed juvenile steelhead. Few steelhead fry use the migration corridor for hatchery smolts and steelhead smolts are too large for hatchery spring Chinook salmon to prey on. Hatchery smolts leave the Wenatchee River within hours or at most days after release and there is no expectation they will attract predators that would stay to prey on natural-origin summer steelhead. LNFH implements disease prevention measures and coordinates with the USFWS OFHC to reduce the possibility of disease transmission through hatchery juvenile releases resulting in negligible effects.

Factor[1]	Range in potential effects for this factor	Effects on UCR spring Chinook salmon	Effects on UCR steelhead
4) Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor, estuary, and ocean	Negligible to negative effect	**The effects are Negligible –** Effects are negligible at this time. Smolt releases from the LNFH program have averaged approximately five percent of the total spring Chinook salmon hatchery production (including releases from Washington, Oregon, and Idaho, combined) and less than 0.05 percent of all juvenile salmonids in the CR Basin. Upon release into the wild, following a year of hatchery rearing, fewer than half of these fish survive the journey to the Pacific Ocean to join tens of millions of other juvenile salmon and steelhead.	**The effects are Negligible –** Effects are negligible at this time. Smolt releases from the LNFH program have averaged approximately five percent of the total spring Chinook salmon hatchery production (including releases from Washington, Oregon, and Idaho, combined) and less than 0.05 percent of all juvenile salmonids in the CR Basin. Upon release into the wild, following a year of hatchery rearing, fewer than half of these fish survive the journey to the Pacific Ocean to join tens of millions of other juvenile salmon and steelhead.
5) RM&E that exists because of the hatchery program	Positive to negative effect	**The net effect is Negligible –** The information provided by RM&E will be beneficial by informing adaptive management of the LNFH spring Chinook salmon program. The effect of observational sampling on ESA-listed spring Chinook salmon is expected to be negligible; effects on natural-origin fish are expected to be small and transitory, not rising to levels that would impede survival or increase physiological functions beyond normal avoidance levels. Monitoring below the hatchery barrier to determine if any adults are present after the collection ladder is closed would continue. USFWS will monitor the incidence of non-migratory smolts (residuals) from the hatchery. Monitoring of post-release survival and behavior of LNFH smolts would be beneficial to determine the speed of emigration and the level of residualism in Icicle Creek and the lower Wenatchee River Basin.	**The effects are Negligible** – The effect of observational sampling on ESA-listed steelhead is expected to be negligible. Changes in behavior of natural-origin fish are expected to be small and transitory, not rising to levels that would impede survival or increase physiological functions beyond normal avoidance levels. USFWS will monitor the incidence of non-migratory spring Chinook salmon smolts (residuals) after release from the hatchery. Monitoring of post-release survival and behavior of LNFH smolts would be beneficial to determine the speed of emigration and the level of residualism in Icicle Creek and the lower Wenatchee River Basin.

6) Construction, operation, and maintenance of facilities that exist because of the hatchery program	Negligible to negative effect	**The net effect is Negative** – The net effect on UCR spring Chinook salmon is negative but these effects are considered small because: (1) Icicle Creek is a minor spawning area for the ESA-listed Wenatchee spring Chinook salmon population (UCSRB 2007), (2) the majority of spawners are likely hatchery-derived (e.g., Carson stock) (NMFS 1999a), (3) little productivity from the natural-origin population is believed to occur (UCSRB 2007), and (4) despite the current increase in ESA-listed hatchery-origin strays, their relative reproductive success would likely be lower than the natural-origin spawners in Icicle Creek (Williamson et al. 2010; Ford et al. 2012). The LNFH primary intake does not comply with NMFS' current screening criteria for anadromous salmonid facility passage design; ESA-listed spring Chinook salmon have been entrained and killed. Since 2010, temporary screening has been implemented to prevent adult spring Chinook salmon from entering the conveyance channel at Structure 1 (S1). By May 2023, the primary diversion intake would be screened, meeting NMFS criteria for protecting anadromous salmonids (NMFS 2011a). Updated fish salvage procedures are in place to release entrained fish and reduce the negative effects from passage delay, injury or mortality. LNFH & COIC share a point of diversion at RM 4.5. Negative effects include entrainment, passage delay, injury, and mortality. ESA-listed species can exit the point of diversion; the upwelling chamber is checked twice daily to release trapped fish. If S5 is closed during broodstock collection; traps are checked twice daily to release entrained fish and reduce negative effects from passage delay, injury, or mortality. Instream structures 1, 2 and 5 negatively affect ESA-listed spring Chinook salmon through entrainment, limited access or delayed passage, increased summer flow temperatures, as well as injury and mortality. The LNFH has adopted a collective instream flow goal of 100 cfs in Icicle Creek. Up to 42 cfs would be diverted year round at S1. Supplemented flows of up to 50 cfs from Snow/Nada Lake Reservoirs would occur in August –	**The net effect is Negative** – No to negligible effects would occur to ESA-listed adult steelhead. Negligible to negative effects would occur to ESA-listed juveniles using Icicle Creek for migration and rearing. The primary intake on the LNFH's point of diversion and water withdrawal system does not comply with NMFS's current screening criteria for anadromous salmonid facility passage design; ESA-listed steelhead have been entrained and killed. By May 2023, the primary diversion intake would be screened, meeting NMFS criteria for protecting anadromous salmonids (NMFS 2011a). Updated fish salvage procedures are in place to release entrained fish and reduce negative effects such as injury or mortality. LNFH & COIC share a point of diversion at RM 4.5. Negative effects include entrainment, passage delay, and mortality. A temporary exit for ESA-listed species has been implemented at the point of diversion; the upwelling chamber is checked twice daily to release trapped fish. Instream structures 1, 2, and 5 negatively affect ESA-listed steelhead and critical habitat through entrainment, limited access or delayed upstream passage, increased summer flow temperatures, as well as harm and mortality. If S5 is closed during broodstock collection, traps are checked twice daily to release entrained fish and reduce negative effects from passage delay, injury, or mortality. The LNFH has adopted a collective instream flow goal of 100 cfs in Icicle Creek. Up to 42 cfs would be diverted year round at S1. Supplemented flows of up to 50 cfs from Snow/Nada Lake Reservoirs would occur in August – September resulting in a larger beneficial effect from RM 5.7 to RM 4.5 and smaller beneficial effects from RM 4.5 to RM 2.8 such as increased flows and decreased water temperatures. When the LNFH may deviate from the collective instream flow goal in order to meet fish production, increased effects on steelhead at S1 may occur including passage delay, decreased water quantity and quality, increased summer flow temperatures, reduced habitat and prey availability as well as harm and mortality, particularly during a dry water year or

		September resulting in larger beneficial effects from RM 5.7 to RM 4.5 and smaller beneficial effects RM 4.5 to RM 2.8 such as increased flows and decreased water temperature as a result of water diversions. When the LNFH must deviate from this collective instream flow goal in order to meet fish production, effects on natural-origin spring Chinook salmon productivity are negative. Negative effects may occur including passage delay, decreased water quantity, increased summer flow temperatures, reduced habitat and prey availability as well as harm and mortality, particularly during a dry water year or times of drought. The overall effect from reduced flows at S1 is likely to be negative but considered small because Icicle Creek is a minor spawning area for spring Chinook salmon and influenced by hatchery-origin spawners (within ESU and outside ESU). The LNFH has adopted a collective instream flow goal of 100 cfs in the Icicle Creek historical channel year round. Proposed stream flows in Icicle Creek historical include a 60 / 40 instream flow split at the historical and hatchery channels. Re-routing of water at S2 has the potential to strand fish (loss of connectivity to upstream or downstream areas), cause passage delay, reduce habitat and prey availability as well as cause harm or mortality. In years when the LNFH deviates from this 100 cfs collective instream flow goal in order to meet fish production (instream daily flow goals of 40 cfs in October, 60 cfs in November – February, and 80 cfs in March), negative effects on spring Chinook salmon productivity may occur, particularly during dry water or drought years. In addition, S2 would not be operating in August resulting in beneficial effects on any juvenile spring Chinook salmon. In September, if the natural flow remaining after subtracting the amount of water diverted by the LNFH and all water users is less than 60 cfs, the LNFH will not route more water into the hatchery channel than the volume of its Snow/Nada Lake storage release (up to 50 cfs) minus the withdrawal from Snow Creek by IPID and diversion at Structure 1 (up to 42 cfs) resulting in further beneficial effects on any juvenile spring Chinook salmon.	times of drought. The LNFH has adopted a collective instream flow goal of 100 cfs in the Icicle Creek historical channel year round at S2. Proposed stream flows in Icicle Creek historical include a 60 / 40 instream flow split at the historical and hatchery channels. Re-routing of streamflow at S2 has the potential to strand fish (loss of connectivity to upstream or downstream areas), cause passage delay, reduce habitat and prey availability, as well as cause harm or mortality. In years when the LNFH deviates from this 100 cfs collective instream flow goal in order to meet fish production (i.e., instream daily flow goals of 40 cfs in October, 60 cfs November - February, and 80 cfs in March), negative effects on steelhead productivity may occur, particularly during dry water or drought years. In addition, S2 would not be operated for aquifer recharge in August resulting in beneficial effects on juvenile steelhead. In September, if the natural flow remaining after subtracting the amount of water diverted by the LNFH and all water users is less than 60 cfs, the LNFH will not route more water into the hatchery channel than the volume of its Snow/Nada Lake storage release (up to 50 cfs) minus the withdrawal from Snow Creek by IPID and diversion at Structure 1 (up to 42 cfs) resulting in further beneficial effects on juvenile steelhead. In March, S2 would only be operated if adult steelhead have not been detected in Icicle Creek resulting in beneficial effects. Habitat PCEs that would be affected are freshwater spawning, rearing, and migration. Effects on steelhead freshwater spawning are likely to be negligible. However, reduced flows in the Icicle Creek historical channel would interfere with functional PCEs for juvenile rearing and migration, and would have negative effects on designated critical habitat since Icicle Creek is a major spawning area that supports a high number of steelhead redds in the Wenatchee Basin (10%). Maintenance activities conducted on S1 & 5 have negative effects on water quantity during low flows. Maintenance of S1 & S5 interferes with functional PCEs that support rearing and migration. Negative effects include increased sedimentation and turbidity, increased water temperatures, stranding of juvenile fish (loss of connectivity to upstream or downstream areas), passage delay, and mortality.

		Habitat PCEs that would be affected are freshwater spawning, migration, and rearing. Effects on freshwater spawning PCEs are likely to be negative but small. Negative effects on freshwater juvenile rearing, and migration PCEs are also likely to occur but are considered small because (1) Icicle Creek is a minor spawning area for the ESA-listed Wenatchee spring Chinook salmon population (UCSRB 2007), (2) the majority of spawners are likely hatchery-derived (e.g., Carson stock) (NMFS 1999a), (3) little productivity from the natural-origin population is believed to occur (UCSRB 2007), and (4) despite the current increase in ESA-listed hatchery-origin strays, their relative reproductive success would likely be lower than for natural-origin spawners in Icicle Creek (Williamson et al. 2010; Ford et al. 2012). Maintenance activities conducted on S1 & 5 have negative effects on water quantity during low flows. Maintenance of S1 & S5 interferes with functional PCEs that support rearing and migration. Negative effects include increased sedimentation and turbidity, increased water temperatures, stranding of juvenile fish, passage delay, and mortality. Hatchery effluent is treated before returned. The average hatchery effluent is less than 1 percent (0.81) per day. Hatchery effluent may affect water quality and quantity but effects are likely to be small; both are monitored to assess impacts on ESA-listed species.	Hatchery effluent is treated before it is returned to the river. During cleaning activities, the average hatchery effluent is less than 1 percent (0.81) annually per day. Hatchery effluent may affect water quality and quantity but effects are likely to be small; both are monitored to assess impacts on ESA-listed species.

Factor[1]	Range in potential effects for this factor	Effects on UCR spring Chinook salmon	Effects on UCR steelhead
7) Fisheries that exist because of the hatchery program	Positive to negative effect	**N/A** Fisheries are included in Section 2.3, the environmental baseline. Terminal fisheries on LNFH fish have been evaluated and authorized in a separate opinion (NMFS 2008b) and are incorporated by reference.	**N/A** Fisheries are not included in Section 2.3, the environmental baseline. Terminal fisheries on LNFH fish have been evaluated and authorized in a separate opinion (NMFS 2008b) and are incorporated by reference.

[1] The framework NMFS followed for analyzing effects of the hatchery program is described in Section 2.4.1of this opinion.
[2] NA = Not applicable.
* This table is a summary of effects, and the effects on each life stage are described in the text below.

2.4.2.1. Factor 1. The hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock

Not applicable for both UCR spring Chinook salmon and UCR steelhead: The proposed action uses spring Chinook salmon of Carson stock that are not included in the ESA-listed UCR Spring-Run Chinook Salmon ESU. The proposed action does not remove fish from the natural-origin population for broodstock since little natural production from the native spring Chinook population occurs in Icicle Creek (UCSRB 2007). LNFH fish are not intended to spawn naturally and they offer no conservation value to ESA-listed UCR spring Chinook salmon or steelhead.

2.4.2.2. Factor 2. Hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities

Negative effect on UCR spring Chinook salmon, negligible for UCR steelhead: As described below, hatchery fish and the progeny of naturally spawning hatchery fish on the spawning grounds, and encounters with natural-origin and hatchery-origin fish at adult collection facilities, are expected to have negative but low effects on ESA-listed spring Chinook salmon. Hatchery fish and their progeny on the spawning grounds and encounters with natural-origin and hatchery-origin fish at collection facilities would be negligible for UCR steelhead.

2.4.2.2.1. Genetic effects

NMFS generally views genetic effects as detrimental because artificial breeding and rearing is likely to result in some degree of genetic change and fitness reduction in hatchery fish and their progeny resulting in negative effects, particularly if they interbreed with fish from natural populations. Information that NMFS is particularly interested in is the number, location, and timing of naturally spawning hatchery fish, the estimated level of gene flow between hatchery fish and fish from natural populations, and the origin and history of the hatchery stock. The more distant the origin compared to the affected natural population the greater the threat, the level, and intensity of hatchery selection.

Regarding outbreeding effects that may occur within or outside the basin, NMFS evaluated the benefits and risks from interactions on the spawning grounds between fish derived from LNFH production and fish from natural-origin populations and concluded that this factor may have a negative effect on ESA-listed spring Chinook salmon. The LNFH spring Chinook salmon program uses broodstock that does not originate from the same ESU. Although natural straying preserves diversity that may otherwise be lost through genetic drift or in re-colonizing vacant habitat, straying can be a risk when it occurs at unnatural levels or from unnatural sources.

LNFH-origin spring Chinook salmon are from an out-of-basin source (i.e., Carson stock derivative). This can have genetic implications when program fish spawn with natural-origin spring Chinook salmon, both in Icicle Creek and in other areas. In the case of Icicle Creek, the USFWS proposes to close Structure 5 when 50 spring Chinook salmon are observed passing above Structure 5 during broodstock collection activities. It is likely that many of these fish would be of LNFH-origin, so the proportion of natural spawners that are of hatchery out-of-basin stock is likely to be large. However, the overall number of spawners in Icicle Creek is a small proportion of the Wenatchee population; because of this, and because there is low likelihood that any progeny produced in Icicle Creek would, upon return as adults, stray into other areas of the Wenatchee Basin, the potential for adverse genetic effects, while possibly large in Icicle Creek, is not substantial outside Icicle Creek.

LNFH-origin spring Chinook salmon may also stray to other areas in the basin, posing a potential threat to ESA-listed Wenatchee spring Chinook salmon population diversity and productivity through gene flow[56]. The proportion of hatchery-origin fish among natural spawners is used as a surrogate measure of gene flow. The LNFH spring Chinook salmon hatchery program has established high standards for limiting pHOS and has implemented new and aggressive measures to comply with the above standards, using a mix of coded-wire tagging and adipose fin removal (ad clipping). Coded-wire tags (CWTs) are currently the accepted method for regional level estimation of LNFH spring Chinook salmon stray rates and harvest contribution inside and outside the Wenatchee basin (USFWS 2011c). Beginning in brood year 2000, LNFH-origin spring Chinook salmon smolts were 100% adipose-clipped and tagged with an average CWT rate of 33% (range 11% to 59%) (Hall 2014). Since then, CWT-tagging rates of LNFH have been systematically reduced to 18%, starting with brood year 2008. This has reduced the number of LNFH fish that are mistakenly classified as hatchery-origin ESA-listed spring Chinook salmon from supplementation programs intercepted at Tumwater Dam while still maintaining stray rate monitoring and harvest contribution (Section 2.3.4).

In 2009, in cooperation with WDFW, the LNFH staff began collecting, sorting, and selectively passing returning adults above Tumwater Dam as a means of controlling the number of hatchery-origin fish in upstream spawning areas. Under the proposed action, all LNFH spring Chinook salmon would be adipose fin-clipped, so at Tumwater Dam, all adipose fin-clipped adult spring Chinook salmon lacking a coded-wire tag (CWT) would be classified as LNFH origin spring Chinook salmon strays, and removed from the Upper Wenatchee Basin. Another means of reducing straying to the upper basin was program reduction. Beginning with brood year 2010, LNFH production was reduced from 1.625 to 1.2 million smolts in an effort to improve juvenile hatchery rearing conditions. Improvements in juvenile rearing conditions may also lead to improved homing fidelity and imprinting success, which may further lead to a reduction in observed LNFH origin spring Chinook salmon stray rates to the Upper Wenatchee Basin.

Estimated numbers of encounters of LNFH-origin fish and the proportion in the Upper Wenatchee escapement from 2004 to 2015 are presented in Table 18. The incidence of LNFH-origin spring Chinook salmon in the upper basin was at most 3.2% (range 0.8% - 3.2%), and overall, during this period, has averaged less than 1% of the Upper Wenatchee spring Chinook salmon escapement. The CWT expansion provides an estimate of hatchery straying that may be somewhat larger than actually occurs because it does not subtract out adults removed during adult management activities at Tumwater Dam. NMFS does not presently consider gene flow from the proposed action to pose a serious or large negative risk to listed spring Chinook salmon in the Upper Wenatchee Basin. The USFWS intends to refine their methodology for verifying pHOS in the Upper Wenatchee Basin.

[56] Gene flow can cause outbreeding depression and loss of among-population diversity in natural salmon populations from non-local hatchery-origin fish.

Another important consideration in analyzing outbreeding effects is straying by LNFH-origin spring Chinook salmon outside the Wenatchee Basin. The only area outside the Wenatchee Basin where LNFH-origin fish appear with any consistency is the Entiat Basin, raising the possibility of risk from LNFH gene flow to the ESA-listed Entiat spring Chinook salmon population. According to a USFWS review of the Entiat Basin spring Chinook spawning population, from 2000 to 2013 (Cooper 2013), LNFH-origin spring Chinook salmon have on average composed 2% of the spring Chinook salmon population on the Entiat Basin spawning rounds, ranging from 0 (in 10 of 14 years) to 10% (Table 19). In the environmental baseline, NMFS assesses the LNFH-origin fish contribution to pHOS in the context of total pHOS from all hatchery sources.

Table 18. Estimated number of LNFH spring Chinook salmon strays into the Upper Wenatchee River from 2004-2015 (USFWS 2017a).

LNFH = Leavenworth National Fish Hatchery; UW SCS = Upper Wenatchee spring Chinook salmon; % = percent; CWT = coded-wire tag

Return Year	UW SCS[1]	UW SCS Carcass Recoveries[1]	% Carcasses Sampled[2]	LNFH-origin CWT Recoveries[3]	LNFH-origin Estimated Recoveries[4]	LNFH-origin Expanded Recoveries[5,6]	LNFH-origin % in UW SCS Escapement[7]
2004	1,607	407	29.0	5	17	51	3.2
2005	1,472	828	56.3	2	4	4	0.3
2006	940	484	51.5	0	0	0	0.0
2007	2,007	517	25.8	0	0	0	0.0
2008	2,141	765	35.7	5	14	42	2.0
2009	2,195	409	18.6	2	11	17	0.8
2010	1,761	382	21.7	1	5	20	1.1
2011	2,990	290	9.7	0	0	0	0.0
2012	2,436	792	32.5	0	0	0	0.0
2013	2,022	588	29.1	0	0	0	0.0
2014	1,389	430	31.0	0	0	0	0.0
2015	1,663	380	22.9	1	4	20	1.2
Estimated mean	**1,885**	**523**	**30.3**	**2**	**5**	**13**	**0.8**

[1] Escapement estimates from (Hillman et al. 2016)
[2] Percentage of Upper Wenatchee River spring Chinook salmon carcass recoveries in the Upper Wenatchee spring Chinook escapement.
[3] CWT recoveries from the Regional Mark Information System: http://www.rmpc.org/.
[4] Number of estimated recoveries derived by percentage of carcasses sampled and CWT recoveries.
[5] Estimated recoveries/CWT rate (not shown).
[6] This is considered a conservative estimate because it does not include removal of adipose-clipped, non-coded-wire-tagged spring Chinook salmon removed at Tumwater Dam from 2009 to 2015.
[7] Percentage of LNFH-origin fish in Upper Wenatchee River spring Chinook salmon escapement derived by expanded recoveries and Upper Wenatchee River spring Chinook salmon escapement estimates.

Table 19. Proportionate contribution of spring Chinook salmon hatchery programs to Entiat spring Chinook salmon escapement 2000-2016(Cooper 2014; USFWS 2017b).

Hatchery Program	**Return Year**																	
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014***	**2015**	**2016***	**Mean**
WNFH	0.13	0.06	0.00	0.03	0.00	0.00	0.04	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Methow	0.06	0.01	0.02	0.03	0.00	0.00	0.02	0.03	0.00	0.00	0.04	0.00	0.00	0.04	0.00	<0.01	0.00	0.02
ENFH	0.44	0.22	0.18	0.22	0.48	0.36	0.07	0.19	0.20	0.38	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.16
LNFH	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.07**	**0.05**	**0.00**	**0.00**	**0.04**	**0.00**	**0.10**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**
Chiwawa	0.06	0.01	0.14	0.03	0.00	0.08	0.13	0.13	0.31	0.09	0.07	0.36	0.28	0.18	0.00	0.05	0.00	0.11
ODFW (various)	0.00	0.00	0.00	0.03	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.01
Sawtooth	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	<0.01
Dworshak	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.21	0.00	0.00	0.02	0.00	0.05	0.00	0.00	0.00	0.00	0.03
Nez Perce	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	<0.01	0.00	<0.01
Clearwater	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	<0.01
Cle Elum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	<0.01
Total	0.69	0.30	0.34	0.32	0.52	0.50	0.57	0.55	0.51	0.51	0.25	0.46	0.34	0.22	0.04	0.18	0.16	0.38
Non-ENFH Total	0.25	0.08	0.16	0.10	0.04	0.14	0.50	0.36	0.31	0.13	0.20	0.46	0.34	0.22	0.04	0.18	0.16	0.22

* No coded-wire tags were recovered during spawning ground surveys for these years, so the origin of hatchery fish was not determined.

From 2000 to 2013, pHOS (from all sources) averaged 44% in the Entiat Basin, composed of hatchery-origin fish from several sources. The largest contributor was the Entiat National Fish Hatchery (ENFH) and the next largest source was the Chiwawa River spring Chinook salmon program. The spring Chinook salmon program at the ENFH has been discontinued and practices of the Chiwawa spring Chinook salmon program thought to cause higher levels of straying have been remedied (Section 2.3.4).

NMFS concludes that the Entiat Basin spawning escapement should be monitored annually to ensure that stray levels decline as expected (because of termination of one program and changes to another) and that the LNFH contribution stray rates remain at or below existing levels. The USFWS would continue to monitor CWT and PIT recovery information, refine their methodology for verifying pHOS, and report on the extent and location of straying within and outside the Entiat Basin. This monitoring is expected to also provide information on levels and proportion of straying of LNFH fish into the Entiat Basin.

In summary, at this time, gene flow from LNFH spring Chinook salmon into ESA-listed spring Chinook salmon populations within or outside of the Wenatchee Basin has a low-magnitude negative effect. The proposed action does not allow captured adult LNFH spring Chinook salmon to be returned to the river. LNFH staff would survey below the hatchery barrier and in the pool below the fish collection ladder after the ladder is closed to confirm the absence of hatchery-origin fish in the creek. Continued monitoring for LNFH strays at Tumwater Dam within the Upper Wenatchee Basin, and in the Entiat Basin, would ensure this conclusion of low-risk continues to hold true.

For UCR steelhead, genetic effects are not a concern because spring Chinook salmon and steelhead do not interbreed.

2.4.2.2.2. Ecological effects

NMFS analyzes competitive interactions on the spawning ground between adults from a natural population and hatchery fish, including such issues as the potential for hatchery fish to compete for spawning sites with fish from natural populations. Although the fidelity of LNFH adults returning to the hatchery is believed to be high (Section 2.4.2.2.1; Hall (2014)), UCR spring Chinook salmon are endangered and even low numbers of LNFH adults interacting with the Wenatchee population could have negative ecological effects (USFWS 2011c). Because little natural production from spring Chinook salmon included in the ESU is thought to occur in Icicle Creek (UCSRB 2007), there is little opportunity for competitive effects on the spawning grounds. Though about 50 spring Chinook salmon that would be allowed above Structure 5 (some of which may be of natural-origin) may compete on the spawning grounds with natural-origin spring Chinook salmon or superimpose redds, the Icicle Creek component of the population is a small proportion of the Wenatchee population, and so whatever amount of competition might occur would not have a meaningful impact on the population. In the Entiat River, to which LNFH salmon are also known to stray, no data exist as to whether hatchery spring Chinook salmon superimpose redds on those of natural-origin spring Chinook salmon, but some such effects are likely to occur. Since pHOS is likely to remain low based on historical escapement rates (i.e., pHOS for receiving populations at 0.8% - 3.4%; see Table 19), the co-occurrence with natural-origin fish is expected to be rare; that is, up to 3.4% of the fish in other basins are of LNFH-origin, and only a subset of the remaining 96.6% is of natural-origin (because the remaining spawners include fish originating from other hatchery programs), so the chance of LNFH-origin fish interacting with a natural-origin fish is low, resulting in negligible effects from superimposition or destruction of eggs and embryos of natural-origin Wenatchee or Entiat spring Chinook salmon as a result of the LFNH program.

Additionally, the proposed hatchery program would continue to implement the necessary adult management actions to remove LNFH hatchery-origin spring Chinook salmon from the Upper Wenatchee Basin by using the LNFH fish collection ladder and Tumwater Dam. Treaty tribal and non-tribal salmon fisheries conducted in Icicle Creek and the lower Wenatchee River, as described in the HGMP (USFWS 2011c) and previous fishery consultations (NMFS 2008b; NMFS 2013e), are very effective at removing LNFH spring Chinook salmon from the action area.

The LNFH would continue to implement disease prevention measures, and coordinates with the USFWS OFHC to reduce the possibility of disease transmission through broodstock resulting in negligible effects. A minimum of 210 collected spring Chinook salmon would be tested annually for all reportable aquatic viruses and bacteria. In addition, all females spawned would be individually tested for *Renibacterium salmoninarum*, the causation agent of BKD. All compromised post-spawn adults would be buried in an earthen pit on LNFH property and all eggs would be destroyed (USFWS 2011c). Discussions about disease effects on rearing areas are in Subsection 2.4.2.3.1.1.

For UCR steelhead, the LNFH program would have a negligible ecological effect. For streams outside of Icicle Creek, pHOS from LNFH-origin fish is low (ranging between 0.08% to 3.2%) (Section 2.4.2.2.1), so there is little risk of hatchery-origin fish superimposing or destroying the eggs or embryos of ESA-listed natural-origin steelhead. Within Icicle Creek, most of LNFH spring Chinook salmon would be removed at the fish collection ladder and would not be allowed to spawn naturally; LNFH staff would survey below the hatchery barrier to determine if any adults are present after the collection ladder is closed. In addition, the proposed action is not likely to result in competition for spawning sites or redd superimposition anywhere in the action area because there are substantial differences in the spatial and temporal spawning distributions between LNFH spring Chinook salmon and the Wenatchee steelhead population. Even if spatial and temporal spawning differences between adult spring Chinook salmon and steelhead did not exist, the USFWS would continue to monitor and report the number, location, and timing of naturally spawning hatchery fish in the Upper Wenatchee and Entiat Basins in order to inform future hatchery program production levels and minimize the ecological risk to the UCR steelhead populations.

2.4.2.2.3. Broodstock Collection Facility Effects

Another effect of the proposed action is inadvertent encounters with ESA-listed spring Chinook salmon during LNFH spring Chinook salmon broodstock collection, both natural-origin and hatchery-origin. Here, NMFS evaluates broodstock collection activities associated with the proposed action (Gale 2012a; USFWS 2011c), and we find that this factor will have a negligible effect on ESA-listed spring Chinook salmon and steelhead, as summarized in Table 20 and discussed below.

Table 20. Summary of natural-origin encounters associated with broodstock collection.

	Maximum Handled & Released	**Maximum Incidental Mortality**
	Annually	
UCR spring Chinook salmon		
NO adult[1]	3	Up to 3
ESN HO adult[2]	120	Up to 120
EC HO adult[3]	50	Up to 50
UCR steelhead		
Adult[4]	<10	0
Juvenile	50	0

[1] All natural-origin spring Chinook salmon handled during broodstock collection are released immediately into Icicle Creek by verifying adipose fin is present and reading scale pattern to determine natural origin.
[2] ESA-listed hatchery-origin safety-net fish are identified by the absence of an adipose fin with a CWT. Fish may be inadvertently incorporated into LNFH broodstock because a proportion of ESA-listed supplementation safety-net and LNFH fish are identically marked (i.e., adipose fin-clipped).
[3] ESA-listed hatchery-origin conservation fish are determined as adipose present with a CWT. All hatchery fish are scanned for CWTs or other identifying tags/marks and the USFWS coordinates with other hatchery programs to determine disposition of fish.
[4] These adult steelhead include all ESA-listed steelhead (i.e., both natural and hatchery fish)

The proposed action proposes collecting approximately 1,000 LNFH-origin spring Chinook salmon as broodstock in their hatchery collection ponds for spawning. Encounters with ESA-listed natural-origin spring Chinook salmon adults entering the broodstock collection ponds or being trapped in the fish trap at Structure 5 are rare, on average one fish per year (USFWS 2011c). After verifying their origin through examination of scale patterns, these fish would be immediately returned to upstream areas of Icicle Creek to continue their migration and avoid harvest impacts.

From 2008 to 2016, ESA-listed adult natural-origin spring Chinook salmon encounters remained roughly the same, at one fish or less per year. Any natural-origin spring Chinook salmon encountered in the holding ponds are immediately returned to Icicle Creek. However, broodstock collection in recent years (2010 to 2014) has shown an increase in the handling of hatchery fish that are ESA-listed (Gale 2012a; Gale 2012b), averaging 31 fish per year (range 3 to 88) during those years. These hatchery fish were predominantly from the Chiwawa Spring Chinook Salmon Hatchery Program (Gale 2012a). The Chiwawa spring Chinook salmon hatchery program also clips the adipose fins of all listed spring Chinook salmon from their safety-net component. Since it is difficult to identify adipose fin-clipped adult spring Chinook salmon hatchery fish as being from the Wenatchee supplementation program (i.e., those without a CWT) during LNFH broodstock collection and spawning activities, these fish were sometimes inadvertently incorporated into the LNFH broodstock. When encounters with ESA-listed hatchery spring Chinook salmon occur, the USFWS will hold ESA-listed conservation program hatchery-origin fish (identified by CWT and adipose fin present) fish up to three days in order to identify and coordinate with the associated hatchery program operators to determine the appropriate action for those fish (e.g., return to conservation programs for broodstock in safety-net programs, release in downstream areas, surplus). The remaining ESA-listed safety-net hatchery-origin spring Chinook salmon, because they cannot be visually differentiated from LNFH production, may be inadvertently incorporated into the LNFH broodstock or excessed for tribal subsistence and ceremonial purposes. Inadvertent lethal and non-lethal spring Chinook salmon take during broodstock collection activities is described in Section 2.8.1.1, Table 40.

Hatchery broodstock collection would have negligible effects on ESA-listed natural-origin spring Chinook salmon because encounters are rare, and very little mortality during annual collection has occurred. Up to three natural-origin spring Chinook salmon are anticipated to be encountered annually, assuming a worst case scenario based on recent historical encounters. For example, 1 natural-origin spring Chinook salmon was encountered in 2016, though the 2016 spring Chinook salmon run size at Bonneville Dam was lower than the 10-year average; so, the encounters at the hatchery could be higher during a year with high spring Chinook salmon run size. Although encounters with ESA-listed hatchery spring Chinook salmon have shown an increase from 2011 to 2013 compared to previous years, the LNFH would identify these hatchery spring Chinook salmon to the extent possible during spawning activities, and no more than 170 hatchery-origin spring Chinook salmon are expected to be encountered. Between 2008 and 2016, an average of 21 hatchery-origin spring Chinook salmon were encountered during broodstock collection, with the highest encounter being 88 fish in 2011; we analyze the effect of encountering up to 170 hatchery-origin spring Chinook salmon (120 for ESA-listed hatchery strays from the safety-net program and 50 for ESA-listed hatchery-strays from the conservation program) to account for a large return year. Because these hatchery-origin spring Chinook salmon are strays from other hatchery programs and are not meant to spawn in Icicle Creek, removal of these fish from Icicle Creek contributes to adult management of other hatchery programs. This number will be reduced further by the recent: (1) marking strategy to better differentiate LNFH origin and Wenatchee River supplementation fish, and (2) reduction in the source of these stray hatchery-origin fish—Chiwawa spring Chinook salmon hatchery production has been reduced by 70% (Miller 2012). The USFWS Mid-Columbia Fish and Wildlife Conservation Office would continue to conduct sampling and determine the origin of spring Chinook salmon encountered during broodstock collection as defined in the broodstock collection take summary (Gale 2012a).

For UCR steelhead, the LNFH program causes only negligible effects as a result of hatchery structures associated with broodstock collection activities. In the course of collecting LNFH spring Chinook salmon for hatchery broodstock, the proposed action is expected to annually handle fewer than 10 ESA-listed, natural- or hatchery-origin adult steelhead total and up to 50 juvenile *O. mykiss*, for broodstock collection, with no incidental mortality associated with adults and juveniles (M. Cappellini, USFWS, personal communication, July 5, 2017) (Section 2.8.1.2; Table 41). All steelhead encounters associated with broodstock collection are for fish that volunteer into the LNFH holding ponds and for the fish encountered in the fish trap at Structure 5. An adult steelhead has entered the water delivery system a handful of times in the past, and we assume 10 or fewer encounters, which would likely apply in larger return years. Under the proposed action, all steelhead encountered during spring Chinook salmon broodstock collection would be documented, and released immediately back into Icicle Creek.

Effects of incidental take of ESA-listed spring Chinook salmon and steelhead are considered negligible. An average of fewer than one ESA-listed natural-origin spring Chinook salmon and 21 ESA-listed hatchery-origin spring Chinook salmon are encountered per year, though up to 3 natural-origin spring Chinook salmon, 120 hatchery-origin spring Chinook salmon from the safety-net programs, and 50 hatchery-origin spring Chinook salmon from the conservation programs may be encountered. Due to overall recent reductions in the Wenatchee supplementation program production, the number of ESA-listed hatchery-origin spring Chinook salmon encountered at LNFH is expected to decrease in the future. Fewer than 10 ESA-listed natural and hatchery-origin adult steelhead and up to 50 juveniles are encountered per year, and the same level of take is anticipated to occur in the future.

In summary, LNFH broodstock collection is directed at unlisted hatchery-origin spring Chinook salmon adults returning to LNFH that are not part of the ESA-listed UCR Spring-Run Chinook Salmon ESU. Although ESA-listed natural-origin and hatchery-origin spring Chinook salmon[57] and steelhead are encountered during LNFH spring Chinook salmon broodstock collection, these encounters are rare (e.g., one natural-origin spring Chinook salmon encountered in 2008 and in 2016 and zero steelhead since 2011). The very small numbers of natural-origin spring Chinook salmon encountered are identified and returned to the river unharmed to spawn naturally. Steelhead are also returned to the river unharmed. Disposition of hatchery-origin spring Chinook salmon will be coordinated with the associated hatchery program operators to determine the appropriate action for those fish (e.g., return to supplementation programs for broodstock, release in downstream areas, surplus).

Based on the above information and the updated fish salvage procedures included in the proposed action, this factor poses a negligible effect on the spring Chinook salmon and steelhead in the action area.

2.4.2.3. Factor 3. Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas

Negligible effect on UCR spring Chinook salmon, UCR steelhead: The release of hatchery-origin fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas is expected to have negligible effects on ESA-listed juveniles.

The most important considerations here are competition and predation by juvenile hatchery fish and premature emigration of natural-origin fish caused by hatchery fish. NMFS evaluated the risks from interactions in juvenile rearing areas between fish derived from LNFH production and ESA-listed spring Chinook salmon and steelhead.

The 2015 Opinion used an index approach (i.e., modeled potential of competition or predation, rather than actually modeling the interaction) to analyze ecological effects of hatchery-origin fish on natural-origin fish. This approach was taken in the 2015 Opinion because the more sophisticated PCD Risk model (Pearsons and Busack 2012) was not fully functional. Since then, the issues with PCD Risk have been resolved. Moreover, the 2015 Opinion did not directly analyze the effect of LNFH-origin juveniles on Chinook salmon in the lower Wenatchee River, which the new model version now incorporates.

[57] Though the Carson stock, used for the proposed action, is not part of the ESA listing of the UCR Spring-run Chinook Salmon ESU, the proposed action encounters other ESA-listed hatchery-origin spring Chinook salmon, such as the fish from the Chiwawa and Nason Creek conservation programs.

Parameters and their values considered in the new PCD Risk model version are shown in Table 21-Table 23. For our model runs, we assumed a 100-percent population overlap between hatchery spring Chinook salmon and all natural-origin species present. Hatchery spring Chinook salmon are released from LNFH in late April and may overlap with natural-origin Chinook salmon (spring and summer races) and steelhead in the action area. However, our analysis is limited to assessing effects on listed species, and this limits overlap of those species in certain areas. In addition, our model does not consider ecological effects on age-0 steelhead because steelhead spawn from March to June with a peak from April to May in the action area (Busby et al. 1996), with fry emergence from June through August. Thus, it is unlikely that any age-0 steelhead would have emerged in time to interact with the hatchery spring Chinook salmon smolts as they migrate downstream (Table 37).

Table 21. Parameters in the PCD Risk model that are the same across all programs. All values from HETT (2014) unless otherwise noted.

Parameter	Value
Habitat complexity	0.1
Population overlap	1.0
Habitat segregation	0.3 for Chinook salmon 0.6 for steelhead
Dominance mode	3
Piscivory	0.0023 for Chinook salmon 0 for steelhead
Maximum encounters per day	3
Predator:prey length ratio for predation	0.25[1]

1 Daly et al. (2009)

Table 22. Age and size of listed natural-origin salmon and steelhead encountered by juvenile hatchery fish after release.

Species	Age Class	Size in mm (CV)
Chinook salmon	0	43 (0.16)
	1	97 (0.09)
Steelhead	1	123 (0.13)
	2	165 (0.05)

Source: (HETT 2014).

Table 23. LNFH fish parameter values for the PCD Risk model.

Parameters	Value
Release number	1,200,000
Size (CV)	142 (0.14) mm
Survival to mouth of Wenatchee River	0.97

Travel time to mouth of Wenatchee River	2 days
Average temperature at release site	5.5°C

Sources: (HETT 2014; USFWS 2011c)

The degree of effect resulting from ecological interactions between hatchery-origin fish and natural-origin fish is largely influenced by the amount of time that the fish co-occur within a reach. That is, LNFH-origin fish are likely to have an ecological effect on natural-origin spring Chinook salmon and steelhead as they travel down to the mouth of the Wenatchee River[58]. Because these ecological interactions cannot be directly observed or counted, it is difficult to quantify such effect. Thus, travel time and rate are reasonable indicators for how much ecological interaction occurs in a system. Currently, the mean travel time from release to the mouth of the Wenatchee River (total of 28.4 RM) for LNFH-origin juveniles is 2 days (HETT 2014), though the travel time can vary depending on environmental conditions. This equates to a travel time of 14.2 RM/day, while taking 3 days would equate to 9.4 RM/day.

Based on the information above, our model results show that LNFH-origin juveniles are likely to have a larger effect on UCR Chinook salmon than on UCR steelhead. The maximum numbers of fish lost are also shown in Table 24 and would not change if more natural-origin fish were present throughout the action area, since the model assumes that all possible interactions are exhausted. These maximum numbers of lost juveniles equate to about 21 Chinook salmon and 6 steelhead adult equivalents, calculated using SARs from the Nason Creek spring Chinook program (0.00465; Grant County PUD et al. 2009) and from the Wenatchee steelhead program (0.0105; PUD and WDFW 2009); we use these SARs because fish from these programs are likely to have life history traits similar to their natural-origin counterparts.

Table 24. Maximum numbers and percentage of natural-origin salmon and steelhead lost to competition with and predation by hatchery-origin steelhead smolts released as a result of the Proposed Action.

	Chinook salmon		**Steelhead**	
	Pred.	**Comp.**[1]	**Pred.**	**Comp.**
Number lost by interaction type	2800	1822	0	530
Total Number	**4622**		**530**	
Adult Equivalents[2]	**21**		**6**	

[1] "Competition" as used here is the number of natural-origin fish lost to competitive interactions assuming that all competitive interactions that result in body weight loss are applied to each fish until death occurs (i.e., when a fish loses 50% of its body weight). This is not reality, but does provide a maximum mortality estimate using these parameter values.

[58] While these LNFH-origin fish are likely to continue having ecological interactions with natural-origin spring Chinook salmon and steelhead after reaching mainstem Columbia River, the level of effect is too small to analyze because LNFH-origin fish are joined by other hatchery-origin spring Chinook salmon from the Methow, Winthrop, Chief Joseph, Chiwawa, and Nason Creek programs.

[2] This was calculated by using the smolt-to-adult survival rates for hatchery fish of each species (see above text) and multiplying by the total number of fish lost. However, this calculation does not account for compensatory survival. If compensatory survival occurs, then the adult equivalents calculated here are likely an overestimate.

Using the most recent abundance of natural-origin spring Chinook salmon from NWFSC (2015) for the Wenatchee River populations (Table 3), the adult equivalent value for Chinook salmon would equate to a 3.8 percent (21/545) reduction in potential adult natural-origin spawners during the juvenile life stage from the Wenatchee River population of the UCR Spring Chinook Salmon ESU. This value also indicates a 1.9 (21/1,090) percent loss of potential adult natural-origin spawners from the whole ESU. Similarly, a 0.6 percent (6/1,025; Table 5) reduction in potential adult natural-origin spawners during the juvenile life stage from the Wenatchee River population of the UCR Steelhead DPS can be expected, which equals a reduction in 0.3 percent (6/2011) from the whole DPS.

Of note, the model is likely overestimating the encounters with natural-origin fish, thus overestimating adverse effects on the ESU, especially natural-origin spring Chinook salmon. For example, our model considers all Chinook runs together, so it is likely that some of the juvenile Chinook salmon preyed upon and/or competed with are unlisted summer Chinook salmon. In addition, some natural-origin juveniles in Icicle Creek may be progeny of other hatchery-origin fish (e.g., Carson stock).

Residual hatchery spring Chinook salmon are not explicitly accounted for in our model at this time. However, surveys have been performed in Icicle Creek and in the Wenatchee River that show that LNFH-origin spring Chinook salmon are not likely to residualize. In 2000 and 2001, the YN conducted a feasibility and risk study in the Wenatchee Basin for the coho reintroduction program[59] in order to determine and minimize the level of adverse ecological interaction of hatchery coho salmon with native species when released in mid-Columbia River tributaries, including Icicle Creek. Icicle Creek was snorkeled from the hatchery release site (RM 2.8) to the mouth three times from July through August in 2000 and once in July 2001. In 2000 and 2001, very few spring Chinook salmon hatchery yearlings were encountered during the coho salmon surveys (five and zero fish, respectively) (Murdoch et al. 2007). In August 2004, the YN and USFWS conducted two comprehensive snorkel surveys from the LNFH head gate downstream in Icicle Creek and in the lower Wenatchee River, including river reaches near Tumwater Dam and the towns of Dryden, Cashmere, and Monitor. The surveys found only four spring Chinook salmon (<1%) hatchery yearling residuals (i.e., 0.00034% of all hatchery smolts) in Icicle Creek four months after smolt release (Murdoch et al. 2011). Thirty-two spring Chinook salmon hatchery yearlings were found in the lower Wenatchee River (river reach Dryden to Cashmere),

[59] The YN has since implemented this program. The effects of that program are discussed in NMFS. 2014a. Endangered Species Act - Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Mid-Columbia Coho Salmon Restoration Program: Operation and Construction. June 26, 2014. NMFS Consultation No.: NWR-2011-05645. 144p. and in NMFS. 2017b. Endangered Species Act - Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation Mid-Columbia Coho Salmon Restoration Program: Operation and Construction. 2/28/2017. NMFS Consultation No.: WCR-2015-3778. 123p.. That program uses LNFH for portions of broodstock collection, partial egg incubation (until eggs are eyed), juvenile acclimation, and release. Currently, the program acclimates up to 500,000 juveniles at LNFH, which is anticipated to be reduced in the future ibid..

but it is not likely that all of these fish encountered are LNFH-origin because the yearlings from the spring Chinook salmon hatchery safety-net supplementation programs in the Wenatchee Basin also pass through this reach. While juvenile LNFH fish could be moving to and residualizing in other tributaries within the Wenatchee Basin, it is not likely, if it occurs at all. Moreover, the likelihood that all of these residualized yearlings (including in Icicle Creek and in the Wenatchee River) survive to have an effect on natural-origin juveniles is likely to be low, if any survive at all. Natural-origin spring Chinook salmon yearlings and steelhead are already actively migrating to the ocean by the time they reach lower stream areas in Icicle Creek and the Wenatchee River where hatchery fish are released to emigrate downstream. While the natural fish may well encounter the LNFH outmigrating smolts and pre-smolts that may choose not to outmigrate, little measurable displacement is expected to occur because the natural-origin fish are smolted and on their way to the ocean.

Overall, NMFS has no doubt that LNFH spring Chinook salmon and natural-origin fish co-mingle for short periods during hatchery releases. The evidence we have, however, indicates that the effects on spring Chinook salmon and steelhead natural populations from any co-mingling are negligible. Best management practices at LNFH for rearing and acclimation help isolate hatchery fish and limit the co-occurrence of hatchery and natural-origin fish and any ecological interactions. Spring Chinook salmon would be acclimated and released at a size determined to result in a fish that is in good health, migrates to the ocean rapidly, and generates adult escapement to sustain the program and provide harvest opportunity (USFWS 2011a). The proposed action would produce pre-smolts and smolts that actively migrate shortly after or upon release, reducing the amount of time that they can interact with ESA-listed UCR spring Chinook salmon and steelhead juveniles in Icicle Creek and in the lower mainstem Wenatchee River. LNFH spring Chinook salmon would be released at a size and life stage that encourages quick migration and steelhead and spring Chinook salmon species tend to use different parts of the mainstem habitat. Based on the information above, NMFS concludes that predation and competition effects on the ESA-listed Wenatchee spring Chinook salmon and steelhead populations from the release of spring Chinook salmon pose only slight negligible risk to these populations, and, thus, do not substantially limit the probability of survival or recovery of these populations.

2.4.2.3.1.1. Disease

Some major diseases identified in salmonids from the Upper Columbia River are Bacterial Kidney Disease (BKD) and Infectious Hematopoietic Necrosis (IHN). Both are caused by pathogens—the first, a bacterium (*Renibacterium salmoninarum*), and the second, IHN virus. In addition, freshwater ich (*Ichthyophthirius multifiliis*), caused by a parasite, is a common disease at LNFH. All treatments are performed in accordance with (IHOT 1995). Specifically, all females spawned are individually tested for *Renibacterium salmoninarum*, and all eggs and accompanying containers are disinfected with iodine solution during the water hardening process following fertilization (USFWS 2011c). There has not been a BKD or IHN breakout at LNFH in the past several years, with the last outbreak in 2014 for IHN (Kondo 2017i).

From 2013 to 2016, the maximum numbers of treatments per year for ich were 60 treatments, typically occurring from end of May through August, for the adult ponds and 52 treatments (of one raceway), typically occurring from mid-to end of August through the first week of October, for juvenile raceways (Kondo 2017v). Ich is treated using formalin, and the effects of formalin in the hatchery effluent is discussed further in Subsection 2.4.2.6.

In addition, the LNFH program is intensively managed to prevent disease transmission (USFWS 2011c). The LNFH coordinates with USFWS's OFHC, now with a veterinarian on station, and juveniles would also be monitored monthly throughout the rearing period (Section 2.4.2.2.2). Bird exclusion devices would be used on all rearing units to minimize the spread of disease through predation (USFWS 2011c). Prior to release, all juveniles would be tested for pathogens at the minimum assumed prevalence level of five percent (USFWS 2011c), which is likely to have negligible effects on UCR spring Chinook salmon and steelhead.

2.4.2.4. Factor 4. Hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor, estuary, and ocean

Negligible effect on UCR spring Chinook salmon, UCR steelhead: Best available information does not indicate that the proposed action at LNFH would exacerbate density-dependent effects on ESA-listed species in the mainstem Columbia River, in the estuary, or in the Pacific Ocean.

NMFS has been investigating this factor for some time. The proposed recovery plan for Snake River Salmon (NMFS 1995) described the issue in this manner: There is intense debate over the issues of carrying capacity and density-dependent effects on natural populations of salmon. However, there is little definitive information available to directly address the effects of ecological factors on survival and growth in natural populations of Pacific salmon. Thus, many of the ecological consequences of releasing hatchery fish into the wild are poorly defined. The proposed recovery plan called on hatchery operators and funding entities to "limit annual releases of anadromous fishes from Columbia Basin hatcheries", and, in fact, releases have declined substantially. Hatchery releases for the entire Columbia Basin now vary between 130 and 145 million fish annually compared to a previous annual production of approximately 200 million fish.

More recently, NMFS has reviewed the literature for new and emerging scientific information over the role and the consequences of density-dependent interactions in estuarine and marine areas. While there is evidence of density-dependent effects affecting salmon survival, the currently available information does not support a meaningful causal link to a particular category of hatchery program. The SCA for the FCRPS opinion (NMFS 2008d) and the September 2009 FCRPS Adaptive Management Implementation Plan (AMIP)(NMFS 2009a) both concluded that available knowledge and research abilities are insufficient to discern any important role or contribution of hatchery fish in density-dependent interactions affecting salmon and steelhead growth and survival in the mainstem Columbia River, the Columbia River estuary, and the Pacific Ocean.

In February 2015, the ISAB[60] released a lengthy report on density dependence[61] in the Columbia River (ISAB 2015) that concludes that density dependence exists, and discusses the contribution

[60] The ISAB consists of a panel of 11 experts that advise the Council, NOAA Fisheries, and Columbia River Basin Indian Tribes.
[61] Density dependence defines the relationship between population density and population growth rate.

of hatchery releases to density-dependent effects. The ISAB report cites strong evidence that robust salmon and steelhead runs are exceeding habitat limits (i.e., carrying capacity) in some areas. According to the ISAB, density dependence is now evident in most of the ESA-listed salmon and steelhead populations examined in the report (primarily UCR and Snake Chinook salmon and steelhead) and appears strong enough to constrain their recovery and additional expansion of spatial distribution (ISAB 2015). This finding is true of populations with strong hatchery influences and those with minimal or no hatchery influence. Results show that current estimates of carrying capacity (5 to 9 million adult fish per year) prior to the development of hydroelectric dams is much less than previously published estimates (7.5 to 16 million adult fish per year) (ISAB 2015). Today, much of the habitat is shared with hatchery fish and numerous non-native species[62]. While hatcheries are capable of boosting runs that spawn naturally, these supplementation programs may be overwhelming the habitat in some areas. This, combined with fewer historical numbers of fish in the basin than previously thought, and continued environmental conditions, such as climate change, chemicals, and intensified land use, results in reduced habitat carrying capacity over time (ISAB 2015). Management actions such as habitat restoration, passage improvement, and judicious harvest are needed to account for these conditions and potentially reduce some of their effects (ISAB 2015). The report concluded there is little direct evidence of density-dependent interactions between hatchery and natural-origin juvenile salmonids in the Columbia River estuary and ocean because of the lack of carefully designed experimental studies (ISAB 2015). For a more detailed discussion of this report, see (NMFS 2017c).

Our conclusion, based on available information, is that hatchery production on the scale proposed in this action and considered in this opinion would have a negligible effect on the survival and recovery of the UCR Spring-run Chinook Salmon ESU. From 2002 to 2011, hatchery smolt releases from the LNFH program have averaged approximately five percent of the total spring Chinook salmon hatchery production (including releases from Washington, Oregon, and Idaho, combined) and less than 0.05 percent of all juvenile salmonids in the Columbia River Basin (Busack 2012). Upon release into the wild, following a year of hatchery rearing, fewer than half of these fish survive the journey to the Pacific Ocean to join tens of millions of other juvenile salmon and steelhead. There is CWT recovery information from fish harvest at sea, but these data “do not give us insight into fish behavior nor inter-specific interactions among stocks in the ocean” (USFWS 2009).

Consequently, as the proposed action contributes so little to the potential issue (e.g., LNFH is not a hatchery supplementation program and has production levels that are meant to contribute to harvest), and the science does not show a likelihood of impacts generally, NMFS believes that the proposed action is not likely to contribute to density-dependent effects on the UCR Spring-run Chinook Salmon ESU and UCR Steelhead DPS in the migration corridor, in the estuary, and in the Pacific Ocean. Therefore, the effects are likely negligible.

NMFS will continue to monitor emerging science and information and will reinitiate section 7(a)(2) consultation in the event that new information (e.g., further review of the 2015 ISAB

[62] In fact, a study cited by the ISAB stated that non-native fish species equal or outnumber native species in Washington, Oregon, and Idaho.

report) reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not considered in this consultation (50 CFR 402.16).

2.4.2.5. Factor 5. Research, monitoring, and evaluation that exists because of the hatchery program

Negligible effect on UCR spring Chinook salmon, UCR steelhead: The net effect of hatchery research, monitoring, and evaluation included in the proposed action is expected to be negligible.

The proposed action addresses the five factors that NMFS takes into account when it analyzes effects of hatchery RM&E (Section 2.4.1. Research, monitoring, and evaluation). It includes M&E to monitor compliance with this opinion and to inform future decisions over how the hatchery program can make adjustments that further reduce risks to ESA-listed spring Chinook salmon and steelhead. No new research on LNFH production is proposed at this time. Effects on ESA-listed spring Chinook salmon and steelhead that are likely to occur due to hatchery M&E activities are expected to be negligible because they are strictly observational surveys; no handling of ESA-listed spring Chinook salmon or steelhead would occur. Any changes in natural-origin fish behavior due to M&E activities are expected to be small and transitory, not rising to levels that would impede survival or increase physiological functions beyond normal avoidance levels.

The USFWS proposes to continue to monitor CWT and PIT recovery information and report on the extent and location of straying within and outside the Wenatchee Basin at previously established monitoring sites. This activity includes the continued monitoring of the genetic effects analyzed in Section 2.4.2.2.1. Any effects from the continued CWT and PIT recovery monitoring are expected to mainly be observational and effects are anticipated to be negligible. Direct handling of ESA-listed species at established monitoring sites are evaluated and authorized under a separate ESA consultation (NMFS 2013a).

The LNFH staff would monitor and report the number, location, and timing of naturally spawning hatchery fish in order to verify that the program is not exceeding the effects analyzed in this opinion, which will inform continued operation of the program. This activity includes continued broodstock collection activities that are analyzed in Section 2.4.2.2.3. Sampling and marking of non-ESA-listed Carson-stock spring Chinook salmon[63] within the LNFH does not constitute a take. However, the proposed activities may cause incidental injury and mortality to ESA-listed natural and hatchery-origin spring Chinook salmon and steelhead during broodstock collection activities for which these effects are included above in Section 2.4.2.2.3. Proposed M&E would also include annual surveys to determine the prevalence of adult hatchery spring Chinook salmon downstream of the hatchery barrier and near the fish collection ladder after broodstock collection is completed. Observation effects include temporary disturbance or displacement of ESA-listed species. Observational effects on ESA-listed UCR spring Chinook salmon and steelhead from these surveys are expected to be short, transitory, and unmeasurable. Thus, observational effects on UCR spring Chinook salmon and steelhead are expected to be negligible.

[63] Sampling and marking is conducted for genetic analysis, disease pathology, smolt condition, fin clipping and/or tagging, etc.

The USFWS also proposes to continue to monitor hatchery smolt travel time and survival through the Columbia River corridor using data from PIT (passive integrated transponder) tag detection at mainstem dams after release and report the rate of non-migratory smolts (residuals) annually. This activity can supplement the continued monitoring of the ecological effects of hatchery juvenile releases analyzed in Section 2.4.2.3—some small proportion of the tags detected at mainstem dams would be from the LNFH program, and could provide some information to help understand metrics related to outmigration and residualism, for example. More likely, such data would be used to evaluate outmigration and other behaviors of larger groups of fish more representative of the basin as a whole. Effects from the continued PIT detection monitoring are strictly observational only (i.e., no handling of fish) and are expected to be negligible.

Surface water diversions, as described in the proposed action, are expected to have a negative effect on natural-origin steelhead and on designated critical habitat (Section 2.4.2.6). The USFWS would also monitor fish passage conditions, including entrained and released ESA-listed spring Chinook salmon and steelhead in the water delivery system. Effects from the continued monitoring and evaluation of surface water diversions would be observational only, and, thus, are expected to be negligible. Handling of any entrained ESA-listed species is addressed in Section 2.4.2.6.

Hatchery actions also must be assessed for masking effects. For these purposes, masking occurs when hatchery-origin fish included in the proposed action mix with and are not distinguishable from natural-origin fish. To avoid the effects of masking, LNFH spring Chinook salmon would be 100-percent adipose fin-clipped and 18% would be coded-wire tagged for easy identification from natural-origin spring Chinook salmon during broodstock collection and monitoring and evaluation activities. Improvements in monitoring of LNFH fish from the proposed action would reduce confusion or concealment of the status of any natural population(s) or the effects of the hatchery program on any natural population(s). Thus, any effects of masking associated with the marking of LFNH are expected to be negligible.

2.4.2.6. Factor 6. Construction, operation, and maintenance of facilities that exist because of the hatchery programs

Negative effect on UCR spring Chinook salmon and UCR steelhead: The net effect on UCR spring Chinook salmon of facilities associated with the proposed action is negative but these negative effects are likely small because: (1) Icicle Creek is a minor spawning area for the ESA-listed Wenatchee spring Chinook salmon population (UCSRB 2007), (2) the majority of spawners are likely hatchery-derived (e.g., Carson stock) (NMFS 1999a), (3) little productivity from the natural-origin population is believed to occur (UCSRB 2007), and (4) despite the current increase in ESA-listed hatchery-origin strays, any relative reproductive success would likely be lower than the natural-origin spawners in Icicle Creek (Williamson et al. 2010; Ford et al. 2012). The net effect on UCR steelhead is negative since Icicle Creek has been identified as a major spawning area for the ESA-listed Wenatchee steelhead population, with 10% of the population’s redds being within Icicle Creek and 100% of the steelhead/resident trout redds in Icicle Creek found within the action area (Hillman et al. 2014). No construction of facilities is included in the proposed action here.

NMFS completed a review on the USFWS instream flow and fish habitat analysis and fish passage analysis reports (Anglin et al. 2013; Skalicky et al. 2013). We notified the USFWS that these analyses included substantial new scientific information that would have a bearing on NMFS' evaluation of the proposed action (Section 1.2). NMFS considered these reports to be part of the best available science specific to the operation of the LNFH instream structures. We recognize that an instream flow and fish habitat analysis cannot in and of itself determine the instream flow requirements for multiple fish species. However, results of the studies are relevant in demonstrating whether an increase or decrease in stream flow would result in a corresponding increase or decrease in quantity of fish habitat. NMFS also recognizes that the results of the fish passage analysis are based on the applied fish passage criteria in the report, and are not intended to determine absolute passage or not. NMFS uses these reports (Skalicky et al. 2013; Anglin et al. 2013) as a way to measure relative, rather than definitive, effects in our analysis of LNFH operation and maintenance of facilities on Icicle Creek ESA-listed salmon and steelhead.

NMFS participated in the IWG[64] to develop an integrated water management plan for Icicle Creek, including establishing a set of instream flow targets for all water users that the IWG adopted to improve the habitat quality and ecological function of Icicle Creek. These recommendations were for a minimum flow of 100 cfs (measured in the historical channel) except in drought years (90% exceedance), when a minimum flow of 60 cfs would apply (Irving 2015a).

Using Skalicky et al. (2013) as a relative guide, NMFS's analysis of the original proposed action (e.g., minimum stream flow of 20 cfs in the Icicle Creek historical channel) would only provide 44 m^2 spawning (13% of peak spawning) and 10 m^2 rearing weighted useable area (WUA) (Skalicky et al. 2013). Conversely, a minimum of 100 cfs would provide 1,603 m^2 spawning (89% of peak spawning) and 249 m^2 rearing WUA (Skalicky et al. 2013). The revised proposed action (e.g., a collective instream flow goal of 100 cfs in Icicle Creek), at the primary intake (Structure 1) and in the historical channel (Structure 2), is likely to substantially improve PCEs and the conservation value of Icicle Creek designated critical habitat that would likely lead to increases in the abundance, productivity, and spatial structure of ESA-listed spring Chinook salmon and steelhead.

To understand the effects of the proposed action on ESA-listed spring Chinook salmon and steelhead, NMFS must first describe the LNFH water supply system. The hatchery's water supply system consists of four major components: (1) point of diversion and gravity flow delivery system (Structure 1); (2) a water control feature (Structure 2); (3) seven wells; and (4) Snow/Nada Lake Basin water supply supplementation reservoirs (Section 1.3; USFWS 2014).

Operation and maintenance of several hatchery facility structures have effects on ESA-listed spring Chinook salmon and steelhead. There are two types of activities described in the proposed action that are likely to negatively affect ESA-listed species by: (1) physical effects (e.g., injuries or mortality caused by entrainment) of the water withdrawal system, and (2) reductions in

[64] A coalition of local water users, federal, state, and local government biologists, and other interested parties working together to improve efficiency of water use and instream flows in Icicle Creek, as described in Section 2.3.3.

freshwater spawning, rearing, and migration areas, including blocked or impeded passage. The hatchery instream structures are (Figure 12):

(1) LNFH diversion dam and intake (RM 4.5);

(2) Structure 2 radial gates (RM 3.8) at the head of the Icicle Creek historical channel; and

(3) Structure 5 (RM 2.9).

The LNFH facility is located on Icicle Creek at RM 2.8, which is also where the outfall from the hatchery is located. The fish ladder is located at the base of the pool where the Icicle Creek historical channel reconnects with the hatchery channel. Operation and maintenance of the LNFH structures can alter fish behavior, and injure or kill eggs, juveniles, and adults. Operations can also degrade habitat function and reduce or limit access to spawning and rearing habitats as well as reduce prey availability and increase summer flow temperatures. Operation and maintenance of LNFH facilities and their specific effects are described below under two sections: physical effects and effects of the reduction in freshwater spawning, rearing, and migration areas.

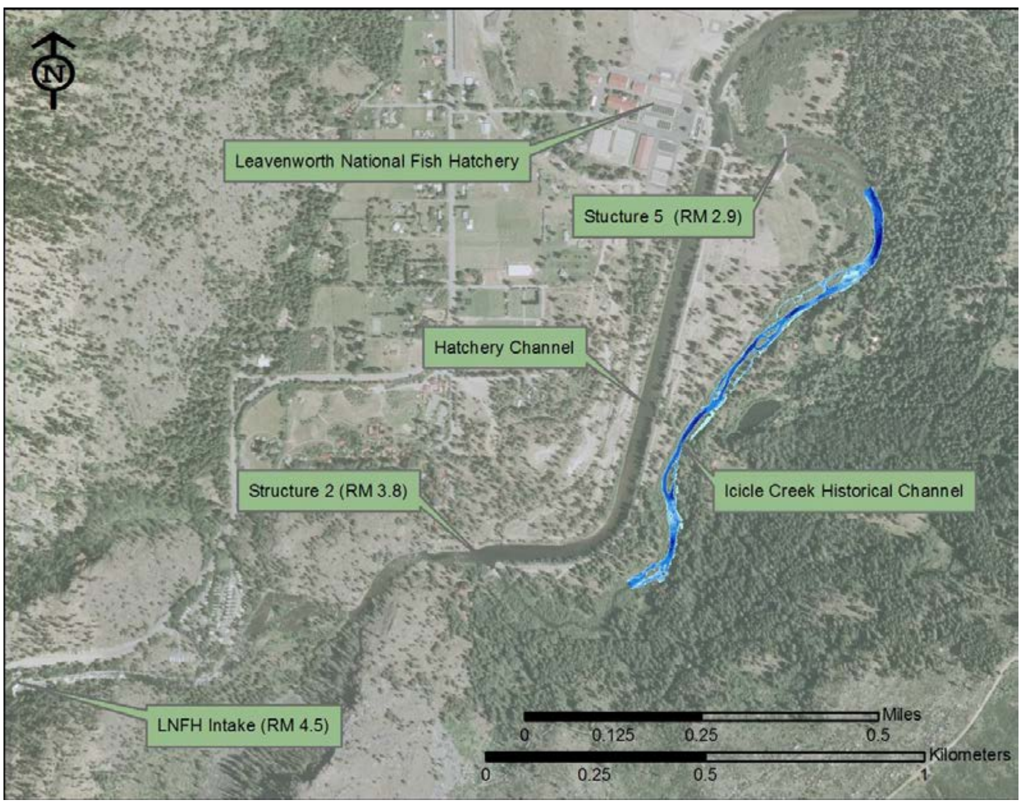

Figure 12. Location of the LNFH facilities and instream structures (Skalicky et al. 2013).

2.4.2.6.1. Physical effects of the LNFH instream structures on spring Chinook salmon and steelhead

A. Point of Diversion and Gravity Flow Delivery System (Structure 1)

LNFH shares a point of diversion with the Cascade Orchards Irrigation Company (COIC) at RM 4.5. It is a concrete base diversion dam with flash boards on top that spans Icicle Creek with a pool weir fish ladder. Water is elevated several feet for the gravity flow to be diverted into a concrete water conveyance channel with a grizzly rack (6 inch bar spacing).

Operational effects

The primary intake on the LNFH/COIC's point of diversion is over 70 years old and lacks screens that comply with NMFS's criteria for anadromous salmonid facility passage design (NMFS 2011c). During operations, ESA-listed species may be entrained in the intake, impinged on cyclone fencing acting as a screen, stranded within the sand settling basin or upwelling chamber, or injured when transferred back to Icicle Creek through COIC's fish bypass or after manual release. Table 25 summarize the likely encounters with the hatchery water delivery system.

Table 25. Summary of encounters associated with the water delivery system

	Maximum Handled & Released[1]		**Maximum Incidental Mortality[1]**
Species	**Adult**	**Juvenile**	**Juvenile**
Spring Chinook salmon	10	1000	50
Steelhead	10	500	5

1 These numbers includes all ESA-listed fish, natural or hatchery fish.

Because the primary intake lacks screening, negative effects may occur on ESA-listed spring Chinook salmon and steelhead through entrainment, such as injury and mortality or from handling and release. NMFS anticipates a very small amount of adult spring Chinook salmon entrainment in the intake because LNFH staff place a section of cyclone fence (with 4-inch plastic-coated mesh) in front of the outer grizzly rack to prevent adult salmonids from entering the intake from mid-July through September. Adult steelhead are not likely to be entrained in the surface water delivery system although they are present during medium to high stream flows when the main Icicle Creek current flows over the middle of the low-head dam, evidenced by the fact that no such entrainment has been observed during the time period that the current hatchery operation and maintenance has been implemented (USFWS 2014).

From May 2011 to July 2017, no live adult spring Chinook salmon or steelhead have been trapped in the water delivery system (Kondo 2017u). The cyclone fence appears to have substantially reduced past rates of entrainment, thus minimizing the effect of the intake on spring Chinook salmon. From 2006 to 2010, the intake entrained 288 adult spring Chinook salmon (6 released; 282 mortalities) and six adult steelhead (zero released; six mortalities) (USFWS 2011c). It is not clear how many of these fish were ESA-listed UCR spring Chinook salmon or steelhead.

Although the cyclone fence reduces entrainment, fish may impinge on the surface of the fence. Since May 2011, the USFWS has not observed fish impinged on the fence (Cappellini 2012). However, post-spawn spring Chinook salmon and steelhead carcasses have been found in the past on the outside rack (USFWS 2014). It is difficult to discern whether these carcasses were previously impinged or were post-spawn mortalities that drifted into the cyclone fence after death. That USFWS has not observed the impingement of live adults suggests the carcasses are post-spawn mortalities. Regardless of cause, NMFS anticipates a small amount of injury to ESA-listed adult spring Chinook salmon and steelhead from encounters with the cyclone fencing, based on past live-fish encounters (e.g., 6 released spring Chinook salmon from 2006 to 2010).

After entering the intake structure, water then enters a small building with a fine rack (1.5 inch bar spacing) and an overflow spill and sediment sluicing section to limit the size of objects entering the gravity pipeline. ESA-listed species may be captured in the upwelling chamber, though the COIC diversion pipe is configured above the hatchery intake pipe, so that fish are more likely to swim into the hatchery intake pipe. Hatchery personnel would check the upwelling chamber twice a day for entrained species to make sure fish escape from the concrete chamber (Cappellini 2012). Only two instances of fish entrainment have been observed in the past 28 years (USFWS 2014), so it is not likely that ESA-listed species would be trapped in this upwelling chamber.

The COIC diversion leads to a small drum screen that bypasses fish back to RM 4.2 on Icicle Creek. The fish return does not work effectively during low flow but the drum screen has been updated. USFWS has devised a temporary exit from the upwelling chamber for fish, including ESA-listed species, which consists of a PVC “fish slide” that returns some entrained fish to Icicle Creek. There is no data regarding the number of fish encounters and mortality resulting from the fish exit, though encounters and mortality are likely close to none because only two fish have been observed in the upwelling chamber in the past 28 years, as discussed above (USFWS 2014).

NMFS anticipates some harm to ESA-listed species due to injury, possible predation following disorientation after release, and potential latent mortality with the temporary fish exit. Although entrainment of ESA-listed species has been a problem in the past, NMFS anticipates this shared COIC diversion would have temporary negative effects on ESA-listed species until proper primary intake screening would be put in place and/or the primary intake is updated by May 2023. An updated drum screen prevents entrained fish from continuing through COIC’s water delivery system. ESA-listed juvenile spring Chinook and steelhead may be diverted into a buried pipeline when water is routed to a sand-settling basin during normal operations. From the sand-settling basin, water in the main pipeline travels to both the outside and inside screen chambers. Both secondary screens meet NMFS’ earlier screening criteria (NMFS 1996). ESA-listed fish may be trapped in the sand-settling basin with no means of returning to Icicle Creek unless manually captured and returned.

From 2006 to 2010, 160 juvenile spring Chinook salmon (159 released; 1 mortality) and 373 juvenile *O. mykiss* (371 released; 2 mortalities) were encountered in the entire water delivery system (USFWS 2011c). From May 2011 to November 2016, a total of 502 juvenile *O. mykiss* were entrained in the LNFH’s water diversion. Of these, 30 *O. mykiss* were entrained from May to November 2011; 40 from February to December 2012; 32 from January to November 2013;

43 from January to October 2014 (USFWS 2014); 176 (including 3 mortalities) from April through October 2015 (USFWS 2016); and 181 (including 2 mortalities) from January through November 2016 (USFWS 2017a). No adult steelhead (determined by size) has been entrained since 2011. Juvenile spring Chinook salmon are also entrained in the water delivery system (e.g., 690 juvenile spring Chinook salmon in 2016). NMFS recognizes that little production of native spring Chinook salmon occurs in Icicle Creek so the majority of spring Chinook salmon juveniles are likely of LNFH-origin. Because we are not able to determine at this time whether these juvenile spring Chinook salmon are ESA-listed natural or hatchery-origin juveniles or LNFH-origin juveniles, we will assume for the purpose of this analysis that all are of natural origin. Here, we analyze the effect of encountering 500 juvenile *O. mykiss* with up to 5 mortalities and 1000 juvenile spring Chinook salmon with up to 50 mortalities per year to account for maximum encounters because the juvenile encounters could be higher than the past encounters if any adult *O. mykiss* (i.e., steelhead or rainbow trout) or spring Chinook salmon spawn right above the intake.

From 2011 to 2014, all entrained fish were captured and released unharmed into the spillway pool at RM 2.8 of Icicle Creek (USFWS 2014). The fish bypass return no longer works properly and is no longer used, but the vicinity of the screens would be checked twice daily. All fish would continue to be netted, placed in a bucket, carried to Icicle Creek, and returned to the creek. To improve capture efficiency of entrained fish, a minnow trap would be installed. Negative effects on ESA-listed species occur when entrained fish are transported through the water delivery system, trapped in the sand-settling chamber, and not released back into Icicle Creek as described below. Negative effects from the primary intake on ESA-listed spring Chinook salmon and steelhead include disorientation, injury, or immediate or latent mortality due to injury or predation. Although many of these effects are difficult to quantify, NMFS anticipates the operation of Structure 1 would have negligible to negative effects on ESA-listed juvenile steelhead until the water delivery system is updated, since Icicle Creek is a major spawning area. Operation of Structure 1 is less likely to negatively affect ESA-listed spring Chinook salmon since little natural production from the native spring Chinook population is thought to occur in Icicle Creek (UCSRB 2007).

Although construction activities are not included in this proposed action, the surface water delivery system would be upgraded or a new water delivery system at the LNFH will be completed by May 2023 to reduce or eliminate current negative effects on ESA-listed fish (Irving 2012a). The primary diversion intake would be screened and, thus, would at that point meet NMFS' current criteria for protecting anadromous salmonids (NMFS 2011a). Since the aggregate benefit of the long-term LNFH infrastructure upgrades is greater than the installation of screens alone, and the infrastructure upgrades are likely to dictate what type of screening is required, this warrants additional time necessary to complete long-term infrastructure improvements and develop screening on the LNFH primary intake that complements the new water delivery system (Section 1.3; Figure 2). To minimize take while the upgrades to the surface water delivery system are implemented, the USFWS updated their fish salvage procedures to better address entrainment of ESA-listed species. Such steps would include:

- Regularly surveying the sand settling basin and successfully capturing and releasing listed species as follows:

i. Protocol for detecting listed species:
   a. Visual observation through snorkeling[65] (to determine if fish are present and capture and release is required) as long as the entire sand settling basin can be viewed.
      i. If any steelhead or spring Chinook salmon are present or if the fish identification is inconclusive, the sand settling basin is drawn down.[66]
   b. If the entire sand settling basin cannot be viewed, or if the snorkeler determines that visual detection through snorkeling is not effective, the sand settling basin is drawn down.
   c. Anytime the sand settling basin is drawn down, all fish in the basin shall be promptly captured and released unharmed into Icicle Creek near the LNFH spillway pool (RM 2.8). If a steelhead is in pre-spawn condition, it shall be released upstream of Structure 1.
   d. If fewer than 2 staff are available to snorkel during the timeframe described below, USFWS will confer with NMFS to assess the benefits and risks associated with performing this protocol understaffed (e.g., risks to the listed species, efficiency of snorkeling, human safety concerns).

ii. Frequency of monitoring for detection:
   a. On a weekly basis, as defined by every 7 calendar days to the extent feasible[67] and no less frequently than every calendar week, starting on April 1 through October (particularly during the UCR steelhead smolt migration in spring and again during the first onset of cold weather during the fall).
   b. Starting on April 1 through October, if, after three weeks, no *O. mykiss* or spring Chinook salmon are encountered (other than during the spring steelhead smolt migration in fall as described above), survey the sand settling basin for the presence of listed species every 31 calendar days. If more than five steelhead were detected during one survey effort, then the monitoring interval would change back to weekly.
   c. During the November through mid-April period, after the onset of cold weather, survey the sand settling basin and remove listed species every 31 calendar days. If more than five *O. mykiss* were detected during one survey effort, then the monitoring interval would change back to weekly.
   d. If surveying the sand settling basin is ineffective (e.g., high sediment loads, typically lasting 3 to 4 days) and/or removing fish from the basin is not possible (e.g., presence of ice covering basin pool, potentially up to a month), confer with NMFS to determine the best method of detection,

[65] The snorkeling is performed by a minimum of two USFWS personnel, at least one being an experienced snorkeler, for the presence of ESA-listed fish. These snorkelers are trained by USFWS (e.g., to accurately identify the species of fish) and tend to have biology degrees. The snorkelers swim parallel and in tandem for a minimum of one pass through the sand settling basin to determine fish presence and identify fish species.

[66] Drawing down the sand settling basin to capture the fish is preferable to capturing the fish without drawing down the sand settling basin for a couple of reasons. First, it allows for better visual of the fish in the sand settling basin, which eliminates human error. It also increases the likelihood of capturing all the fish in the sand settling basin through better detection.

[67] Feasibility determined by staff availability.

   d. immediately survey basin and remove ESA-listed species as soon as possible, and return to regular survey schedule as stated above.
   e. If no ESA-listed fish is present in the sand settling basin (e.g., if the sand settling basin has no water) and no fish could enter the water delivery system (e.g., if the hatchery is not withdrawing water from Structure 1), no monitoring of the sand settling basin is necessary.

- Conferring with NMFS to adaptively manage and alter the protocol described above, only to benefit ESA-listed species and to prevent damage to the aging structure.

- Including results of listed spring Chinook salmon or *O. mykiss* detection from the above actions and monitoring in annual reports submitted to NMFS (USFWS 2017a).

Negative effects could occur if the juvenile salmonids are trapped in the sand settling basin. Such effects include delay in smolt outmigration. When juvenile salmonids are ready to outmigrate into the ocean (mid-April to mid-June for steelhead; May and June for spring Chinook salmon), they progressively experience many physiological changes that allows them to adapt from living in freshwater to living in seawater, called smoltification. During smoltification, negative effects can occur on these juvenile fish if they stay in freshwater too long because their bodies are less able to survive in freshwater. For example, coho salmon (*O. kisutch*) appear to have a larger physiological stress response as they undergo smoltification, concurrent with a depression in their immune competence (Schreck et al. 1993), meaning that they are more susceptible to stressors and diseases. Migratory delay can also increase residualism in salmonid species, meaning that some fish may never migrate to the ocean and remain in freshwater.

Migratory delay effects on listed fish are likely negligible. The numbers of juvenile *O. mykiss* captured in the sand settling basin and released from April through July (when juvenile steelhead smolt) were 41 in 2015 (USFWS 2016) and 31 in 2016 (USFWS 2017a). No juvenile spring Chinook salmon was found in the sand settling basin in May and June (when juvenile spring Chinook salmon smolt) of 2015 (USFWS 2016), and 34 juvenile spring Chinook salmon were found in the sand settling basin in May and June of 2016 (USFWS 2017a). Thus, even if migratory delay effects occur on these juvenile fish, the number of affected fish is small. In addition, the fish are held back at the beginning of their smoltification process (while they are still more physiologically adapted to living in freshwater) and are not held back from outmigration for long (i.e., sand settling basin is checked every calendar week), minimizing the effect of and the likelihood of migratory delay.

Predation is likely to have negligible effect because larger fish that can prey on smolts are mostly excluded from the sand settling basin with the use of cyclone fence during the times when adults may enter the intake pipe.

Starting immediately, USFWS and USBR will be taking the necessary steps to comply with NMFS's screening criteria by May 2023. This time period would allow for appropriate screening to be developed in consideration of any changes to the primary intake that may be developed as a result of USFWS' plans to upgrade/alter its water delivery system. It will be particularly important for the USFWS to monitor the effects of the water delivery system and associated structures, and evaluate fish salvage collection to ensure minimum effects on ESA-listed species. Survey results will be included in LNFH monitoring annual reports and NMFS would evaluate incidental take levels on an annual basis.

In summary, temporary actions are in place to reduce negative effects on ESA-listed species associated with the aging water delivery system. LNFH staff would regularly monitor the sand settling basin and survey and release fish weekly when ESA-listed steelhead are likely to be encountered and regularly survey and release fish monthly when ESA-steelhead are less likely to be encountered. Negative effects and the current level of incidental take of ESA-listed species are expected to continue until the current LNFH water delivery system is upgraded to include fish screening or a new system is installed that meets NMFS' criteria for anadromous fish passage facilities (NMFS 2011a). Best effort would be made to return all spring Chinook salmon and steelhead to the river unharmed. Survey results would be included in LNFH monitoring annual reports and the USFWS in cooperation with NMFS would evaluate incidental take levels on an annual basis. Fish salvage would comply with NMFS fish handling procedures, such as handling the fish with extreme care and keeping the fish in the water to the maximum extent possible.

Maintenance effects

Maintenance is performed annually at the gravity intake (Structure 1). The following describes these maintenance activities:

- Sediment flushing of Structure 1 typically occurs in late winter or early spring but may occur any time between November 1st and June 1st (USFWS 2014). The sediment settles in a pool, which has formed below the intake building, while the water and any fish continue to flow back into Icicle Creek. In one to two hours, the channel is flushed of sediment. Boards are then put back in place, the slide gate is opened, and the plywood boards at the entrance rack are removed (USFWS 2014).

- Sediment flushing of the Structure 1 fish ladder up to two times a year (between November 1st and June 1st). Stream flow into the diversion structure's fish ladder is reduced and the boards within the ladder are removed to flush accumulated sediments. When this occurs, the fish ladder is inoperable for two to three days (USFWS 2014). The boards in the fish ladder are only adjusted to optimize fish passage when it is safe for personnel and necessary.

- Securing a debris boom by covering the diversion structure with tarps with sand bags to prevent board leakage during the low flow period to maintain water surface elevation for gravity flow into the point of diversion. Tarps are removed in the early fall when stream flow increases.

- Sediment in the sand settling basin is removed occasionally. Removing of sediment involves draining the basin, netting any entrained fish and releasing them into Icicle Creek, then excavating the sand.

During maintenance activities, LNFH staff collect water samples to measure potential increases in turbidity to ensure compliance with Washington State's Water Quality Standards for Surface Waters WAC 173-201A. Temporary negative effects on ESA-listed species would occur during sediment removal activities by reducing flows to the extent of normal intake operation discussed above (i.e., maintenance activities do not require additional withdrawal than normal hatchery operation), and then greatly increasing flows as fish are encountering increased turbidity while being flushed into Icicle Creek along with accumulated sediment and debris. In addition, fish passage for ESA-listed adult spring Chinook salmon strays and adult and juvenile steelhead is interrupted both during installation and operation of the debris boom during low flow periods and also via the diversion structure fish ladder when it is blocked for up to three days after maintenance occurs. During sediment removal of the enclosed sand settling basin, ESA-listed species are entrained and subject to increased sedimentation and turbidity while being netted and released into Icicle Creek. Fish may become disoriented and be subject to predation once they are returned to Icicle Creek. Negative effects on ESA-listed species during maintenance at Structure 1 also include reducing water quality in the Icicle Creek historical channel during summer and fall low flows when fish are already stressed due to decreased cover, food, and increased water temperatures. Although many of these effects are difficult to quantify, NMFS anticipates maintenance activities at Structure 1 would continue to have negligible effects on spring Chinook salmon and negative effects on ESA-listed steelhead until the water delivery system is updated.

With the above actions in place, NMFS expects that the negative effects associated with the primary intake (i.e., passage impediment, injury, or mortality) on encountered ESA-listed juvenile steelhead and negligible effects on encountered spring Chinook salmon would be reduced in the interim until the water delivery system is upgraded by May 2023 as described in the proposed action and supplemental information to the HGMP (Irving 2012b; USFWS 2011c). Following the installation of screening on the primary intake, the total take of listed juvenile species is anticipated to decrease significantly. After an upgrade or replacement of the current LNFH water delivery system, fish will no longer be drawn into the primary hatchery water intake and entrained in the sand settling basin. In addition, water delivery system upgrades would decrease the amount of maintenance required to keep the existing point of diversion running properly and improve conditions for ESA-listed steelhead in Icicle Creek by reducing sedimentation, turbidity, and passage impediments.

Cyclone fencing at Structure 1 (deployed at the grizzly rack from mid-July through September) may also be removed for maintenance for about 2 hours to remove debris from the fence; frequency of such maintenance is difficult to predict (Kondo 2017f). Though such removal may result in spring Chinook salmon carcass enter the water delivery system (e.g., in 2016, 2 adult carcasses were found on the inside rack in August (USFWS 2016)), it is not likely to affect live spring Chinook salmon because an adult spring Chinook salmon is strong enough to swim out of the pipe on its own.

B. Structure 2 (Icicle Creek Historical Channel) and Hatchery Aquifer Recharge

The proposed action includes continued operation of Structure 2, which re-routes water from the Icicle Creek historical chancel into the hatchery channel, for various purposes (see Section 1.3), including recharge of hatchery wells. The USFWS believes that adaptively managing the operation of Structure 2 would increase the reliability, efficiency, flexibility, and safety of operating Structure 2 (USFWS 2014). The LNFH has installed variable frequency drive pumps on all of its wells to increase control of pumping rates and capacity to reduce their ground water diversions. They are also assessing the extent to which flooding the hatchery channel contributes to well recharge (USFWS 2014).

The LNFH operates seven wells that produce the quality of water needed to sustain its fish production program (USFWS 2014). The hatchery needs between 1,060 and 6,590 gallons per minute (gpm) of ground water during its fish production cycle (Sverdrup Civil 2000). As discussed in Section 1.3, the hatchery's wells draw water from deep and shallow aquifers (USFWS 2014). Sufficient water (i.e., ~80 cfs) to recharge the hatchery wells does not naturally flow into the hatchery channel when the stream flow in Icicle Creek above both channels is below 300 cfs and flow into the Icicle Creek historical channel is unrestricted through Structure 2 (USFWS 2014). Dewatering of the hatchery channel reduces the wells' capacity to pump water to the hatchery (USFWS 2014).

Operational effects

Under the proposed action, when flow in Icicle Creek is below approximately 380 cfs, the LNFH proposes, as needed, to lower one or more of the radial gates of Structure 2 for fifteen consecutive days at a time up to five times a year (75 days total annually) to ensure aquifer well recharge; in addition, LNFH may also use Structure 2 to increase flows in the hatchery channel to promote smolt emigration, aid in flood control, and perform routine maintenance of structures. As described in Section 1.3, when adjustments are made to Structure 2 (i.e., raising or lowering gates at Structure 2), it would be done slowly and incrementally to avoid rapid water levels changes and to prevent fish stranding (USFWS 2014). Ramping rates would be conducted according to the WDOE Clean Water Act 401 certification process and would not exceed one inch per hour (WDOE 2010). However, ramping rates may increase during emergency flood control actions, but a rate has not been established for emergencies (Cappellini 2014). The Icicle Creek historical channel would be surveyed for stranded fish after adjustments are made to Structure 2 if radial gate(s) are lowered (USFWS 2011c). Since this activity began in 2010, only one instance of fish stranding was observed and fish were returned to the mainstem (Cappellini 2014). When making adjustments to Structure 2, USFWS also proposes to monitor turbidity through water sampling to ensure compliance with Water Quality Standards for Surface Waters (WAC 173-201A) (USFWS 2014). Negative effects on ESA-listed spring Chinook salmon and steelhead include stranding, reduced access to cover, reducing drifting invertebrate prey species, increased summer water temperatures, degraded conditions for upstream and downstream passage, and diminished connectivity to improved habitat conditions upstream or refugia downstream of the Icicle Creek historical channel.

Although many of these effects are difficult to quantify, they are likely to negatively affect ESA-listed steelhead in Icicle Creek. Effects on ESA-listed spring Chinook salmon due to operation of Structure 2 are likely to be negative but are anticipated to be small in scope because: (1) Icicle Creek is a minor spawning area for the ESA-listed Wenatchee spring Chinook salmon population (UCSRB 2007), (2) the majority of spawners are likely hatchery-derived (e.g., Carson stock) (NMFS 1999a), (3) little productivity from the natural-origin population is believed to occur (UCSRB 2007), and (4) despite the current increase in ESA-listed hatchery-origin strays, their relative reproductive success would likely be lower than the natural-origin spawners in Icicle Creek (Williamson et al. 2010; Ford et al. 2012). In 2011 and in 2014, Structure 2 was not operated for aquifer recharge of hatchery wells. Structure 2 was operated three times in 2012 (February, September, and October) and twice in 2013 (February and September) to recharge hatchery wells (Kondo 2017p). During low flow or drought years, frequency of water diversions from the Icicle Creek historical channel to the hatchery channel would increase; it is not possible to predict to what extent these actions would occur, but they would continue to be small in scope, with little adverse effect on spring Chinook salmon for the same reasons described above.

The proposed action also includes operations that are likely to have beneficial effects on ESA-listed spring Chinook salmon and steelhead in Icicle Creek. Structure 2 would not be operated in August, resulting in increased stream flows in the historical channel for ESA-listed fry emergence and juvenile salmonids. In September, if the natural flow (measured at the hatchery intake) remaining after subtracting the amount of water diverted by the LNFH and all water users is less than 60 cfs, the LNFH would not route more water into the hatchery channel than the volume of its Snow/Nada Lake storage release (up to 50 cfs) minus the withdrawal from Snow Creek by IPID and diversion at Structure 1 (up to 42 cfs), resulting in increased flows and rearing habitat for all juveniles. In March, Structure 2 would only be operated if adult steelhead have not been detected in Icicle Creek[68], with the result that, if steelhead *are* present, there would be increased flows in the historical channel and improved spawning access for returning adult steelhead. In May, Structure 2 would be operated to allow the installation of a DIDSON™ fish counter, but such operation is not expected to have any negative effect on steelhead that would be present in May because the flow will remain above 300 cfs, which allows for enough water for both spawning and rearing (Skalicky et al. 2013). The removal of the DIDSON™ fish counter at the end of the spring Chinook salmon run does not require altering the flow in Icicle Creek (Kondo 2017n), so there would be no effect on listed species.

Maintenance effects

The effect of routine maintenance of Structure 2 is described above. Other maintenance of Structure 2 is not included in the proposed action.

C. Structure 5

Structure 5 is located at the downstream end of the Icicle Creek historical channel and is composed of a bridge with a foundation to support racks, flashboards, and/or fish traps. Starting in 2011, Structure 5 remains open all year except when the number of returning adult spring Chinook salmon passing upstream of Structure 5 during broodstock collection (May through July) exceeds 50 fish[69] or when the structure is undergoing maintenance (USFWS 2014).

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[68] Steelhead presence will be determined through examination of PIT detection data in the mainstem Columbia River, the Wenatchee River, and lower Icicle Creek Irving, D. B. 2015a. Addendum to the USFWS Supplemental Biological Assessment - Water Use at Leavenworth National Fish Hatchery: A Plan for Interim and long-term actions to further improve stream flows. May 11, 2015. U.S. Fish and Wildlife Service, Leavenworth, Washington..

[69] The 50 fish "trigger" was developed by the adaptive management group (USFWS 2014). To enumerate the number of spring Chinook salmon that have passed Structure 2, a combination of survey techniques would be used including an underwater DIDSON™ fish counter (acoustical imaging sonar camera) and snorkel and bank surveys (USFWS 2014).

Operational effects

When Structure 5 is closed, effects on ESA-listed adult spring Chinook salmon and adult and juvenile steelhead include blockage of upstream passage, passage delay, injury, and mortality. When Structure 5 is adjusted (installing or removing flashboards or weirs) in tandem with Structure 2 (raising and lowering gates), effects can include blocked or reduced passage, injury, mortality, stranding of fish (includes fish cut off from the stream; trapped in pools), increased summer water temperatures, and turbidity.

Passage at Structure 5 will not be closed for longer than a week while spring Chinook salmon broodstock are being collected (May through July) unless fish traps are installed and checked twice daily (Monday through Friday) to release entrained ESA-listed steelhead upstream or downstream of Structure 5 (depending on spawning condition). Any natural-origin spring Chinook salmon are released upstream to avoid the tribal fishery. If crowding is occurring or more than five steelhead are encountered in one day, the traps would be checked on weekends also to reduce temporary negative effects such as passage delay, injury or mortality. Impeded passage of ESA-listed adult steelhead and adult natural-origin spring Chinook salmon would likely be short and transitory, thus the negative effects are likely to be minimal.

Also, additional operation of Structures 2 or 5 may also occur after discussion with and consensus of the adaptive management group, with prior notification to NMFS SFD, to improve flow or increase fish passage opportunities. Of note, such operation would be performed only to benefit the fish by increasing fish passage opportunities.

When Structure 5 is adjusted in tandem with Structure 2 (removing flashboards or weirs at Structure 5), it is done slowly and incrementally at a rate that avoids rapid water level changes to prevent negative effects such as stranding of fish (USFWS 2014). As described in Section 1.3 ramping rates would be conducted according to the WDOE Clean Water Act 401 certification process and would not exceed one inch per hour (WDOE 2010). Ramping rates may increase during emergency flood control actions, but a rate has not been established for emergencies (Cappellini 2014). After adjustments are complete, the vicinity of Structure 5 near the base of the Icicle Creek historical channel is surveyed for stranded fish and any stranded fish are captured and returned to the stream (USFWS 2014).

When making adjustments to Structure 5, USFWS also proposes to monitor turbidity through water sampling to ensure compliance with Water Quality Standards for Surface Waters (WAC 173-201A) (USFWS 2014). Temporary negative effects on ESA-listed spring Chinook salmon and steelhead include stranding, reduced access to cover, reduced drifting invertebrate prey species, increased summer water temperatures, degraded conditions for upstream and downstream passage, and diminished connectivity to improved habitat conditions upstream or refugia downstream of the Icicle Creek historical channel. Although many of these effects are difficult to quantify, since ESA-listed species began utilizing this restored habitat over the last few years, they are likely to negatively affect abundance, productivity, and spatial structure of ESA-listed steelhead in Icicle Creek because it supports a major spawning area that contributed over 10% of the spawning redds in the Wenatchee Basin (4th highest production area in the basin) in 2014 (Hillman et al. 2014). Effects on ESA-listed spring Chinook salmon due to operation of Structure 5 are likely to be negative but are anticipated to be small in scope because: (1) Icicle Creek is a minor spawning area for the ESA-listed Wenatchee spring Chinook salmon population (UCSRB 2007), (2) the majority of spawners are likely hatchery-derived (e.g., Carson stock) (NMFS 1999a), (3) little productivity from the natural-origin population is believed to occur (UCSRB 2007), and (4) despite the current increase in ESA-listed hatchery-origin strays, their relative reproductive success would likely be lower than the natural-origin spawners in Icicle Creek (Williamson et al. 2010; Ford et al. 2012).

Maintenance effects

Maintenance at Structure 5 may affect ESA-listed steelhead and natural-origin spring Chinook salmon by temporarily decreasing flows, increasing summer water temperature, and increasing turbidity. Large wood and debris can accumulate upstream of Structure 5 and may need to be removed from upstream of the structure and placed downstream (USFWS 2014). If necessary, under the proposed action, Structure 2 will be operated to reduce stream flow into the Icicle Creek historical channel to allow for the removal of such debris and to ensure worker safety (USFWS 2014). This activity is necessary after high stream flow events and lasts less than one week. The hatchery makes every attempt to perform this activity while Structure 2 is in operation for other reasons or during low stream flows and typically occurs once or twice a year (USFWS 2014); since 2007, maintenance of Structure 5 has occurred when Structure 2 was being operated for other reasons (Kondo 2017q). Maintenance at Structure 5 may temporarily affect ESA-listed steelhead and natural-origin spring Chinook salmon by decreasing flows and increasing turbidity downstream of Structure 5. These effects would likely be short and transitory, resulting in a negligible effect. However, when Structure 2 is operated to reduce flows for maintenance of Structure 5, temporary negative effects are likely to occur to ESA-listed species in the Icicle Creek historical channel including: reduced access to cover, reduced drifting invertebrate prey species, increased summer water temperatures, degraded conditions for upstream and downstream passage, and diminished connectivity to improved habitat conditions upstream or refugia downstream of the Icicle Creek historical channel.

Although many of these operational and maintenance effects are difficult to quantify since ESA-listed species just recently began utilizing this restored habitat over the last few years, they are likely to negatively affect abundance, productivity, and spatial structure of ESA-listed steelhead in Icicle Creek because it supports a major spawning area that contributed over 10% of the spawning redds in the Wenatchee Basin (4th highest production area in the basin) in 2014 (Hillman et al. 2014). Effects on ESA-listed spring Chinook salmon due to operation of Structure 5 are likely to be negative but are anticipated to be small in scope because: (1) Icicle Creek is a minor spawning area for the ESA-listed Wenatchee spring Chinook salmon population (UCSRB 2007), (2) the majority of spawners are likely hatchery-derived (e.g., Carson stock) (NMFS 1999a), (3) little productivity from the natural-origin population is believed to occur (UCSRB 2007), and (4) despite the current increase in ESA-listed hatchery-origin strays, their relative reproductive success would likely be lower than the natural-origin spawners in Icicle Creek (Williamson et al. 2010; Ford et al. 2012).

D. Snow and Nada Lakes Supplementation Reservoirs

Prior to the construction of the LNFH, stream flow and water temperatures in Icicle Creek might be insufficient to meet production demands at times (Brennan 1938) based on water right allocations (USFWS 2014). A supplementary water supply project in Snow and Nada lakes was developed and LNFH obtained a water right of 16,000 acre-feet (ac-ft.) per year in 1942. The lakes are located approximately seven miles from the hatchery and one mile above in elevation. Water is released through a tunnel from Snow Lake to Nada Lake into Snow Creek, a tributary to Icicle Creek that enters at RM 5.7, ~ 1 mile above the LNFH's intake system. The USBR's contract with IPID also allows IPID to divert up to 30 cfs from Upper Snow Lake until their annual allowance of 750 AF is exhausted, though IPID has not diverted much water from Upper Snow Lake in the past (see Section 2.3.2).

The lake reservoirs are accessed by foot at least twice a year (typically in late July and early October) to open and close the water control valve. Additional trips may occur to adjust releases from the lakes and to perform maintenance. Flow recorders at three locations help manage the reservoirs: (1) at the outlet valve for upper Snow Lake; (2) at the mouth of the main tributary entering upper Snow Lake; and (3) at the outlet to Nada Lake; stream flow is also monitored near the mouth of Snow Creek (USFWS 2014).

Operational effects

Wurster (2006) and Montgomery Water Group (2004) reports that in most years the reservoirs are capable of providing up to 50 cfs of supplemental flow into Icicle Creek (upstream of the hatchery and below other major diversions) with a reasonable expectation of refilling the withdrawn amount by July of the following year. The USFWS provides supplemental flows of up to 50 cfs in August and September to ensure that the LNFH can withdraw its full water right of 42 cfs from Icicle Creek; that is, the amount of water withdrawn into the hatchery during these months is fully compensated for at a point upstream of the hatchery (at the confluence of Icicle Creek and Snow Creek) through the supplementation from the reservoirs.

During the months of August and September when the USFWS is releasing 50 cfs of supplemental flow into Icicle Creek, the beneficial effect of releases is an increase of 50 cfs from Snow Creek (RM 5.7) to the hatchery intake (RM 4.5). Beneficial effects include increased stream flow, slightly decreased water temperature during summer low flows, and increased prey resources. With Snow/Nada Lakes supplementation in August and September, cooling of instream water temperature averaged 0.98 °C (range 0.2 °C to 1.81 °C) for the years 2005-2016 (Kondo 2017n). If summer water temperatures are very high, at or near the lethal threshold for salmon and steelhead, an increase of approximately one degree could have a greater effect on salmonid survival than when temperatures are lower. At Structure 1 (hatchery intake), downstream of supplemented flows, beneficial effects would be smaller (though neutral to positive nonetheless) because 42 cfs is removed. If the remaining 8 cfs were not diverted to the COIC intake for irrigation[70], there would then be an increase of 8 cfs from Structure 1 downstream to Structure 2, resulting in a beneficial effect on ESA-listed species downstream of the primary intake (RM 4.5 to RM 2.8).

This positive to neutral effect of flow supplementation is particularly important in light of climate change. According to USDA (2017a), a dataset derived from models of climate change effects on air temperature and precipitation, the mean August water temperature in Icicle Creek within the action area may rise from 14.5 °C today to 16.5 °C in 2040 and to 17.5 °C in 2080 (Kondo 2017x). This dataset also shows that the temperature in Snow Creek (which the reservoir water is drawn through) may also rise (from 9.2 °C today to 11.3 °C in 2040 and 12.2 °C in

[70] This may be unlikely to occur since the COIC operates during the irrigation season from May – September.

2080) (Kondo 2017x), but would nonetheless remain cooler than the mainstem Icicle Creek. We note that these modeled temperature rises should be used only to understand the general nature of predicted changes because there is considerable uncertainty around these estimates[71]. Despite this uncertainty, it appears that supplementation from the reservoir would continue to help cool the stream from the confluence of Icicle Creek and Snow Creek downstream as climate change effects take place. The effects of the supplementation on Icicle Creek flow under climate change scenarios are discussed in detail in Subsection 2.4.2.8.

Operation of the Snow and Nada Lakes can release nearly 7,000 ac-ft. of storage[72] with an estimated 60% probability that inflows to upper Snow Lake would meet or exceed the released volume (USFWS 2014) (Wurster 2006). As described in Section 1.3, the reservoirs would provide up to 50 cfs in the months of August and September to meet hatchery production needs. If events such as prolonged equipment malfunction or two or more consecutive years of drought occur, this may alter the lake reservoir release operations. If this occurs, and the USFWS determines it is necessary to alter releases, re-initiation of consultation may be necessary (Cappellini 2014). Although unlikely, a long-term drought would require a reduction in supplemental flow from the Snow/Nada Lake Supplementation Reservoirs. The amount of reduction cannot be speculated at this time and would be dependent on IPID's use of its priority water to Snow/Nada Lake and Snow Creek. Negative effects of altered release operations would be reduced stream flow, increased summer temperatures, reduced habitat, and reduced connectivity to upriver habitat. In this event, no likely beneficial effects would be anticipated since supplemental flows of up to 50 cfs may be limited or may not occur, and re-initiation of consultation would likely be necessary.

Maintenance effects

Maintenance of Snow/Nada Lakes Reservoirs is not anticipated to affect ESA-listed spring Chinook salmon or steelhead. The equipment and facilities usually require minimal observational maintenance. USFWS staff would service the flow gages, remove debris from the dams and flow meters, replace batteries, and conduct safety inspections about twice a year (USFWS 2014). Snow Creek is too steep for either species to ascend, and, thus, construction and maintenance activities do not directly affect them. In addition, maintaining the facilities is unlikely to generate sufficient turbidity to affect either species in habitats downstream. These effects are considered negligible.

E. Water rights

The proposed action includes six water rights issued from 1942 to 1980 for the LNFH.

Operational effects

Utilization of water rights through withdrawals may also affect other stream-dwelling organisms that serve as food for juvenile salmonids by reducing the amount or quality of habitat and through displacement and physical injury. The LNFH complies with water rights permits listed

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[71] Sources of uncertainty in modeled future temperatures include, but are not limited to, the lack of local topography and detailed riparian shade conditions in the models (which alter microclimate and stream temperature within reaches), as well as variation among alternative future emissions scenarios and multiple climate models used to predict changes in air temperature and precipitation.

[72] A water volume recommended by Wurster (2006).

in Table 23. As mentioned above, the LNFH would supplement 50 cfs from Snow and Nada Lakes reservoirs to offset the 42 cfs diversion for hatchery operations in August and September. These effects are analyzed under Section 2.4.2.6.1, A, B and D.

Table 26. Water Rights for the LNFH (USFWS 2011c).

Certificate Number	Priority Date	Source	Amount	Use
1824	03/26/1942	Icicle Creek	42 cfs[1] (18,851 gpm[2])	Fish propagation
1825	03/26/1942	Snow and Nada Lakes	16,000 acre feet	Instream flow
016378	08/01/1939	Groundwater (1 Well)	1.56 cfs (700 gpm)	Fish propagation
016379	06/01/1940	Groundwater (1 Well)	2.01 cfs (900 gpm)	Fish propagation
3103-A	10/16/1957	Groundwater (1 Well)	2.67 cfs (1,200 gpm)	Fish propagation
G4-27115C	10/20/1980	Groundwater (4 Wells)	8.69 cfs (3,900 gpm)	Fish propagation

[1] Cubic feet per second
[2] Gallons per minute

Maintenance effects

No maintenance of water rights is included in the proposed action. Maintenance of water diversion structures to utilize water rights is included above under the associated water diversion structures (Section 2.4.2.6.1).

F. Flood control

In the spring, fall, and winter (or during a rain-on-snow event), floods and/or high stream flows occur in Icicle Creek (USFWS 2011). High discharge events generally last less than two weeks (USFWS 2014). Under the proposed action, to reduce potential flood damage to downstream infrastructure, the LNFH may lower the radial gates at Structure 2 when water levels approach within one foot of the bottom of the bridge deck at Structure 5 or when excessive amounts of debris accumulate on Structure 2 or Structure 5 (USFWS 2014).

Operational effects

The frequency of floods and/or high stream flow events is unpredictable but can occur fairly regularly in Icicle Creek (USFWS 2014). Lowering Structure 2 for flood control may occur as little as once every four years or as much as twice a year (USFWS 2014) and may result in negative effects on listed steelhead by impeding adult and juvenile passage and rearing, increasing turbidity and sediment, displacing ESA-listed adult spring Chinook salmon and adult and juvenile steelhead. Since 2007, Structure 2 was operated for flood control three times (November 7-14 in 2008, January 7-9 in 2009, and November 17-18 in 2015 (Kondo 2017p)). These past operations of Structure 2 for flood control are not likely to have had an effect on ESA-listed adult spring Chinook salmon because adult spring Chinook salmon are not present during the winter. The effect on ESA-listed adult steelhead would have been small because, though passage may be impeded, the adult migration and spawning does not occur until later (starting in March). The effect was likely to have been small on ESA-listed juvenile spring Chinook salmon and steelhead because they are rearing in the winter, not requiring passage.

The longer these events last and/or more frequently they occur, the more likely that these events would have a negative effect on ESA-listed adult and juvenile spring Chinook salmon and steelhead. If these events occur more than two weeks at a time as much as twice a year (i.e., long and frequently), this is likely to have temporary negative effects on ESA-listed adult and juvenile spring Chinook salmon and steelhead utilizing the Icicle Creek historical channel for spawning, rearing, and migration.

Maintenance effects

As described in Section 1.3, stream bank armoring is located at three locations: (1) the diversion structure; (2) water return; and (3) the entrance to the fish ladder. Past flooding events have undermined stream banks near the LNFH fish ladder and nearly breached the pollution abatement pond. This area may require stream bank repair, as well as at the LNFH diversion structure (RM 4.5), if affected by future flooding (Cappellini 2014). Maintenance of hatchery structures during flood control is included above under the associated water diversion structures (Section 2.4.2.6.1, A, B, and C). There is no construction included in the proposed action. Any stream bank armoring or alterations would be analyzed in a separate ESA consultation.

G. Pollutant discharge and effluent

As with most or all hatcheries, LNFH discharges water from its facility operations back into the stream. This discharge returns water to Icicle Creek, restoring flow to a level similar to what would occur if LNFH did not divert water at Structure 1. The effects of flow are considered in Section 2.4.2.6.2. Here, we consider the effects of the pollutants and other substances in the discharge on the ESA-listed salmon and steelhead present in Icicle Creek downstream of the discharge.

A number of substances may be introduced into the hatchery water before it is released. These substances include: biological waste, formaldehyde, sodium chloride, iodine, medicated feed, potassium permanganate, and hydrogen peroxide. The hatchery also uses other chemicals, such as chlorine and injectable drugs, to prevent or treat diseases, but those chemicals are not likely to be discharged into Icicle Creek or would only be discharged at a negligible quantity, and are therefore likely to have no discernible effects on listed species. For more details about these chemicals, see EPA (2015).

The primary effect to be considered resulting from this discharge is the amount of phosphorus (resulting from biological waste) released into the stream. Phosphorus is an important nutrient for primary production, and is a limiting nutrient in Icicle Creek. Increase in phosphorus in streams can increase the algal activity, which decreases the carbon dioxide in the water through photosynthesis. As a result, the pH in the water increases, and the water becomes more alkaline. In particular, the summer months are considered critical for pH because the water is warm and flow is low, so algal activity is likely to be higher and is likely to affect pH more than during other high or average flow months. Increased pH has been shown to have lethal effects in extreme circumstances that are not likely to be present under the proposed action. In addition, increased pH can also have sublethal effects, such as reduced ammonia and urea efflux on many salmonid species (Groot. C. et al. 1995).

The LNFH operates and monitors its water discharge consistent with NPDES Permit No. WA-000190-2. In October 2011, LNFH submitted an application for a new NPDES discharge permit. In conjunction with the new application for a NPDES permit, the LNFH complies with their

WDOE issued CWA 401 Water Quality Certification (order No. 7192) (WDOE 2010), which was not terminated when EPA terminated its associated 2005 draft NPDES permit; however the LNFH submitted a new CWA 401 certification application to address significant changes to hatchery operations to the WDOE in October 2011.

The EPA's proposed NPDES permit for LNFH includes performance-based interim limits[73] for phosphorus level in the effluent and temperature of effluent that are based on recent-year hatchery operations (Table 27). As discussed below, hatchery operations have been modified, starting in 2010, in a manner that could possibly reduce the amount of phosphorus in the effluent compared to the data used to calculate the interim limit for phosphorus. The temperature of the effluent from current operations is likely to be similar to the interim temperature limit. Although NMFS analyzes the effect of phosphorus at the maximum limit allowed under the NPDES

[73] Although the permit expires after 5 years, the proposed compliance schedule allows LNFH 9 years 11 months after the effective date of the final permit to meet the final temperature and total phosphorus effluent limitations EPA. 2016a. Preliminary Draft NPDES EPA Fact Sheet. The U.S. Environmental Protection Agency (EPA) Re-Proposes to Issue a National Pollutant Discharge Elimination System (NPDES) Permit to Discharge Pollutants Pursuant to the Provisions of the Clean Water Act (CWA). NPDES Permit No. WA0001902. 87p, EPA. 2016b. Preliminary Draft NPDES Permit. Authorization to Discharge under the National Pollutant Discharge Elimination System. Permit No. WA0001902. Environmental Protection Agency, Seattle, Washington. 68p.. During this compliance period, the interim limits apply to LNFH.

permit, NMFS believes this is likely to be a conservative approach because, as discussed below, the actual operation is likely to have less severe effects on ESA-listed species.

Table 27. Summary of Effluent Limitations as proposed in the draft NPDES permit

Discharge Location	Parameter	Duration	Effluent Limitations	
			Monthly Average	Maximum Daily
Rearing Ponds and Raceways Other than Times of Drawdown for Fish Release	Temperature (Interim)	Year-round	17 °C as the 7-Day Average of the Daily Maximum Recorded Temperatures	
	Temperature (Final)	August 15 - July 15	13 °C as the 7-Day Average of the Daily Maximum Recorded Temperatures	
		July 16 - August 14	16 °C as the 7-Day Average of the Daily Maximum Recorded Temperatures	
	Phosphorus (Interim)	March 1 - May 31; July 1 - October 31	15 µg/L[1]	17 µg/L[1]
			1.4 kg/day[1]	1.6 kg/day[1]
	Phosphorus (Final)		--	0.52 kg/day[2]
Adult Pond and Raceways during Drawdown for Fish Release	Temperature (Interim)	Year-round	17 °C as the 7-Day Average of the Daily Maximum Recorded Temperatures	
	Temperature (Final)	August 15 - July 15	13 °C as the 7-Day Average of the Daily Maximum Recorded Temperatures	
		July 16 - August 14	16 °C as the 7-Day Average of the Daily Maximum Recorded Temperatures	
	Phosphorus (Interim)	March 1 - May 31; July 1 - October 31	15 µg/L[1]	17 µg/L[1]
			1.4 kg/day[1]	1.6 kg/day[1]
	Phosphorus (Final)		--	0.52 kg/day[2]
Offline Settling Basins/Pollution Abatement Ponds (Outfall 002)	Temperature (Interim)	Year-round	17 °C as the 7-Day Average of the Daily Maximum Recorded Temperatures	
	Temperature (Final)	August 15 - July 15	13 °C as the 7-Day Average of the Daily Maximum Recorded Temperatures	
		July 16 - August 14	16 °C as the 7-Day Average of the Daily Maximum Recorded Temperatures	
	Phosphorus (Interim)	March 1 - May 31; July 1 - October 31	97 µg/L	108 µg/L
			1.7 kg/day	1.9 kg/day
	Phosphorus (Final)		--	0.52 kg/day[2]

Source: (EPA 2016b)
[1] These interim limits apply to the combined discharge of Outfall 001 and any other outfalls in use, except for Outfall 002.
[2] The final limit for phosphorus applies to the total combined hatchery discharge from the raceways, adult ponds, and pollution abatement ponds from March 1 through May 31 and from July 1 through October 31.

Operational effects

In the 2015 Opinion, NMFS examined the effects of effluent from hatchery operations and maintenance. The majority of hatchery effluent is discharged from Outfall 001 throughout the year, at RM 2.8, though discharge from Outfall 001 would be reduced by the amount of discharge from Outfall 006. Because Outfall 006 discharges into the hatchery channel and the amount of total discharge from Outfall 001 is offset by the discharge from Outfall 006, the effect on listed species would be the same whether the effluent is discharged from Outfall 001 and/or 006. The hatchery also uses Outfalls 004 and 005 (RM 2.8 and 2.75 respectively) for 1 to 2 weeks in late April to release hatchery pre-smolts. When Outfalls 004 and/or 005 are in operation, discharge from Outfall 001 is reduced by the amount released at the other outfall(s).

The hatchery also releases approximately 1 cfs of water from Outfall 002 (RM 2.7), which discharges effluent from the LNFH abatement ponds to Icicle Creek during the majority of the year; when the hatchery is cleaning the raceways or adult ponds, such cleaning activities may increase the released amount of effluent up to 5 cfs for up to a few hours each day from Outfall 002 (Hall and Kelly-Ringel 2011). This effluent represents an average total contribution of less than 0.2 (0.16) percent of the total stream flow annually per day and approximately 2 percent (2.27 percent) of the total stream flow during minimum flows. During cleaning activities, the average hatchery effluent is less than 1 percent (0.81) per day and up to approximately 11 percent (11.36 percent) of the total stream flow for up to a few hours each day during minimum flows. Excess river water from the primary intake empties into the pollution abatement ponds, which further contributes to the dilution of waste. It is likely that any discharge would dilute quickly within the abatement ponds, and any detectable difference would be localized and small, with the exception of phosphorus effects, as discussed below. In the summer, return water from the abatement ponds is likely warmer than water in Icicle Creek due to solar heating over the larger surface area (Hall and Kelly-Ringel 2011), but flow contributions are minimal. The spillway pool provides a deep-water refugia with cooler temperatures than other downstream areas of Icicle Creek (Kelly-Ringel 2007) and would help reduce effects on ESA-listed species during minimum flows that occur in the summer months.

The total facility discharges proportionally small volumes of water with waste (predominantly biological waste) into a larger water body, which results in temporary, very low or undetectable levels of contaminants, with the exception of phosphorus as discussed below. General effects of various biological waste in hatchery effluent are summarized in (NMFS 2004c), which describes findings from studies from various geography (including Washington, though not specific to LNFH or Icicle Creek), though the biological waste (except phosphorus, as discussed below) is not likely to have a detectable effect on listed species because of the use of the abatement pond that reduces the biological waste, as well as the small volume of waste compared to the stream flow. For example, the phosphorus limits summarized in Table 27 are an end-of-the pipe limit, meaning that the limit is imposed on the concentration of pollutants at the moment the effluent leaves the facility and that the effluent will further be diluted the moment it enters Icicle Creek. Though we could not determine the specific distance over which the phosphorus levels would return to the ambient levels for Icicle Creek, some studies found that water quality recovered within 175 meters (about 0.11 miles) to 400 meters (about 0.25 miles) downstream of the hatchery outfall while one study found that recovery was not completely reached within 1 kilometer (about 0.62 miles) (NMFS 2004c).

With climate change reducing the flow during the summer months, the proportion of the effluent compared to the instream flow could increase during those months. However, the proposed action helps dilute the hatchery effluent during the low flow months by providing additional flow (up to 50 cfs) to the stream through the Snow/Nada Lakes supplementation.

The proposed NPDES permit allows for an interim limit[74] for temperature (Table 27) based on the 95th percentile of best-quality data points taken on temperature measurements from 2011 to 2015 that was the most representative statistical temperature to use in calculations (EPA 2016a); that is, if the hatchery operates in the way it did from 2011 to 2015, the effluent from such operation is likely to fall below the interim limit of 17 °C 95% of the time. Said another way, the temperature of the effluent from current operations is likely to only rarely exceed 17 °C because the hatchery operations from 2011 to 2015 had effluent temperature under 17 °C 95% of the time and because the operation has not changed since 2011 to change the effluent temperature. Icicle Creek temperatures in summer months can exceed 15 °C (59 °F) and during the winter temperatures can fall below 10 °C (34 °F) (WRWSC 1998). Temperatures as high as 21 °C (70 °F) have been recorded in Icicle Creek (Mullan et al. 1992a). Hall (2013) reported that Icicle Creek experienced downstream warming in the action area with a high of 18.7 °C (65.6 °F) in 2012. When the temperature in Icicle Creek is higher than 17 °C, the hatchery effluent can help cool the stream.

The stream temperature is only likely to be an issue for salmonid species during summer (through September) because Icicle Creek starts to cool down, is partially frozen, or has snow melt flowing in during other times of the year to keep the stream cool. During summer, adult and juvenile spring Chinook salmon and juvenile steelhead are likely to be in Icicle Creek. For adult spring Chinook salmon, migration blockage does not start until 20 °C, and sublethal effects do not occur until about 17.5 °C (Richter and Kolmes 2005). For juvenile spring Chinook salmon, the optimal temperature for rearing is between 12 and 17 °C. For steelhead juvenile rearing, the recommended range of temperature is 16 to 17 °C (Richter and Kolmes 2005). Thus, the interim limit for temperature at 17 °C is not likely to have any discernible effect on juvenile growth for both species because the interim limit requires that the 7-day average temperature falls within the recommended temperature range for rearing, and exceedances of 17 °C are anticipated to be rare and limited in duration. The interim temperature limit is similarly below the temperature thresholds where sub-lethal effects or migration blockage would be expected for adult spring Chinook salmon. Adult steelhead are not present in the summer in Icicle Creek and therefore will not be exposed to effluent temperatures of concern. In addition, the effects of the interim limit would be of limited duration because the NPDES permit requires a final limit for temperature (Table 27) that is even more protective of salmonids.

The proposed NPDES permit also allows for interim limits[75] for phosphorus (Table 27). These interim limits are set based on the 95th percentile of best quality data points taken on phosphorus measurement from 2006 to 2011 that was the most representative statistical phosphorus concentration to use in calculations (EPA 2016a). However, NMFS notes that the current operation of the hatchery is likely to be producing less phosphorus in its effluent than the

[74] The permit also includes final limits for temperature at 16 °C, which, when achieved, would not have any adverse effect on salmonid species because it is within the optimal temperature for salmonid species, as discussed below.
[75] The permit also includes final limits for phosphorus at 0.52 kg/day total for all discharges, which, when achieved, would not have any adverse effect on salmonid species because such phosphorus loading is not anticipated to cause a pH that is higher than 8.5 (EPA. 2016a. Preliminary Draft NPDES EPA Fact Sheet. The U.S. Environmental Protection Agency (EPA) Re-Proposes to Issue a National Pollutant Discharge Elimination System (NPDES) Permit to Discharge Pollutants Pursuant to the Provisions of the Clean Water Act (CWA). NPDES Permit No. WA0001902. 87p.).

maximum allowed under the interim limits, and, therefore, is likely to have less severe effects on ESA-listed species than what is analyzed below for three reasons. First, the hatchery reduced its spring Chinook salmon production in 2010 from 1.6 million juveniles to 1.2 million juveniles (25% reduction), resulting in less feed used (and less phosphorus in the effluent) towards the end of the dataset used to calculate the interim limit. Second, the hatchery built a second abatement pond in 2010, which became operational (and likely started to reduce the phosphorus in the effluent) in 2011, so the dataset used to calculate the interim limit only takes partial account for effect of abatement pond.[76] Third, the amount of phosphorus in the effluent is likely to vary throughout the year because the amount and type of feed (primary source of phosphorus in the effluent) used in the hatchery could vary throughout the year (Table 28)(USFWS 2011c; Table 18); that is, while the maximum interim limit would apply for all parts of the year under the permit, feed usage outside the time of most feed used (e.g., April, August) would, in reality, be lower, and therefore the hatchery would likely be putting out less phosphorus in the effluent during times of less feed used, as described in (USFWS 2011c; Table 18).

Table 28. Estimated amount of feed used per month (in lbs).

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Spring Chinook salmon	1960	3504	9816	16075	7828	6982	18293	23567	13160	13604	5034	2318
Coho[1]	N/A	922	4550	4732	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total	1960	4426	14366	20807	7828	6982	18293	23567	13160	13604	5034	2318

Source: (Kondo 2017h; USFWS 2011c)

[1] While the coho program is not part of the proposed action, the feed used for this program contributes to the phosphorus effluent. As discussed above, the effects of the coho program were analyzed in (NMFS 2014a; NMFS 2017b).

Increased phosphorus could also benefit salmonid species because phosphorus is typically a limiting nutrient for prey sources. For example, Boersma et al. (2009) found that the growth rate of *Daphnia* (one prey source for salmonids) is increased with increased phosphorus in the algae, meaning that increase in phosphorus in Icicle Creek could provide a larger mass of prey for salmonids.

On the other hand, high levels of phosphorus could also be a concern for salmonid species in Icicle Creek because phosphorus, an important nutrient for primary production, is a limiting nutrient in Icicle Creek. While the level of dissolved oxygen (DO) is also a common issue associated with high phosphorus loading in ocean or lake systems, it is not likely to be an issue with the phosphorus level associated with the interim limit because the effluent is discharged into a river system, where decaying algae is not aggregated to decrease the DO level in the water. For example, the 2002 water quality study by the Washington Department of Ecology did not find any dissolved oxygen impairments in Icicle Creek from phosphorus concentrations (WDOE 2002). This is also supported by the EPA's model predictions because model simulations show DO levels would be much higher than 9.5 mg/L (DO standard to protect salmonid species for

[76] This pattern of two reductions are also reflected in the dataset used by the EPA. The average phosphorus contributions by the hatchery are 59.7 µg/L, 45.7 µg/L, and 25.1 µg/L respectively for the periods of 2006-2008, 2010, and 2011Kondo, E. 2017g. Memo to File - Data of phosphorus in LNFH effluent used by EPA to set NPDES interim limit. April 19, 2017. NMFS, Portland, Oregon. 4p..

both the EPA and Ecology) throughout Icicle Creek ((Kondo 2017r)). A DO level of 9.5 mg/L provides full protection (approximately less than 1% lethality, 5% reduction in growth, and 7% reduction in swimming speed) of salmonid species ((Ecology 2002)). The EPA's model predicts the DO levels to range from 9.95 mg/L to 12.25 mg/L under three scenarios (no supplementation flow, 42 cfs supplementation, and 50 cfs supplementation) ((Kondo 2017r)). Of note, the DO level is predicted to be lower with flow supplementation because the model uses DO level for Snow Lake of 9.79 mg/L ((Kondo 2017r)). Therefore, while we recognize the uncertainties surrounding the model outputs, it is not likely that the DO level in Icicle Creek would decrease to a level that is likely to have a negative effect on salmonid species.

The increase in phosphorus in Icicle Creek can increase the algal activity, which decreases the carbon dioxide in the water through photosynthesis. As a result, the pH in the water increases, and the water becomes more alkaline. In particular, the summer months are considered critical for pH because the water is warm and flow is low, so algal activity is likely to be higher and is likely to affect pH more than during other high or average flow months. The EPA's water quality criterion for pH to protect freshwater aquatic life (including salmonid species in freshwater habitat) is to remain within the range 6.5 to 9, while the Ecology water quality criterion for pH ranges between 6.5 and 8.5, with a human-caused variation within the above range of less than 0.5 units. In addition, the upper limit of recommended pH for salmonid aquaculture in hatchery settings ranges from 8.0 to 8.5 (Bardach et al. 1972; IHOT 1995), meaning that the optimal pH is likely to be below 8.5 for salmonid species.

Though we cannot quantify the pH level that would result from operating under the maximum allowed under the interim phosphorus limit, the effluent with phosphorus loading in accordance with the interim limits could create an environment in Icicle Creek with an elevated pH. We note that, in the 2002 water quality study, the Washington Department of Ecology detected the maximum pH as 9.06 with the hatchery contributing about 1.25 kg/day[77] of phosphorus in August and September (WDOE 2002). Although the maximum phosphorus interim limit allowed under the NPDES permit would be 3.1 kg/day for a monthly average, with daily maximum of up to 3.5 kg/day—more than twice that under the 2002 study—the proposed action also includes an addition of up to 50 cfs in Icicle Creek during the critical low-flow months, which increases the dilution rate over that taking place during the 2002 study.

The model that the EPA used to predict pH (QUAL2Kw) shows that the maximum pH during critical flow period (September) with the interim phosphorus level is likely to be between 8.99 and 9.02, depending on the amount of flow added to Icicle Creek below the outfall (Kondo 2017r). We note that pH of 9.02 is more likely to be the maximum pH rather than 8.99 because the model run that produced the pH of 9.02 assumed an additional flow of additional 42 cfs below the hatchery outfall (compared to the 50 cfs assumed in the model run that produced the pH of 8.99), which accounts for irrigation withdrawals that are likely to occur. Similarly, the model predicted a maximum pH of 8.82 with additional 50 cfs of flow and 8.88 with additional

[77] While the study also had a concentration-based contribution (i.e., 13µg/L), we find that total mass loads (in kg/day) are more comparable to each other (from the study vs. interim limit) because the effects of concentration-based contribution also depends on the volume of water in the effluent. Because the effluent varies in the volume of water depending on the outfall, total mass load from all of the hatchery effluent is more useful as one value showing the total hatchery contribution.

42 cfs of flow (Kondo 2017r). The model assumed August 2002 conditions for August flow conditions and late September 2002 flow conditions for September flow conditions (Kondo 2017r). Based on historical data from Irving (2015a), 7 out of 21 years had a lower average September flow than the average flow in September 2002. Similarly, 11 out of 21 years had lower average August flow than the average flow in August 2002. Though we do not have information about how the flows used for modeling compare among the historical years, flows lower than those used for the model are likely to occur based on the historical pattern and in light of climate change likely reducing flow in the future. In addition, the model used a monthly average limit as the model input; presumably, a more severe increase in pH could occur than that predicted in the model if the hatchery discharges phosphorus at the daily maximum limit for consecutive days with reduction in phosphorus on other days to meet the monthly average limit. Therefore, we note that the effluent with phosphorus loading in accordance with the interim limit is likely to cause a pH that is higher than what is predicted in the model, though it is not likely to be substantially higher[78].

Determining the exact pH in Icicle Creek through direct sampling for pH is difficult for two reasons. First, the affected area is unknown; thus, to ensure that pH is not elevated anywhere in Icicle Creek, measurements would have to be taken in multiple locations with small distance between the sampling locations. Second, because there is uncertainty as to when pH would rise depending on many environmental factors, such as temperature and available sunlight, sampling would have to occur frequently throughout the day. We find that measuring phosphorus at the end of the pipe is a reasonable connection to tracking pH because the amount of phosphorus directly affects the shift in pH in Icicle Creek (e.g., as predicted by QUAL2Kw model), and it is most likely that phosphorus concentrations resulting from hatchery output would only decrease with distance from the outfall.

Until the monitoring requirement under the NPDES permit is implemented, we would expect the phosphorus in the effluent to remain the same as current operations and under the interim limit if the amount of feed used is about the same because feed is the primary driver for phosphorus loading in the effluent. Thus, we consider the amount of feed to represent a consistent proportional amount of phosphorus in the effluent until the monitoring is implemented.

While we could not find much information specifically about spring Chinook salmon or steelhead, the findings from various studies described below are likely to be similar in applicability for understanding effects resulting from high pH on spring Chinook salmon and steelhead because the species used for those studies are biologically similar to spring Chinook salmon and steelhead. Of note, the studies described here were all performed in freshwater because salmonids' biochemical reactions differ in salt water.

The pH threshold that leads to salmonid mortality varies based on many environmental factors. Wagner et al. (1997) found that pH of 9 can induce rainbow trout[79] mortality with high temperature (21.7 °C). However, pH of 9, without other additional stressors, does not seem to

[78] For example, we would consider an increase of pH from 9 to 9.5 as substantial; because pH is calculated using an exponential equation, the change in pH from 9 to 9.5 indicates a 5-fold increase in alkalinity.

[79] Rainbow trout is the resident counterpart to steelhead. Thus, the conclusions made about rainbow trout are likely to be very similar, if not identical, to conclusions that can be made about steelhead.

cause mortality in rainbow trout. This is evident in other studies that used higher pH levels on rainbow trout. For example, Wilkie et al. (1996) showed that free-swimming rainbow trout are capable of long-term survival (28 days) at pH 9.5. McGeer and Eddy (1998) showed that rainbow trout could survive even in pH of 10.5 under certain conditions, though we are not likely to see such high pH in Icicle Creek even with the maximum amount of phosphorus allowed under the interim limit. Similarly, McGeer et al. (1991) found that coho salmon (*Oncorhynchus kisutch*) did not show significant changes in physiological constituents when the fish were exposed to pH of 9.4 and 10 for 12 to 144 hours, though the study's focus was to understand differences in response among stocks from various locations, so the results are not useful for our analysis below. However, Yesaki and Iwama (1992) found that pH of 10.1 is lethal to rainbow trout in soft water (concentration of $CaCO_3$ at 4 mg/L). The pH increase in Icicle Creek during the critical months is not likely to cause salmonid mortality because we have no indications that Icicle Creek has water quality stressors to the extent examined in these studies that would contribute to mortality.

Increase in pH has been shown to also have sublethal effects on salmonid species. Exposure to water with elevated pH results in reduced ammonia and urea efflux on many salmonid species (Groot. C. et al. 1995), though it is unclear exactly what level of pH starts to trigger this response. However, Wilkie and Wood (1991) found that rainbow trout[80] are capable of adapting to high pH (9.5) within 48 hours of exposure, though they noted that the ammonia excretion was initially blocked. Wilkie and Wood (1995)[81] determined that such adaptation is possible through storing the ammonia in white muscles when the excretion is blocked or reduced, but it may be an energetically expensive adaptation (e.g., increased lactic acid production). Similarly, Wilkie et al. (1999)[82], and supported by Laurent et al. (2000)[83], found that chloride ion influx was restored within 72 hours of exposure to pH of 9.5, and sodium ion balance within rainbow trout was reestablished through reduction in both influx and outflux of sodium ions. Though current understanding of salmonid biology does not allow for a quantification of the amount of energy spent on adapting to an elevated pH, such diversion of energy can interfere with salmonid behavior patterns. In particular, when the pH is likely to be elevated in Icicle Creek, juvenile steelhead and spring Chinook salmon (likely to be of Carson stock-origin) are likely to be rearing and adult spring Chinook salmon (likely to be of Carson stock-origin) are likely to be spawning. However, these sublethal effects do not prevent the fish from swimming out of unfavorable habitat, thereby reducing the likelihood that the fish will be exposed to a high pH for an extended period of time. Therefore, the sublethal effects of elevated pH in Icicle Creek on spring Chinook salmon and steelhead are also likely to be short term.

Another effect of high pH is the potential to increase toxicity of aluminum to salmonid species. For example, Gundersen et al. (1994) found that aluminum-induced mortality was higher for rainbow trout at weakly alkaline pH (7.95–8.58). However, Poléo and Hytterød (2003) attributed this finding to a high aluminum concentration used in the study and found that more naturally relevant concentrations of aluminum do not have an acute toxic effect on Atlantic salmon (*Salmo salar*) under alkaline conditions (pH>9.0). Similarly, Winter et al. (2005) did not find acute

[80] Adult rainbow trout was used for this study.
[81] Sub-adult to adult rainbow trout were likely to have been used for this study based on weight (290.5 +/- 12.9g).
[82] Sub-adult to adult rainbow trout were likely to have been used for this study based on weight (229.0 +/- 5.7g).
[83] Sub-adult to adult rainbow trout were likely to have been used for this study based on weight (175-250g).

toxicity to rainbow trout with naturally relevant concentrations of aluminum until pH of 10. We have no indication that aluminum levels in Icicle Creek are high, so spring Chinook salmon and steelhead in Icicle Creek are not likely to see any acutely toxic effects from aluminum.

Increase in pH has also been shown to affect salmonid embryos. In Rahaman-Noronha et al. (1996), ammonia excretion in rainbow trout embryos was reduced when it was treated in water with pH of 10. Further study showed that alkaline water (pH of 9.7) induced expression of genes in rainbow trout that regulate ammonia, urea, and nitrogen excretion (Sashaw et al. 2010). NMFS notes that these experiments used high pH levels that are not likely to occur in Icicle Creek. However, the pH level for the negative effects to start occurring is likely lower than the pH described in the studies (because these studies were designed to use water with high pH to trigger observable effects), but the precise threshold is unknown. To the extent adverse effect occur, the number of spring Chinook salmon embryos present in Icicle Creek in August and September that would be affected is likely to be small, as discussed below.

Though the Wenatchee River, in addition to Icicle Creek, is also water quality limited for pH, we focus our analysis on Icicle Creek for several reasons. First, the Wenatchee River is much bigger than Icicle Creek[84] and can dilute the LNFH-effluent to levels at which changes in pH caused by the proposed action are trivial. This is true because the assimilative capacity of Wenatchee River for phosphorus is 7.76 kg/day (Carroll et al. 2006), which is more than double the daily maximum allowed by the interim limits[85], meaning that the Wenatchee River has the capacity to absorb 7.76 kg/day of phosphorus without affecting the aquatic life. Second, Icicle Creek is the first major contributor of phosphorus into the Wenatchee River, with all of the other major phosphorus discharge being downstream from the confluence with Icicle Creek). Thus, the cause of elevated pH in the Wenatchee River likely stems downstream from the confluence with Icicle Creek.

Although many of these effects are difficult to quantify, effects on ESA-listed spring Chinook salmon from the phosphorus in the effluent are likely to be negative but are anticipated to be small in scale because Icicle Creek is no more than a minor spawning area for the ESA-listed Wenatchee spring Chinook salmon population (UCSRB 2007) and the majority of spawners are likely hatchery-derived (e.g., Carson stock) (NMFS 1999a).

The effluent, if it contains the maximum amount of phosphorus allowed under the interim limit, is likely to negatively affect ESA-listed steelhead in Icicle Creek, which supports a major spawning area that contributes over 10% of the spawning redds in the Wenatchee Basin (4th highest production area in the basin) in 2014 (Hillman et al. 2014), though the effects are likely to be limited. When the phosphorus increases the pH to a level that affects juvenile steelhead, the area within which the phosphorus from the effluent could contribute to a high pH (2.8 RM, from the hatchery outfall to the confluence of Wenatchee River) includes less than 9% of intrinsic

[84] For example, in 2016, the Wenatchee River had an average flow of 3,611 cfs below the confluence with Icicle Creek (USGS 12459000) compared to the average flow of 742.6 cfs in Icicle Creek above the hatchery (USGS 12458000) that doesn't account for additional withdrawals before it reaches the Wenatchee River.

[85] Of note, although the interim total maximum phosphorus limit of the effluent is 3.5 kg/day, the limit applies at the end of the pipe. That is, by the time the effluent reaches the Wenatchee River, some of the phosphorus is likely to have been absorbed by the environment, so the phosphorus loading caused by the hatchery is likely to be less than 3.5 kg/day.

potential area (i.e., a small amount of useful habitat) within the major spawning area (Kondo 2017m). Moreover, the effluent is likely to affect only a small portion of that 2.8 RM, though the exact area cannot be quantified. For example, the 2002 water quality study found that with the hatchery contributing about 1.25 kg/day of phosphorus in August and September, and the pH in Icicle Creek exceeded the pH of 9[86] only at the mouth of Icicle Creek with pH levels below 8.5[87] near the hatchery outfall (RM 2.3) (Kondo 2017j).

As mentioned previously, for the purposes of this analysis, NMFS assumed LNFH operations contribute the maximum limit allowed under the NPDES permit. However, the actual operations are likely to have less severe effects on ESA-listed species than what is analyzed above.

Other contaminants likely to appear in the hatchery and effluent are from chemicals used to treat diseases that may occur in the hatcheries as a result of the pathogens being introduced via water that is drawn from the natural environment, thus reducing the risks discussed in Section 2.4.2.3.1.1, Disease. Currently, formaldehyde, sodium chloride, and iodine are used at a level lower than the therapeutic level approved by the U.S. Food and Drug Administration and in accordance with the label instructions, though other chemicals such as medicated feed and potassium permanganate may be used if the veterinarian on station determines that such chemicals are necessary to treat a disease; in addition, hydrogen peroxide, if used, can largely replace formaldehyde, but it is currently not used because of restriction on storage (Kondo 2017c).

These therapeutic chemicals are not likely to be problematic for ESA-listed species because they are discharged in a very small amount into a moving body of water that can dissipate the harmful effects quickly. For example, iodine is used for about 15 to 30 minutes at a time at 75 parts per million (ppm), three times a year (Kondo 2017c). Similarly, formalin was used in the past at a low concentration and for a short duration. For 2013 through 2016, formalin was used in the adult ponds typically from the end of May through August as a flow-through treatment at 200 ppm for 1 hour, with the maximum number of treatments being 60 treatments per year in 2016. For the juvenile raceways, formalin was used from mid- to end of August through September, occasionally into the first week of October during 2013 through 2016, with a treatment being 50 ppm for 4 to 6 hours; one treatment refers to treating a single raceway, and the maximum number of treatments was 52 treatments per year ((Kondo 2017v)).

In addition, chemicals such as formalin, medicated feed, and potassium permanganate (though the operation primarily uses formalin) are especially likely to be used in smaller amounts than that historically used at the hatchery because LNFH now has a veterinarian on station, which allows for a shorter time for the disease to spread than if the veterinarian was not on station by providing a quick response time to prescribe the treatment (Kondo 2017v). However, the exact amount that may be used cannot be determined at this time because the veterinarian has not been on station for very long, so historical use of these chemicals at LNFH (such as that described above) is not likely to be representative of future use. These chemicals are diluted when added to

[86] Sample with highest pH indicated pH of 9.06.
[87] Sample with highest pH indicated pH of 8.37.

the effluent (either by 5 cfs or 42 cfs, depending on the outfall), which are then diluted by the water in Icicle Creek as described above.

These therapeutic chemicals are also not likely to be problematic for ESA-listed species because many of them break down quickly in the water and/or are not likely to bioaccumulate in the environment. For example, formaldehyde (component of formalin, in addition to water and methyl alcohol[88]) readily biodegrades within 30 to 40 hours in stagnant waters, so it is likely to biodegrade even quicker in streams. Formaldehyde is also not expected to bioaccumulate in aquatic organisms, as it is transformed by them through various metabolic pathways. Similarly, potassium permanganate would be reduced to compounds of low toxicity quickly, on the order of minutes. In addition, hatchery-use concentrations of sodium chloride (table salt) are 2 to 3 times above naturally-occurring concentrations in freshwaters, but sodium chloride occurs naturally in the environment, and the volumes used are quite small compared to the total volume of water discharged by hatcheries (EPA 2015).

Therefore, operation of the facility is likely to have negative effects on water quality, and the USFWS would monitor water quality pursuant to the NPDES permit to ensure compliance with any applicable limits. All of the water used by the hatchery would be returned to Icicle Creek, minus any leakage and evaporation. Because all outfalls are close to one another (locations ranging from RM 2.7 to 2.8) and because most effluent is likely to be similar in composition (i.e., most water would contain feed, fish excretion, therapeutic chemicals, etc., though they may be different in concentration), the individual outfalls are not likely to differ in effect on ESA-listed fish; rather, the hatchery effluent as a whole is likely to have the effects described above. Due to the above conditions, effects from hatchery effluent are likely to be negative, though any changes to the quality of habitat due to effluent on ESA-listed spring Chinook and steelhead are likely short and transitory.

Maintenance effects

The a single bank of raceways is cleaned every day, which could increase the hatchery effluent from Outfall 002 from 1 cfs up to 5 cfs for a few hours per day (Hall and Kelly-Ringel 2011). During such cleaning activities, the average hatchery effluent is less than 1 percent (0.81) annually per day and up to approximately 11 percent (11.36 percent) of the total stream flow for up to a few hours each day during minimum flows. Though pollutants may peak during these cleaning activities, the hatchery must still comply with the relevant effluent limitations described in the NPDES permit. Thus, the effect on listed species is the same as that described above.

2.4.2.6.2. Effects on freshwater spawning, rearing, and migration areas from the LNFH instream structures on spring Chinook salmon and steelhead

Under the proposed action, the operation of the LNFH instream Structures 1, 2, and 5 affect ESA-listed species through water withdrawals or by blocking or impeding adult and juvenile passage.

[88] The concentration of methyl alcohol in formalin is not likely to be high enough to harm fish (EPA. 2015. Federal Aquaculture Facilities and Aquaculture Facilities Located in Indian Country within the Boundaries of Washington State. Biological Evaluation for Endangered Species Act Section 7 Consultation with the National Marine Fisheries Service and the U.S. Fish and Wildlife Service. NPDES General Permit WAG130000. December 23, 2015. 191p.).

The operation of Structure 1 (primary intake; RM 4.5) would remove up to 42 cfs of stream flow a month year-round. Effects of these water withdrawals are provided in Table 29. Under the 50^{th} percentile exceedance scenario, the instream flow could be decreased up to 31.1 percent during the summer months between Structure 1 (RM 4.5) and the hatchery outfall (RM 2.8), meaning the flow could be reduced up to 31.1 percent during the month of September for 1.7 river miles of Icicle Creek. During the 90^{th} percentile exceedance scenario, the instream flow could be decreased up to 46.6 percent during the month of September for that same 1.7 river miles. The greatest reductions in instream flows, under both an average and dry water year, would occur during the months of September and October, resulting in potential negative effects on spring Chinook salmon and steelhead. During the remainder of the calendar months, in average and dry water years, instream flow reductions would range from 1.5 to 18.1 percent and 1.8 to 28.5 instream flow reductions, respectively, resulting in potential negligible effects on spring Chinook salmon and steelhead. The following paragraphs describe specific effects that are likely to occur on various life stages of spring Chinook salmon and steelhead.

For Structure 1 withdrawals, there are sufficient instream flows (i.e., 100 cfs or greater) in Icicle Creek for salmonid juvenile passage during the months of April, May, June, and July because 100 cfs exceeds the juvenile upstream passage recommended of 64 cfs. In addition, the 100 cfs instream flow provides at least 392 m^2 usable rearing area annually for spring Chinook salmon and 249 m^2 for steelhead (Skalicky et al. 2013). There is also a high probability (76 to 90 percent) that sufficient instream flows (i.e., 80 cfs, 60 cfs, and 40 cfs) would occur during the months of January through March and August through December, resulting in 10 to 24 percent flow reductions in no more than 16 out of 21 years (Table 29; Table 30). LNFH water withdrawals at Structure 1 would have no effects on adult migration and spawning of steelhead because, for adult steelhead, migration and spawning ends in June when flows in Icicle Creek are likely to meet the recommended instream flows. Some effects are likely to occur on adult spawning of natural-origin spring Chinook salmon due to Structure 1 water withdrawals because spawning typically ends in September. Fragmentation of instream habitat could occur due to greater instream flow reductions during this time period. Any adult fish that are present would likely hold in pools until instream flows improved. (Willis et al. 2016) found that low flows do not always pose an oxygen risk to fall Chinook salmon holding in pools, even when fish fill the pools to capacity, as long as the average weekly maximum temperature did not exceed 23 °C. In August, mean water temperature in Icicle Creek within the action area is predicted to rise currently from 14.5 °C to 16.5 °C in 2040 and to 17.5 °C in 2080 (Section 2.4.2.6.1, D), though NMFS emphasizes that there is considerable uncertainty around these estimates. Increased stream temperatures due to low flows on adult spring Chinook salmon holding in pools may increase the risk of temperature-induced mortality as well as the incidence of poaching or predation. ESA-listed natural-origin spring Chinook salmon use Icicle Creek for migration and spawning to some degree; however, they are likely unmarked hatchery-origin strays from the Wenatchee Basin, and little productivity is anticipated to occur (Sections 1.3 and 2.4.2.6). Adult natural-origin spring Chinook salmon would be at the very end of their life cycle during the lowest instream flow projections (i.e., near or after spawning), would not be present in high numbers, and are likely to experience these negative effects for a very short period of time before natural death that occurs after spawning. Potential negative effects on adult spring Chinook salmon due to operation of Structure 1 would likely be minimal.

Due to Structure 1 water withdrawals, negligible effects, at most, are likely to occur during the critical steelhead fry emergence period from June to August in Icicle Creek (USFWS 2014). For the Wenatchee steelhead population overall, which includes production in Icicle Creek, fry emergence typically occurs by the end of July (Hillman et al. 2014). During this peak emergence time, flow is reduced by 3.5 percent in June to 9.5 percent in July (Table 29), which would still provide 82 percent to 97 percent of weighted usable areas (i.e., available habitat)(Skalicky et al. 2013). Steelhead may be negatively affected (e.g., through reduction in available prey species upon emergence and reduced foraging and resting habitat) if they emerge as late as August 8, as has occurred in some years (Table 37). Similar negative effects are more likely to occur on natural-origin spring Chinook salmon sub-yearlings (fry and parr) because they have been captured in juvenile outmigration traps located in other areas of the Wenatchee Basin from February to November (Mackey et al. 2014). ESA-listed natural-origin spring Chinook salmon use Icicle Creek for migration and spawning to some degree; however, their presence is rare, and little productivity is anticipated to occur (Section 1.3). Due to rare encounters and low productivity of natural-origin spring Chinook salmon present in Icicle Creek at this time, negative effects on fry, such as reduced foraging and resting habitat and reduction in available prey species (i.e., primarily insects and small invertebrates) are anticipated to be infrequent.

Due to Structure 1 water withdrawals, some negligible effects are likely to occur on juvenile spring Chinook and steelhead upstream and downstream passage and juvenile rearing, rising to likely negative effects during the months of September and October (i.e., instream flow reductions of 19.3 to 31.1 and 40.9 to 46.6 percent; Table 29). Juvenile spring Chinook salmon and steelhead migrate and rear during all months of the year. Fragmentation of instream juvenile habitat could likely occur due to greater instream flow reductions during these months. Any juvenile fish that are present would likely hold in pools until instream flows improved. Increased stream temperatures due to low flows on juvenile salmon and steelhead holding in pools may increase the risk of temperature-induced mortality as well as the incidence of predation. As instream flows improve in November, juvenile spring Chinook salmon and steelhead are likely to migrate to more favorable habitat in Icicle Creek.

Table 29. Estimated effects of operation of Structure 1 (S1) in an average water year/50th exceedance flow and in a dry water year/90th exceedance flow.

Month	**50th Total[1] (cfs)**	**S1 Diversion Estimated Use[2] (cfs)**	**Instream Flow Reduction (%)[3]**	**90th Total[4] (cfs)**	**S1 Diversion Estimated Use[5] (cfs)**	**Instream Flow Reduction (%)[6]**
January	269	39	14.5	162	39	24.1
February	256	41	16.0	150	41	27.3
March	320	42	13.1	179	42	23.5
April	587	42	7.2	459	42	9.2
May	1443	21	1.5	1138	21	1.8
June	1615	27	1.7	780	27	3.5
July	674	34	5.3	357	34	9.5
August	227	41	18.1	144	41	28.5
September	132	41	31.1	88	41	46.6
October	197	38	19.3	93	38	40.9
November	473	40	8.5	164	40	24.4

December	308	41	13.3	169	41	24.3

[1] Data from USFWS (2014).
[2] Data from USFWS (2014) and Irving (2015).
[3] Percent of instream flow that would be reduced based on the proposed action (LNFH Structure 1 diversions) during an average water year.
[4] Data from USFWS (2014).
[5] Data from USFWS (2014) and Irving (2015).
[6] Percent of instream flow that would be reduced based on the proposed action (LNFH Structure 1 diversions) during a dry water year.

The proposed action includes a collective instream flow goal of 100 cfs. Stream flows as the result of the proposed action are likely to deviate from this collective instream flow goal of 100 cfs in average or dry water years or during two or more consecutive years of drought depending on natural flows and the combined water diversions from collaborative water users in Icicle Creek based on historical observations and future climate change general trend predictions[89].The LNFH may need to deviate from that instream flow goal, particularly during a dry water year, in order to meet production levels under the *U.S. v. Oregon* Management Agreement (*U.S. v. Oregon* 2009), resulting in reduced instream flows (< 100 cfs). Likewise, in average to wet years, instream flows may be markedly better than the proposed instream flows (Irving 2015b; Kondo 2017l; Kondo 2017w; Wade et al. 2013). The LNFH would operate Structure 1 for water withdrawals as described in Table 29 until infrastructure improvements are completed that have the potential to reduce water diversions at Structure 1 by as much as 20 cfs in the long-term.

Table 30 provides the instream flow goals, described as an average daily minimum[90], for LNFH operation by month and the ability to meet those instream flow goals based on historical water use for LNFH hatchery operations. Based on instream flow data and operational needs from 1994 to 2014[91], the LNFH has met the 100 cfs (or higher) monthly instream flow goal from April through July in all 21 years. There are no instream flow goals for August and September because the proposed action includes flow supplementation during those months that is likely to fully compensate for hatchery withdrawal. In October, the instream flow goal of 40 cfs has been met in 18 out of 21 years. In November through February, the instream flow goal of 60 cfs has been

[89] Instream flow data and hatchery water needs based on actual data for (i.e., historical) future climate change were analyzed from 1994 to 2014 (Irving, D. B. 2015a. Addendum to the USFWS Supplemental Biological Assessment - Water Use at Leavenworth National Fish Hatchery: A Plan for Interim and long-term actions to further improve stream flows. May 11, 2015. U.S. Fish and Wildlife Service, Leavenworth, Washington.) and for future climate change general trend predictions in 2040 and 2080 (Kondo, E. 2017l. Memo to File - Findings for climate change research performed by Amilee Wilson. April 7, 2017. NMFS, Portland, Oregon. 229p, Kondo, E. 2017w. Memo to File - U.S. Forest Service database for climate change flow predictions (VIC flow metrics). April 7, 2017. NMFS, Portland, Oregon. 13p.)(Wade, A. A., and coauthors. 2013. Steelhead vulnerability to climate change in the Pacific Northwest. Journal of Applied Ecology 50:1093–1104.).

[90] Monitoring the instream flow as a daily average is sufficient because the hatchery operation does not alter the flow quickly, especially with the operation of Structure 2. Structure 2 must be operated to open one inch of gate per hour to minimize fish stranding, which could take up to 12 hours to fully open the gates. Thus, an operation of Structure 2 that causes a large deviations from the instream flow goal is unlikely and impractical because Structure 2 would immediately have to be operated to return the flows to above the minimum instream flow to offset the low instream flow to average the minimum instream flow. In addition, the lowest flow allowed would be dictated by the highest natural flow because a low flow, as a result of hatchery operation, would have to be offset by a higher natural flow to meet an average daily minimum. That is, the closer the initial instream flow to the daily minimum flow, the smaller the range of operation can be to achieve the average daily minimum instream flow.

[91] Historical data includes a combination of average and dry water years.

met in 19 out of 21 years. In March, the instream flow goal of 80 cfs has been met in 19 out of 21 years.

Structure 2 would not be operated in August. In September, if the natural flow remaining after subtracting the amount of water diverted by the LNFH and all water users is less than 60 cfs, the LNFH will not route more water into the hatchery channel than the volume of its Snow/Nada Lakes storage release (up to 50 cfs) minus the withdrawal from Snow Creek by IPID and diversion at Structure 1 (up to 42 cfs). If the natural flow remaining after subtracting the amount of water diverted by the LNFH and all water users is greater than 60 cfs, LNFH may route water into the hatchery channel to the extent that would leave 60 cfs in the historical channel.

The operation of Structure 2 for aquifer recharge, as proposed (i.e., not operating Structure 2 in August, with limited potential operation in September), would increase instream flows in the Icicle Creek historical channel compared to how Structure 2 was operated historically and would improve conditions for juvenile passage and rearing. Beneficial effects are likely to occur in August due to no operation of Structure 2 resulting in improved instream flows for steelhead fry emergence and juvenile migration and rearing. In September, if the natural flow remaining after subtracting the amount of water diverted by the LNFH and all water users is less than 60 cfs, the LNFH would not route more water into the hatchery channel than the volume of its Snow/Nada Lake storage release (up to 50 cfs) minus the withdrawal from Snow Creek by IPID and diversion at Structure 1 (up to 42 cfs). If 60 cfs is maintained in the Icicle Creek historical channel in September, beneficial effects are likely to occur because of improved juvenile rearing conditions. Negligible effects are likely to occur five months of the year (November – February) due to reduced instream flows (60 cfs). Negligible effects are likely to occur in March due to reduced instream flows (80 cfs). In October, there would be negative effects on juvenile rearing conditions from reductions in instream flows (40 cfs).

NMFS also considered the long-term operations for LNFH surface water withdrawals in the proposed action. LNFH would develop and evaluate plans to reduce the amount of surface water needed to meet salmon production requirements by installing a partial recirculating aquaculture system (pRAS). LNFH anticipates that full conversion of LNFH rearing facilities to pRAS technology could reduce water needs by at least 20 cfs. The unused portion of LNFH's surface water right would be placed in a water trust to enable greater operational flexibility for the hatchery to provide additional instream flow in Icicle Creek. Design documents for a pilot pRAS to be tested at the hatchery have been developed. In 2015, infrastructure (valve and pipeline replacement and repair) improvements were completed in preparation for the system. LNFH anticipates the pilot pRAS to begin within the next 3 to 4 years (W. Gale, USFWS, personal communication, February 28, 2017). If a pRAS is successful and LNFH is able to convert its rearing facilities to pRAS technology[92], long-term effects on ESA-listed species are likely to be beneficial by reducing surface water withdrawals by up to 20 cfs allowing the LNFH to meet the 100 cfs instream goal nearly all months of the calendar year. NMFS supports the above actions. These are important and required long-term steps toward improving instream habitat in Icicle Creek; however, NMFS does not rely on implementation of these long-term actions for our jeopardy and critical habitat analyses. Due to the uncertainty of implementation of the long-term

[92] Any effects of the installation and implementation of pRAS will be evaluated in a separate section 7 consultation.

actions, NMFS considered that ongoing operations would continue into the future under the proposed flow regime described above and analyzes effects on ESA-listed species accordingly.

Table 30. Probability of meeting minimum instream flow goals with Structure 2 operation based on historical water use (average/dry combined).

Month	**Minimum Instream flow goals in the Icicle Creek historical channel**[1]	**Probability of Meeting Instream Flow**[2]
January	60 cfs	19/21 yrs.
February	60 cfs	19/21 yrs.
March[3]	80 cfs	19/21 yrs.
April	100 cfs	21/21 yrs.
May	100 cfs	21/21 yrs.
June	100 cfs	21/21 yrs.
July	100 cfs	21/21 yrs.
August	N/A	N/A
September	N/A	N/A
October	40 cfs	18/21 yrs.
November	60 cfs	19/21 yrs.
December	60 cfs	19/21 yrs.

[1] Proposed instream flow goals for the Icicle Creek historical channel during Structure 2 operations for aquifer recharge.
[2] Number of years out of 21 in which LNFH would meet the instream flow goal in the next 21 years based on 50th and 90th flows combined (Gale 2015).
[3] Structure 2 would not be operated in March if adult steelhead are present.

In understanding the effects of future Structure 2 operations, NMFS analyzed two scenarios below, one for an average flow year (50th % exceedance flow) and one for a dry year (90th % exceedance flow). However, NMFS notes that these two scenarios are for illustrative purposes only and that the future water availability does not necessarily fall into these categories (e.g., there could be years that are between the two scenarios).

Table 31 describes the effects of Structure 2 operations in an average water year or 50th % exceedance flow. The LNFH would implement a 60% historical and 40 % hatchery channel split. A "50th % Flow" represents the available stream flow above Structure 1. A "50th % Available at

Split" represents the available stream flow below the Structure 1 diversion (50th Flow – 42 cfs). For example, if there is 172 cfs at the 50th % Flow, 130 cfs would be available at the split of the historical and hatchery channels for re-routing into the hatchery channel for aquifer recharge. Using the 60% historical / 40% hatchery channel split, 78 cfs (60% of 130 cfs) would be maintained in the historical channel while 52 cfs (40% of 130 cfs) would be routed into the hatchery channel.

Table 31. Effects from Structure 2 (S2) operations in an Average Water Year/50th% Exceedance (flow = 60% historical / 40% hatchery channel split; cfs) (USFWS 2014).

Month	**50th % Flow**	**50th % Available at Split[1]**	**Historical Channel (operating S2)[2]**	**Hatchery Channel (operating S2, max.)[3]**
January	269	228	148	80
February	256	213	133	80
March	320	276	196	80
April	587	474	N/A	N/A
May	1443	1326	N/A	N/A
June	1615	1484	N/A	N/A
July	674	533	N/A	N/A
August	227	130	--	--
September	132	54	--	--
October	197	157	94.2	62.8
November	473	431	N/A	N/A
December	308	265	185	80

[1] Under this scenario, in April through July and in November, enough flow is available for a "natural" flow split to occur and operation of S2 is unnecessary.
[2] 60% of instream flow available at the split between the historical and hatchery channels up to a maximum of 80 cfs into the hatchery channel. When > 80 cfs is available, the remaining cfs will be left in the historical channel.
[3] Maximum directed down Hatchery Channel is equal to 80 cfs; at flows less than 200 cfs, maximum flow directed down Hatchery Channel is equal to 40% of available.

Table 32 describes the effects of Structure 2 operations in a dry water year or 90th% exceedance flow under a 60% historical and 40 % hatchery channel split.

Table 32. Effects from Structure 2 (S2) operations in a Dry Water Year/90th% Exceedance (flow = 60% historical/40% hatchery channel split; cfs) (USFWS 2014).

Month	90th% Flow	90th% Available at Split	Historical Channel (operating S2)[1]	Hatchery Channel (operating S2, max.)[2]
January	162	121	72.6	48.4
February	150	107	64.2	42.8
March	179	135	81	54
April	459	346	NA	NA
May	1138	1021	NA	NA
June	780	649	NA	NA
July	357	216	136	80
August	144	47	--	--
September	88	10	--	--
October	93	53	40	21.2
November	164	122	73.2	48.8
December	169	126	75.6	50.4

[1] 60% of instream flow available at the split between the historical and hatchery channels up to a maximum of 80 cfs into the hatchery channel. When > 80 cfs is available, the remaining cfs would be left in the historical channel.

[2] Maximum directed down Hatchery Channel is equal to 80 cfs; at flows less than 200 cfs, maximum flow directed down Hatchery Channel is equal to 40% of available.

NMFS also used the stream flow data from the USFWS' SBA provided in Table 31 and Table 32 (USFWS 2014) and the USFWS LNFH passage evaluation and instream flow and fish habitat analysis reports (Anglin et al. 2013; Skalicky et al. 2013) to conduct an analysis of effects specifically on freshwater spawning, rearing, and migration areas for ESA-listed species. NMFS focused on the instream flow and fish habitat analysis based on Instream Flow Incremental Methodology (IFIM) to determine relative effects on ESA-listed salmon and steelhead (Anglin et al. 2013) because IFIM is used nationwide and is accepted by most water resource managers as the best available tool for determining the relationship between stream flows and fish habitat (WDOE 2010). It is often preferred over toe-width, wetted-width, or Hatfield and Bruce methods because it is relatively time and data intensive producing more relevant, applicable, and comprehensive results. As mentioned in Section 2.4.2.6, the recommended instream flows for spring Chinook salmon and steelhead provided in the study were applied as general benchmarks in concert with the IWG instream flow goal of 100 cfs. The following sections describe NMFS' analyses related to each life stage.

It is important to keep in mind that NMFS (1999b) reported spring Chinook spawning in Icicle, Peshastin, and Ingalls Creeks were likely from hatchery-derived populations, and the Upper Columbia River Salmon Recovery Board stated that little natural production from the native spring Chinook population occurs in Icicle Creek (UCSRB 2007). The LNFH has also encountered an increased number of ESA-listed adult hatchery spring Chinook salmon strays (31 annual average) in recent years (2010 to 2014). Ford et al. (2012) reported that the relative reproductive success of hatchery-origin spring Chinook salmon from Wenatchee supplementation programs is approximately half of the natural-origin spring Chinook salmon productivity. Thus, effects on freshwater spawning and migration, passage, and rearing are anticipated to be negative but small in scope. In the analysis below adult and juvenile spring Chinook salmon and steelhead are grouped according to spawning and migration, upstream/downstream passage, and rearing because they share instream flow recommendations/goals.

2.4.2.6.2.1. Effects on freshwater spawning and migration of areas of ESA-listed adult spring Chinook salmon and steelhead

NMFS analyzed the effects of operation of the LNFH Structures 1, 2, and 5 on adult spring Chinook salmon and steelhead upstream passage for spawning and migration during an average water year (i.e., 50th Exceedance) (Figure 13) with and without the proposed action. The 200 cfs recommendation for adult salmonid passage in Anglin et al. (2013) and an instream flow goal of 100 cfs developed by the IWG and included in the proposed action were used as benchmarks to determine effects on ESA-listed spring Chinook salmon and steelhead.

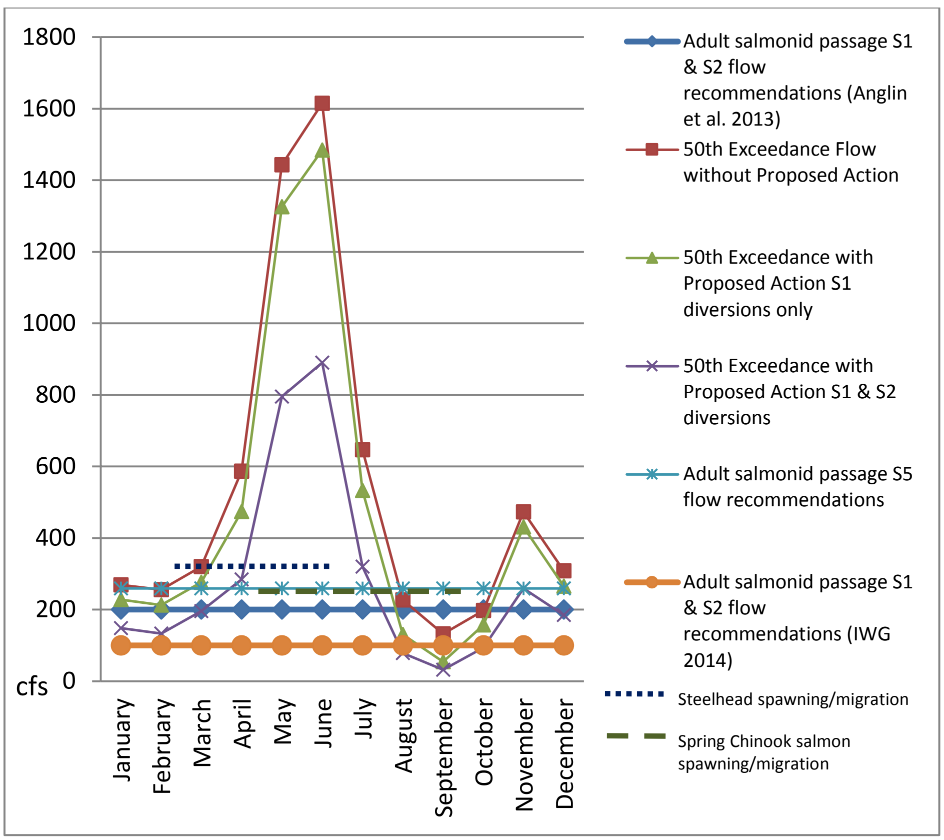

Figure 13. Effects of the operation of the LNFH Structures 1, 2 & 5 and associated stream flows on spawning and migration of ESA-listed species during an average water year (50th exceedance).

Steelhead spawning and migration occurs March – June. Spring Chinook salmon spawning and migration occurs May – September. The ideal adult salmonid flow recommendation for passage at Structures 1 & 2 is 200 cfs (Anglin et al. 2013). The collective management adult salmonid flow recommended by the IWG for passage at Structure 1 & 2 is 100 cfs. Reduced stream flows from operation of the LNFH Structures 1 & 2 during an average water year (50^{th} Exceedance) would have no effect on ESA-listed adult species during the months of January, February, October, November, and December because they are not present in Icicle Creek during this time. Water diversions would have no to negligible effects on ESA-listed steelhead during spawning and migration in the months of March and April (196 and 284 cfs, respectively) because proposed stream flows meet both adult salmonid flow recommendations for passage. Water diversions would have negligible effects on ESA-listed adult steelhead and spring Chinook salmon during spawning and migration in the months of May and June due to potential velocity barriers (795 and 890 cfs, respectively) (Anglin et al. 2014). Water diversions would have no effect in July on spring Chinook salmon because stream flows meet the adult salmonid flow recommendations, and no adult passage effects in August and September because adult spring Chinook salmon would already be on the spawning grounds. In addition, the proposed action would not operate Structure 2 during the month of March if adult steelhead were present resulting in beneficial effects such as increased stream flow and expanded access to upstream spawning areas.

NMFS also examined the effects of adult passage during an average water year at the LNFH Structure 5 for ESA-listed adult spring Chinook salmon and steelhead and determined no to negligible[93] effects are likely to occur year-round (Figure 13). The ideal adult salmonid flow recommendation for passage at Structure 5 is < 260 cfs (Anglin et al. 2013). The collective management adult salmonid flow recommended by the IWG for passage at Structure 5 is 250 cfs however; this instream flow is not provided during much of the natural hydrograph except during April – July during an average water year and May – June during a dry water year. During water operation of Structure 5, stream flows meet these criteria in all months of the year during an average water year except during the month of March where potential depth limitations may occur (Anglin et al. 2013).

NMFS also analyzed the effects of operation of the LNFH Structures 1, 2, and 5 on adult spring Chinook salmon and steelhead upstream passage for spawning and migration during a dry water year (i.e., 90^{th} Exceedance) (Figure 14).

[93] Possible depth limitation would occur to ESA-listed steelhead during the month of March only.

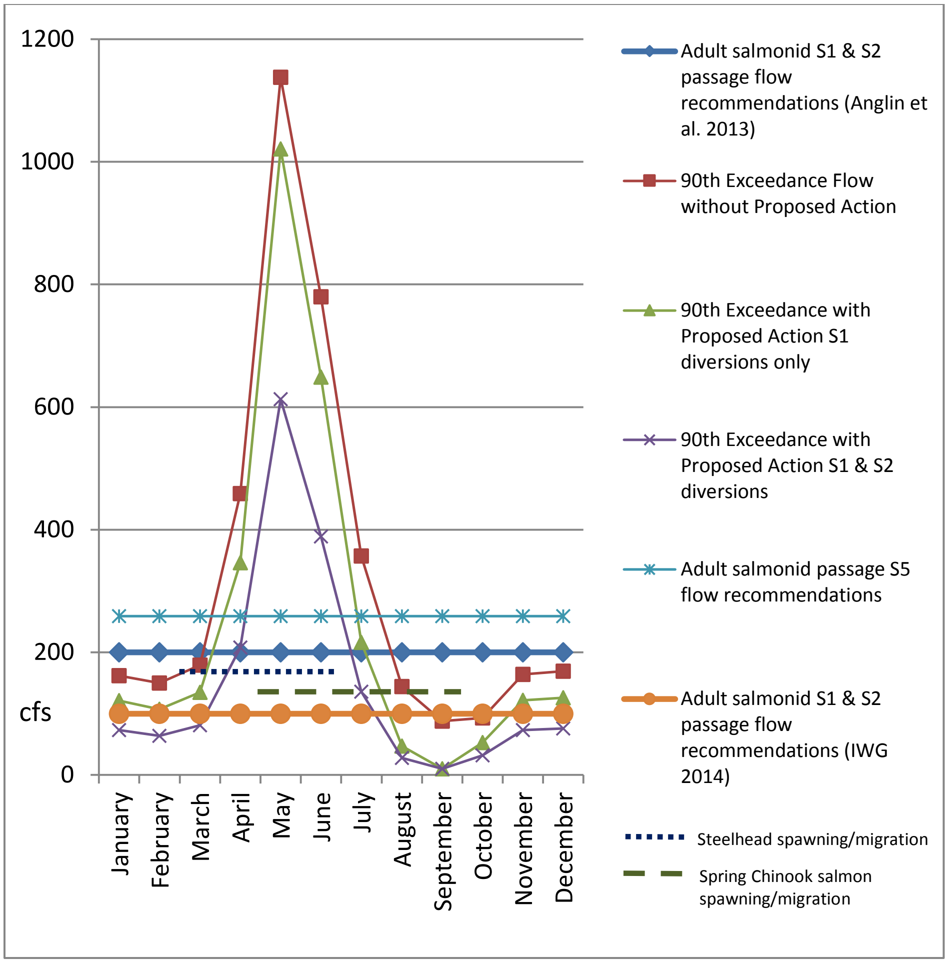

Figure 14. Effects of the operation of the LNFH Structures 1, 2 & 5 and associated stream flows on spawning and migration of ESA-listed species during a dry water year (90th exceedance).

Steelhead spawning and migration occurs March – June; spring Chinook salmon spawning and migration occurs May – September. The ideal adult salmonid flow recommendation for passage at Structures 1 & 2 is 200 cfs (Anglin et al. 2013) and the adult salmonid flow recommended by the IWG for passage at Structure 1 & 2 is 100 cfs. Reduced stream flows from operation of the LNFH Structures 1 & 2 during a dry water year (90th Exceedance) would have no effect on ESA-listed adult species during the months of January, February, October, November, and December because they are not present in Icicle Creek during this time. Water diversions would have negligible effects on ESA-listed steelhead during spawning and migration in the months of March and April (81 cfs and 208 cfs, respectively) due to possible depth limitations (Anglin et al. 2014). Water diversions would have no effects on ESA-listed steelhead and spring Chinook salmon during spawning and migration in the months of May and June because flows are 613 cfs and 389 cfs, respectively. Water diversion would have negligible effects in July for spring Chinook salmon because stream flows meet the adult salmonid flow recommendation (136 cfs) with possible depth limitations (Anglin et al. 2014), and no adult passage effects in August and September because adult spring Chinook salmon would already be on the spawning grounds. In addition, the proposed action would not operate Structure 2 during the month of March if adult steelhead were present resulting in beneficial effects such as increased stream flow and expanded access to upstream spawning areas.

NMFS also examined the effects of passage during a dry water year at the LNFH Structure 5 for ESA-listed spring Chinook salmon and steelhead (Figure 14). The adult salmonid flow recommendation for passage at Structure 5 is < 260 cfs (Anglin et al. 2013). The collective management adult salmonid flow recommended by the IWG for passage at Structure 5 is 250 cfs. However, the natural hydrograph does not supply this level of flow during much of the year. NMFS determined no effects would occur during the months of January, February, May, June, August, September, October, November, and December due to adequate stream flow during a dry water year or lack of fish presence. During the months of March and April (81 and 208 cfs), negligible effects would occur to ESA-listed adult steelhead due to possible depth limitations (Anglin et al. 2014). During the month of July (136 cfs), negligible effects would occur to ESA-listed adult spring Chinook salmon also due to possible depth limitations (Anglin et al. 2014).

In summary, after examining effects of the operations of LNFH Structures 1, 2, and 5 in both an average and dry water year, water diversions and structures would have no to negligible effects on ESA-listed spring Chinook salmon and steelhead adult passage during spawning and migration annually. The net effect of reduced stream flows due to proposed action would be negligible because proposed stream flows meet or nearly meet or exceed the ideal adult salmonid flow recommendations (Anglin et al. 2013) for passage during spawning and migration of ESA-listed adult spring Chinook salmon and steelhead for the LNFH water diversions and structures.

2.4.2.6.2.2. Effects on migration passage of ESA-listed juvenile salmonids

NMFS analyzed the effects of operation of the LNFH Structures 1, 2, and 5 on juvenile salmonid passage migration during an average water year (i.e., 50th Exceedance) (Figure 15). Effects on ESA-listed spring Chinook salmon and steelhead juvenile passage migration would be identical because upstream flow passage recommendations (Anglin et al. 2013) apply to both juvenile salmon and steelhead. ESA-listed spring Chinook salmon and steelhead juveniles in this section are referred to as "juvenile salmonids". The IWG did not have a juvenile salmonid upstream passage recommendation for Structures 1, 2, and 5, so the Anglin et al. (2013) recommendation will be used as an ideal upstream passage goal.

ESA-listed juvenile salmonid upstream passage and migration occurs year-round. The flow recommendation for juvenile salmonid upstream passage at Structures 1 and 2 is 64 cfs (Anglin et al. 2013). Water withdrawals from operation of LNFH Structures 1 & 2 retain sufficient flows (64 cfs or greater) during an average water year to provide juvenile upstream passage in nearly all months. September instream flows may be insufficient to provide upstream juvenile passage (32 cfs) resulting in potential negative effects. The proposed action would not operate Structure 2 in August resulting in beneficial effects on ESA-listed juvenile salmonids from lack of Structure 2 operations. In September, if the natural flow remaining after subtracting the amount of water diverted by the LNFH and all water users is less than 60 cfs, the LNFH would not route more water into the hatchery channel than the volume of its Snow/Nada Lake storage release (up to 50 cfs) minus the withdrawal from Snow Creek by IPID and diversion at Structure 1 (up to 42 cfs) resulting in beneficial or neutral effects on juvenile salmonid passage by potentially increasing instream flows for downstream passage and slightly decreasing summer water temperature.

The flow recommendation for juvenile salmonid upstream passage at Structure 5 is 125 cfs (measured at Structure 2) (Anglin et al. 2013). Water withdrawals from operation of LNFH Structure 5 during an average water year would have negligible effects on juvenile salmonid upstream passage at Structure 5 January – July and November – December due to adequate flows (125 cfs or greater) but with possible velocity limitations (Anglin et al. 2014). The exceptions would be three months (August (78 cfs), September (40 cfs), and October (94 cfs)) out of the year where the effects would likely be negative due to potential depth and velocity limitations for ESA-listed juvenile salmonid upstream passage (Anglin et al. 2014).

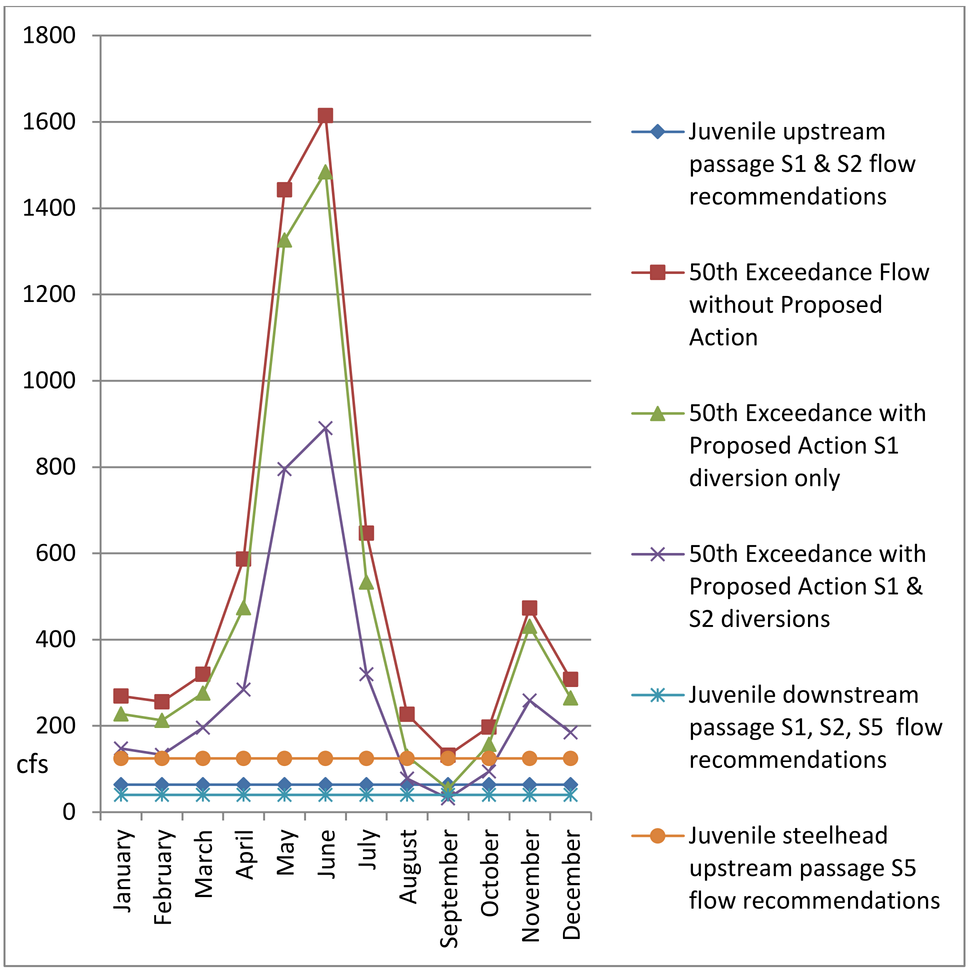

Figure 15. Effects of the operation of the LNFH Structures 1, 2 & 5 and associated stream flows on passage and migration of ESA-listed juvenile salmonids during an average water year (50^{th} exceedance).

NMFS also analyzed the effects of operation of the LNFH Structures 1, 2, and 5 on juvenile salmonid downstream passage migration during an average water year (i.e., 50^{th} Exceedance)

(Figure 15). ESA-listed juvenile salmonid downstream passage and migration can also occur year-round. The flow recommendation for juvenile salmonid downstream passage at Structures 1 & 2 is 40 cfs (Anglin et al. 2013). The IWG did not have a juvenile salmonid downstream passage recommendation for structures 1, 2, and 5, so the Anglin et al. (2013) recommendation would be used as an ideal downstream passage goal. Water withdrawals from operation of LNFH Structures 1 & 2 during an average water year would have negligible effects on juvenile salmonid downstream passage due to sufficient flows (40 cfs or greater) but with possible velocity limitations all months of the year. The proposed action would offset Structure 2 diversions by providing up to 50 cfs of supplemental flows in Icicle Creek during the months of August and September likely resulting in beneficial to neutral effects on ESA-listed species by potentially increasing instream flows for downstream passage and slightly decreasing summer water temperature. The proposed action would not operate Structure 2 in August likely resulting in beneficial effects on ESA-listed juvenile salmonid passage.

In addition, NMFS analyzed the effects of operation of the LNFH Structures 1, 2, and 5 on juvenile salmonid downstream passage migration during a dry water year (i.e., 90^{th} Exceedance) (Figure 16). As mentioned above, ESA-listed juvenile salmonid upstream passage and migration can occur year-round. The flow recommendation for juvenile salmonid upstream passage at Structures 1 & 2 is 64 cfs (Anglin et al. 2013). The IWG did not have a juvenile salmonid downstream passage recommendation for structures 1, 2, and 5 so the Anglin et al. (2013) recommendation was used as an ideal downstream passage goal.

Water withdrawals from operation of LNFH Structures 1 & 2 during a dry water year would have no to negligible effects on juvenile salmonid upstream passage due to sufficient flows (40 cfs or greater) January through July and in November and December but with possible velocity limitations. The exceptions are the months of September (10 cfs) and October (32 cfs), where the effect would be negative because depth and velocity limitations would occur for juvenile salmonids during these two months. However, the proposed action would offset Structure 2 diversions by providing up to 50 cfs of supplemental flows in Icicle Creek during the months of August and September likely resulting in beneficial to neutral effects on ESA-listed species by potentially increasing instream flows for downstream passage and slightly decreasing summer water temperature. The proposed action would not operate Structure 2 in August resulting in beneficial effects on ESA-listed juvenile salmonid passage. In addition, the proposed action includes an instream flow goal of 40 cfs for the month of October. Based on instream flows and production needs, the LNFH met this goal (with Structure 2 being operated) in 18 out of 21 years analyzed in Irving (2015a) (Gale 2014).

The flow recommendation for juvenile salmonid upstream passage at Structure 5 is 125 cfs (Anglin et al. 2013). The IWG did not have a juvenile salmonid upstream passage recommendation for structures 5, so the Anglin et al. (2013) recommendation will be used as an ideal upstream passage goal. Operation of the LNFH Structure 5 during a dry water year would have no effects on juvenile salmonid upstream passage during the months of April through July due to sufficient flows (125 cfs or greater). The exceptions would be the months of January through March and August through December where stream flow was not sufficient for upstream passage of Structure 5 ranging from 10 cfs to 81cfs causing potential depth limitations resulting in negative effects on ESA-listed juvenile salmonids.

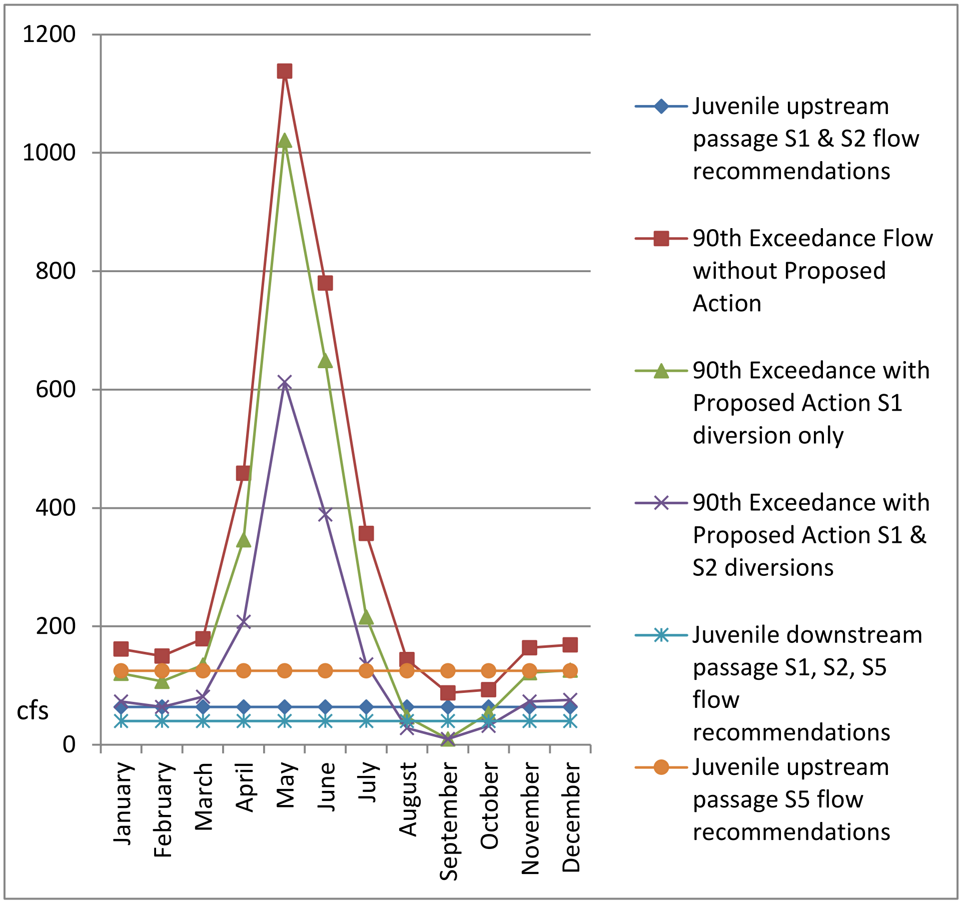

Figure 16. Effects of the operation of the LNFH Structures 1, 2 & 5 and associated stream flows on passage and migration of ESA-listed juvenile salmonids during a dry water year (90th exceedance).

NMFS also analyzed the effects of operation of the LNFH Structures 1, 2, and 5 on juvenile salmonid downstream passage migration during a dry water year (i.e., 90th Exceedance) (Figure 16). ESA-listed juvenile salmonid downstream passage and migration can also occur year-round. The flow recommendation for juvenile salmonid downstream passage at Structures 1 & 2 is 40 cfs (Anglin et al. 2013). Water withdrawals from operation of LNFH Structures 1 & 2 during a dry water year would have no effects January through August and October – December on juvenile salmonid downstream passage due to sufficient flows (40 cfs or greater) nearly all months of the year. Negative effects are likely to occur to ESA-listed juvenile salmonid downstream passage for Structures 1, 2 and 5 during the month of September where stream flows were only 10 cfs, potentially causing depth and velocity limitations. However, the proposed action would offset diversions by providing up to 50 cfs of supplemental flows in Icicle Creek during August and September resulting in beneficial or neutral effects on ESA-listed species by increasing instream flows for downstream passage and decreasing water temperature. The proposed action would not operate Structure 2 in August resulting in beneficial effects on ESA-listed juvenile salmonids from Structure 2 operations during that month. In addition, the proposed action includes an instream flow goal of 40 cfs for the month of October. Based on instream flows and production needs, the LNFH met this goal (with Structure 2 being operated) in 18 out of the 21 years analyzed in Irving (2015a) (Gale 2014).

In summary, after examining the effects of operations of LNFH Structures 1, 2, and 5 in both an average and dry water year, water diversions and instream structures would have no, negligible, and negative effects on annual juvenile steelhead and spring Chinook salmon upstream and downstream passage migration. The net effect of reduced stream flows and limited access at structures 1, 2, and 5 due to the proposed action on ESA-listed spring Chinook salmon upstream and downstream passage would be negative but small since Icicle Creek is not a major production area for this species (UCSRB 2007). The net effect of reduced stream flows and blockage at structures 1, 2, and 5 due to the proposed action on ESA-listed juvenile steelhead upstream and downstream passage would be negative since Icicle Creek is a major spawning area. Negligible effects occur during the month of September in an average water year where the stream flow was 54 cfs potentially causing lack of upstream passage for ESA-listed juvenile salmonids at Structures 1 and 2. Negative effects also occurred in September and October during an average water year where stream flow was only 54 cfs, and 94 cfs, respectively, causing depth and velocity limitations for ESA-listed juvenile salmonid upstream passage at Structure 5. Effects were negative during a dry year in September with stream flows of 10 cfs, of recommended downstream passage flows (40 cfs). In addition, during a dry year, negative effects may occur in the month of September (10 cfs) for downstream passage of ESA-listed juvenile salmonids at Structure 5. During all other months of the year during an average or dry water year, only negligible effects, if any, would occur for ESA-listed juvenile salmonid upstream or downstream passage migration at the LNFH Structures 1, 2, and 5. However, the proposed action would offset diversions by providing up to 50 cfs of supplemental flows in Icicle Creek during August and September resulting in beneficial to neutral effects on ESA-listed species by potentially increasing instream flows for downstream passage and slightly decreasing summer water temperature. The proposed action would not operate Structure 2 in August resulting in beneficial effects on ESA-listed juvenile salmonids from no Structure 2 operations during that month. In addition, the proposed action includes an instream flow goal of 40 cfs for the month of October. Based on instream flows and production needs, the LNFH met this goal (with Structure 2 being operated) in 18 out of 21 years analyzed in Irving (2015a) (Gale 2014).

2.4.2.6.2.3 Effects on rearing of ESA-listed juvenile salmonids

NMFS analyzed the effects of operation of the LNFH Structures 1, 2 and 5 on juvenile salmonid rearing during an average water year (i.e., 50th Exceedance) (Figure 17). Effects on ESA-listed spring Chinook salmon and steelhead juvenile rearing would be identical because stream flow passage recommendations (Anglin et al. 2013) apply to both juvenile salmon and steelhead. The IWG did not have a juvenile salmonid rearing recommendation for structures 1, 2, and 5 so the Anglin et al. (2013) recommendation will be used as an ideal juvenile rearing goal. ESA-listed spring Chinook salmon and steelhead juveniles in this section are also referred to as “juvenile salmonids”.

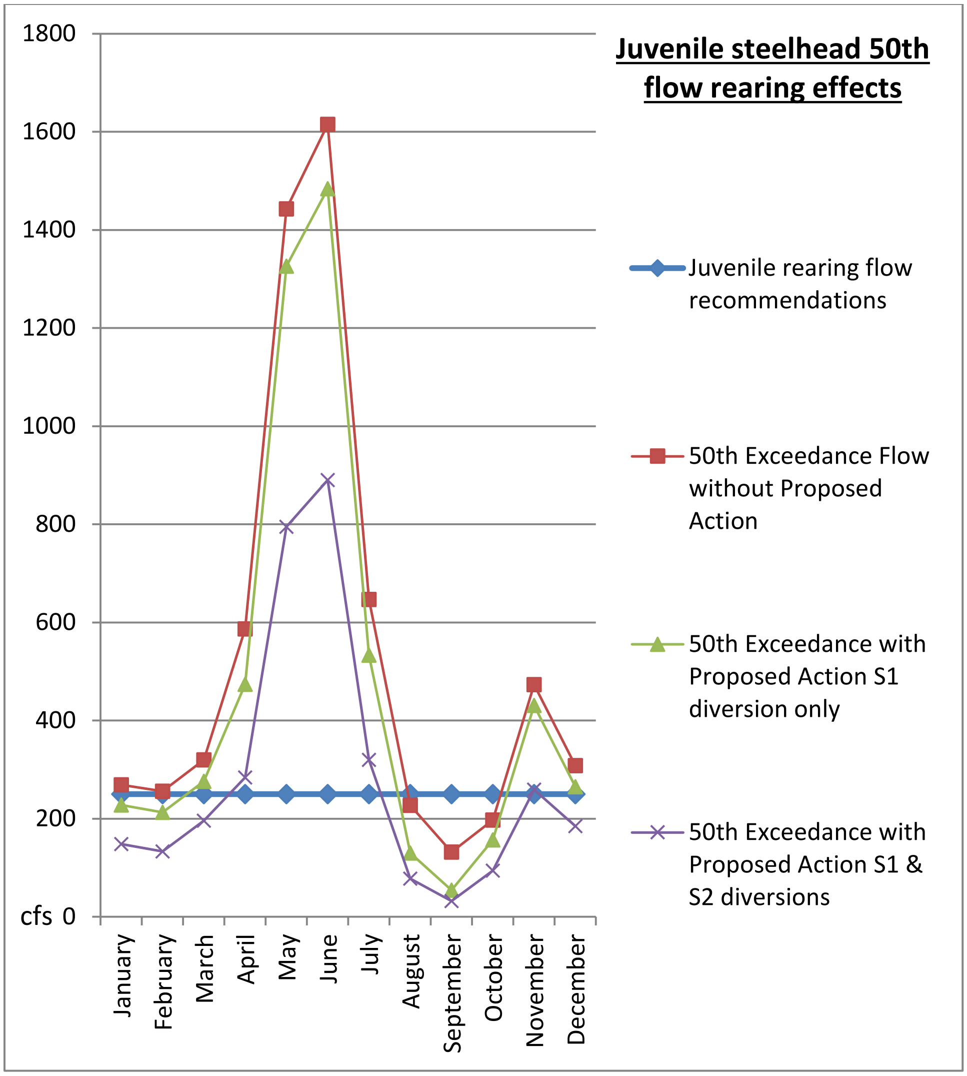

Figure 17. Effects of the operation of the LNFH Structures 1, 2 & 5 and associated stream flows on rearing of ESA-listed juvenile salmonids during an average water year (50th exceedance).

ESA-listed juvenile salmonid rearing occurs year-round (i.e., during all months of the year). The ideal flow recommendation for juvenile salmonid rearing at Structures 1 and 2 is 250 cfs (Anglin et al. 2013). Water withdrawals from operation of LNFH Structures 1 & 2 during an average water year would have no to negligible effects on juvenile salmonid rearing in April through July and during the month of November due to sufficient flows (250 cfs or greater) with possible velocity limitations (Anglin et al. 2013). The effects on ESA-listed juvenile salmonid rearing due to operation of LNFH Structures 1 and 2 during the months of January through March, August through October, and December in an average water year would be negative. Negative effects are due to insufficient stream flow ranging from 54 cfs in September to 196 cfs in March of the recommended stream flow (250 cfs). However, the proposed action would offset diversions by providing up to 50 cfs of supplemental flows in Icicle Creek during the months of August and September resulting in beneficial to neutral effects on ESA-listed species by potentially increasing instream flows and slightly decreasing summer water temperature for rearing salmonids. The proposed action would not operate Structure 2 in August resulting in beneficial or neutral effects on ESA-listed juvenile salmonids from no operation of Structure 2 during that month. In addition, the proposed action includes an instream flow goal of 40 cfs for the month of October. Based on instream flows and production needs, the LNFH met this goal (with Structure 2 being operated) in 18 out of the 21 years analyzed in Irving (2015a) (Gale 2014).

NMFS also analyzed the effects of operation of the LNFH Structures 1, 2, and 5 on juvenile salmonid rearing during a dry water year (i.e., 90th Exceedance) (Figure 18).

As mentioned above, ESA-listed juvenile salmonid rearing occurs year-round (i.e., during all months of the year) and the ideal flow recommendations for juvenile salmonid rearing at Structures 1 and 2 is 250 cfs (Anglin et al. 2013). The IWG did not have a juvenile salmonid upstream passage recommendation for Structures 1, 2, and 5, so the Anglin et al. (2013) recommendation will be used as an ideal juvenile instream rearing goal. Water withdrawals from operation of LNFH Structures 1 & 2 during a dry water year would have no to negligible effects on juvenile salmonid rearing in May and June with possible velocity limitations (Anglin et al. 2014). The effects on ESA-listed juvenile salmonids due to operation of LNFH Structures 1 and 2 during the months of January through April and July through December in a dry water year would be negative.

Negative effects are due to insufficient stream flow of 10 cfs in September to 208 cfs in March of the recommended stream flow (250 cfs) with both potential depth and velocity limitations for juvenile salmonid rearing. The proposed action would offset diversions by providing up to 50 cfs of supplemental flows in Icicle Creek during the months of August and September, resulting in beneficial to neutral effects on ESA-listed species by potentially increasing instream flows and decreasing summer water temperatures for rearing salmonids. In addition, the proposed action includes an instream flow goal of 40 cfs for the month of October. Based on instream flows and production needs, the LNFH met this goal (with Structure 2 being operated) in 18 out of the 21 years analyzed in Irving (2015a) (Gale 2014).

After examining the effects of operations of LNFH Structures 1, 2, and 5 in both an average and dry water years, as discussed below, water diversions and instream structures would have no, negligible, and negative effects on ESA-listed juvenile spring Chinook salmon and steelhead rearing annually. The net effect of reduced stream flows and limited access at structures due to the proposed action on ESA-listed juvenile spring Chinook salmon rearing would be negative but small since Icicle Creek is a minor spawning area (UCSRB 2007) with low productivity (Ford et al. 2012). Net effects on ESA-listed juvenile steelhead rearing would be negative since Icicle Creek supports a major spawning area. Negative effects on juvenile steelhead rearing may occur during January through March, August through October and December in an average water year where the stream flow was only 54 cfs to 196 cfs (recommended 250 cfs) causing lack of adequate stream flow for ESA-listed juvenile salmonid rearing at Structures 1 and 2.

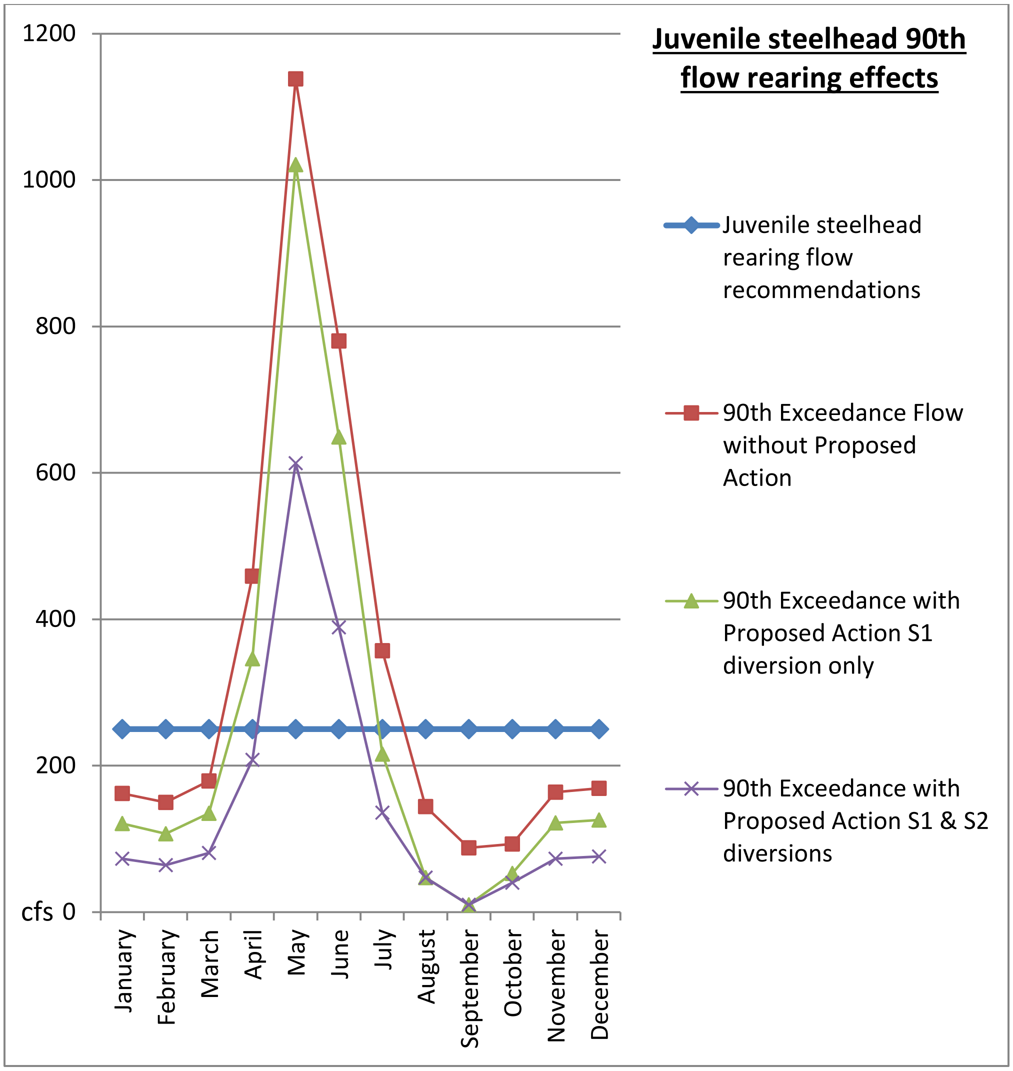

Figure 18. Effects of the operation of the LNFH Structures 1, 2 & 5 and associated stream flows on rearing of ESA-listed juvenile salmonids during a dry water year (90^{th} exceedance).

Negative effects may also occur in January through April and July through December in a dry water year where stream flow was only 10 cfs to 208 cfs (recommended 250 cfs) causing lack of adequate stream flow and depth and velocity limitations for ESA-listed juvenile salmonid rearing at Structures 1 and 2. The proposed action would offset diversions by providing up to 50 cfs of supplemental flows in Icicle Creek during August and September resulting in beneficial to neutral effects on ESA-listed species by potentially increasing instream flows and slightly decreasing summer water temperature. In addition, the proposed action includes an instream flow goal of 40 cfs for October. Based on instream flows and production needs, the LNFH met this goal (with Structure 2 being operated) in 18 out of the 21 years analyzed in Irving (2015a) (Gale 2014).

Reduction in streamflow in the mainstem Icicle Creek from operation of the LNFH structures 1, 2, and 5 would likely negatively impact juvenile spring Chinook salmon and steelhead in a variety of ways including: reduced access to cover, reduced drifting invertebrate prey species, increased summer water temperatures, degraded conditions for upstream and downstream passage, and reduced connectivity to improved habitat conditions upstream or refugia downstream of the Icicle Creek historical channel. Although many of these effects are difficult to quantify, they are likely to negatively affect abundance, productivity, and spatial structure of the ESA-listed Wenatchee steelhead population. They are also likely to have negative effects on any progeny of ESA-listed natural or hatchery adult spring Chinook salmon using Icicle Creek for spawning and migration but these negative effects are likely to be small because: (1) Icicle Creek is a minor spawning area with no designated critical habitat for the ESA-listed Wenatchee spring Chinook salmon population (UCSRB 2007), (2) the majority of spawners are likely hatchery-derived (e.g., Carson stock) (NMFS 1999b) and stray hatchery fish, (3) little productivity from the natural-origin population is believed to occur (UCSRB 2007), and (4) despite the current increase in ESA-listed hatchery-origin strays, any relative reproductive success would likely be lower than the natural-origin spawners in Icicle Creek (Williamson et al. 2010; Ford et al. 2012).

The proposed action also includes measures that are beneficial for ESA-listed spring Chinook salmon and steelhead rearing juveniles. The LNFH has adopted a collective instream flow goal of 100 cfs in Icicle Creek as compared to a minimum flow of 20 cfs (baseline effects) in the Icicle Creek historical channel. This benefits ESA-listed juveniles in Icicle Creek by increasing instream flows and expanding available rearing habitat. Structure 2 would not be operated in August when steelhead fry are emerging likely resulting in increases in fry survival.

The proposed action provides up to 50 cfs of supplemented instream flow from Snow/Nada Lakes Reservoir in August and September increasing instream flows when they are typically at their lowest and decreasing summer water temperatures. In September, if the natural flow remaining is less than 60 cfs after subtracting the amount of water diverted by the LNFH and all water users, the LNFH will not route more water into the hatchery channel than the volume of its Snow/Nada Lake storage release (up to 50 cfs) minus the withdrawal from Snow Creek by IPID and diversion at Structure 1 (up to 42 cfs) resulting in neutral effects. When the collective instream flow goal of 100 cfs cannot be met due to natural flow limitations, the LNFH would operate under daily average instream flow goals of 40 cfs in October, 60 cfs from November – February, and 80 cfs in March to meet hatchery production targets resulting in reduced negative effects on spring Chinook salmon and steelhead juvenile rearing in Icicle Creek. Beneficial effects likely to occur from these actions are increased water quantity for fry/parr/smolt growth and rearing development, connectivity to upstream habitat for juveniles and downstream passage, increased prey availability, and decreased summer water temperatures.

2.4.2.6.3 Summary of effects on ESA-listed species

Based on the information and analyses above, operation of the water delivery system and flow management included in the proposed action would have negligible effects on ESA-listed adult spring Chinook salmon and steelhead spawning and migration (Section 2.4.2.6.2.1). Negative effects on ESA-listed juvenile spring Chinook salmon and steelhead juvenile passage migration and rearing would occur (Sections 2.4.2.6.2.2 and 2.4.2.6.2.3). In particular, escapement data

(Section 1.3) demonstrate that both spring Chinook salmon and steelhead are recolonizing the Icicle Creek historical channel after access to the area was restored in 2011. However, some negative effects likely to occur due to the proposed action include degraded water quantity, lack of adult fish passage, entrainment, injury or mortality, diminished habitat connectivity, sedimentation, and turbidity.

Little natural production from the natural-origin fish included in the Wenatchee spring Chinook population is thought occur in Icicle Creek (UCSRB 2007) but an increase in ESA-listed hatchery-origin spring Chinook salmon encounters have occurred annually from 2008 to 2014 (Gale 2015b). Due to lack of data regarding the proportion of hatchery and natural fish in Icicle Creek, effects on natural-origin adult spring Chinook salmon cannot be measured at this time. However, no to negligible effects are likely to occur for UCR adult spring Chinook salmon because an average of 200 cfs is provided during the spawning season. Negative effects are likely to occur to spring Chinook salmon juveniles in Icicle Creek but we believe the effects on juvenile spring Chinook salmon are small because it is not an important spring Chinook salmon natural production area[94] (UCSRB 2007) (NMFS 1999b).

The proposed action would also have potential beneficial effects on ESA-listed spring Chinook salmon and steelhead. The LNFH would not operate Structure 2 during the month of March when adult steelhead are present resulting in beneficial or neutral effects such as increased instream flows, decreasing summer water temperatures, and expanded access to upstream spawning habitat for UCR adult steelhead. The LNFH would also offset water diversions during the months of August and September with supplemented flow from the Snow/Nada Lake Reservoirs resulting in neutral effects on UCR adult spring Chinook salmon and steelhead juvenile passage and rearing. The LNFH would monitor and report on these effects as well as adult and juvenile passage conditions between the upstream diversion site and the location downstream where water is returned to the river. No construction of facilities are proposed at this time. After weighing all effects associated with operation, and maintenance of hatchery facilities, the net effects are negative for UCR steelhead because Icicle Creek is a major spawning area and negative for UCR spring Chinook salmon but these effects are considered small in scope because Icicle Creek is not a major production area for the Wenatchee spring Chinook salmon natural population.

NMFS recognizes and supports the LNFH's infrastructure upgrades and instream flow improvements (i.e., long-term actions) described in the proposed action while meeting their production targets. However, NMFS only relies on our analysis of the short-term actions (i.e., water delivery system operational changes and instream flow improvements) described in Section 1.3 in making our effects determinations.

2.4.2.7. Factor 7. Fisheries that exist because of the hatchery program

Not applicable for UCR spring Chinook salmon, UCR steelhead: There are no fisheries-related effects included in the proposed action. As indicated in Table 17, fisheries in the action area have

[94] Productivity includes ESA-listed natural-origin and hatchery-origin strays, which belong to the UCR Spring-run Chinook Salmon ESU.

previously been evaluated and authorized in separate biological opinions (NMFS 2008b; NMFS 2013a).

2.4.2.8. Effects of the Action Under Climate Change

To understand the effects of the proposed action under climate change, NMFS examined local climate change information, data, and studies, in addition to consideration of the IPCC global report and existing literature. Since the 2015 Opinion, NMFS has examined, and in some cases, re-examined, the climate change literature and modeling for the Pacific Northwest, including:

(1) Wade et al. 2013 – Steelhead Vulnerability to Climate Change in the Pacific Northwest
(2) Wade et al. 2017 – Accounting for adaptive capacity and uncertainty in assessments of species' climate-change vulnerability
(3) ISAB 2007 – Independent Scientific Advisory Board 2007 Climate Change Impacts on Columbia River Basin Fish and Wildlife
(4) BPA 2017 – Bonneville Power Administration, River Management Joint Operating Committee (RMJOC II), 2017 Reservoir Operations Assessment for Climate Change in the Columbia River Basin
(5) Irving 2015 – Water Use at Leavenworth National Fish Hatchery and Icicle Creek Instream Flow: A Plan for Interim and Long-Term Solutions
(6) USFS 2016 – U.S. Forest Service Western U.S. Streamflow Metrics – A Dataset of Modeled Flow Metrics for Streams in Major River Basins of the Western U.S. for Historical and Future Climate Change Scenarios (USFS flow modeling)
(7) USFS 2013 – U.S. Forest Service Regional Database and Modeled Stream Temperatures (NorWeST)

Upon examination, each of the above sources was reasonably consistent with findings in the recent IPCC global climate change reports (IPCC 2013; IPCC 2014). However, three sources of data from the list—USFS flow modeling, Irving (2015), and NorWeST—were likely candidates to provide climate change information on a local scale (i.e., Icicle Creek action area). With the help of the YN and the CTCR, NMFS was able to obtain the datasets from USFS flow modeling and NorWeST and work with our Northwest Fisheries Science Center to derive a local estimate of projected summer instream flows. The discussion about temperature predictions using NorWeST can be found in Section 2.4.2.6.1.

Specific climate change impacts on ESA-listed species using the historical dataset (Irving 2015) are described above under Factor 6 (Section 2.4.2.6). Information on longer-term climate change effects associated with the action area, including the Wenatchee and Entiat sub-basins, and in Icicle Creek (where facility effects are likely to occur), are described below. NMFS provides a general description of climate change effects; few studies have made the connection between climate change, freshwaters systems, and impacts on productivity of species that experience those environments specifically in terms of extent and numbers of take (Wade et al. 2013).

The effects of climate change are likely to be already occurring, though the effects are difficult to distinguish from effects of climate variability in the near term. Recent flow data in Icicle Creek, like those from Irving (2015) that were used in Section 2.4.2.6, likely capture most of the near-term variability. However, baseline historical flows may or may not be effective predictors of long-term future flows because much uncertainty surrounds any climate change predictions.

In evaluating the current proposed action, NMFS used "downscaled" projections that have been developed through appropriate scientific procedures, where available, because such projections provide higher resolution information that is more relevant to spatial scales used for analyses of a given species (Glick et al. 2011) despite the higher uncertainty and variability associated with smaller-scale modeling. With regard to our analysis of climate effects under the proposed action, downscaled projections were available in some cases but primarily on a larger geographic scale (e.g., Upper Columbia Basin or Wenatchee River Sub-Basin) than the action area.

2.4.2.8.1. Climate Change Effects for the Upper Columbia River Watershed

Studies examining the effects of long-term climate change on salmon populations have identified a number of common mechanisms by which climate variation is likely to influence salmon sustainability (Ford et al. 2011). Climate futures are inherently uncertain, and vulnerability assessments are often based upon only one plausible climate and hydrologic change scenario – different inputs would lead to different outputs (see, for example, Crozier et al. (2008)). Within the action area, there is limited research on the effect of climate change on UCR spring Chinook salmon or steelhead. Thus, all outputs from climate change studies (e.g., air and water temperature, stream flow, snowpack levels, etc.) should be interpreted with caution until a better understanding of the complexity of habitat conditions and population status is achieved, further refinements and improvements in climate modeling occur, and research is available to measure or project future long-term effects of climate change with greater certainty. The following sections describe longer-term climate change effects associated with broad-scale geographic areas, and Table 33 summarizes findings from those studies.

Table 33. General predicted climate change impacts both globally and in the Columbia Basin. Legend: + = increase; - = decrease; -- = not available for this study

Source	Geographic Area	Temperature		Precipitation		Stream Flow	
		2040	2080	2040	2080	2040	2080
*IPCC 2014	Globally	+0.3 to +0.7 °C[1]	+1.5 – +2.0 °C[2]	+10 to 20%[3]		+winter -summer	+winter flow -summer flow
ISAB 2007[4]	Columbia Basin	+1.1 to +4.7 °C	--	+13%	--	+winter -summer	--
Wade et al. 2013	Wenatchee Basin	+1 °C[5]	--	--	--	+6-10% winter 0% summer[5]	--
*Wade et al. 2017	Columbia Basin	+1.5 °C	--	--	--	+winter flow[6]	--
*BPA RMJOC 2017[7]	UCR Basin	1.3 – 2.8 °C	--	-5% to +10%	--	+winter flow -summer flow	--

*Additional data sources added since the 2015 biological opinion; 2080 time frame was not examined or was unavailable for sources other than IPCC (2014).

[1] These are sea surface temperature increases (not instream temperatures) from 2016 to 2035 time period.

[2] These are sea surface temperatures (not instream temperatures) from 2081 to 2100 time period.

[3] These are precipitation estimates for 2080-2100, relative to 1986-2005.

[4] These estimates are based on Snover et al. (2013) *in* ISAB (2007); estimates include updates from Snover et al. (2013).

[5] Temperature and stream flow increases/decreases from 1970-1999 to 2030-2059 time period; no precipitation data included in study; predicts zero change in summer stream flows.
[6] Though the study does not directly indicate that winter flows would increase, increase is likely because the number of winter high-flow days was projected to increase by approximately 1.5 days by 2040.
[7] 2040 estimates are based on 2014 BPA RMJOC report; updated 2040 and 2080 estimates are not yet available (E. Pytlak pers. comm. 2017).

Wade et al. (2013)

In Wade et al. (2013), a spatial method for assessing salmon vulnerability to projected climatic changes (i.e., scenario for the years 2030–2059) was applied to steelhead across the entire Pacific Northwest (PNW). Steelhead exposure to increased temperatures and more extreme high and low flows during four of their primary freshwater life stages—adult migration, spawning, incubation and rearing—were examined. Results of the study estimated exposure to higher temperatures for adult steelhead would be greatest in the Lower Columbia River, UCR, Lower Snake, Far Upper Columbia, and Willamette Basins. (Wade et al. 2013). During steelhead migration, shifts in frequency and timing of high temperatures and increases in the duration and intensity of high flows were also predicted to be less prevalent in the UCR Basin as compared to other areas of the PNW (Wade et al. 2013). However, during steelhead rearing, exposure (e.g., lack of cover due to low stream flows) was more prevalent for the summer time period (Wade et al. 2013). Thus, climate change may result in changes to flows and temperatures within the UCR Basin that could exacerbate the effects of other anthropogenic (i.e., human made) habitat alterations.

In addition, Wade et al. (2013) recognizes that habitat quality and population status are not independent, though those these two variables are not as strongly correlated as one might expect. Most threatened populations are in the West Cascades and UCR Basins, which have a wide range of habitat qualities (Wade et al. 2013). Moreover, some coastal and Upper Columbia rivers have poor habitat quality but relatively robust population status. This illustrates an inability of broad-scale models to account for interactions between current and historical factors, including physical habitat complexity and harvest, hatchery, and resource management, such as water withdrawal, that determine population productivity (Wade et al. 2013). All modelling methods have limitations, from computational requirements to reliability of projections to clarity of underlying assumptions (Wade et al. 2013).

Wade et al. (2017)

In Wade et al. (2017), steelhead vulnerability to climate change was assessed for the Columbia Basin species (including UCR steelhead) by using three major elements of vulnerability (exposure, sensitivity, and adaptive capacity). The model also used four categories of metrics (climate, habitat, demographic, and genetic, with climate metrics representing exposure, habitat metrics representing sensitivity, and demographic and genetic metrics representing both sensitivity and adaptive capacity) (Wade et al. 2017). The study found that the Wenatchee population of UCR steelhead ranks between 20.1 to 40.0 in vulnerability, with the ranking of 100 being the most vulnerable (Wade et al. 2017, Figure 2). In addition, habitat and demographic metrics, rather than climate exposure metrics, contributed the most to UCR steelhead vulnerability (Wade et al. 2017).

This study found that vulnerability results that incorporated metrics representing adaptive capacity differed greatly from results obtained using a more traditional approach that incorporated only climate-exposure metrics and habitat-based metrics of climate sensitivity

(Wade et al. 2017). Though no information about UCR spring Chinook salmon is available from this study, the accuracy of predicting climate change effects on UCR spring Chinook salmon is likely to vary, depending on how UCR spring Chinook salmon's adaptive capacity is incorporated into such predictions.

ISAB (2007)

Climate change may have long-term effects that include, but are not limited to, depletion of cold water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and increased competition among species (ISAB 2007).

Specific to the Columbia River Basin, the Independent Scientific Advisory Board (ISAB) identified a number of effects climate change would have in the Columbia River Basin that could affect salmonid species; Icicle Creek and its tributaries, including Snow Creek, are likely to undergo similar climate change effects, though the effects may be slightly ameliorated in Icicle Creek (see Section 2.3.7, Climate Change). A few of these effects include: (1) Water temperature increases, and depletion of cold water habitat that could reduce the amount of suitable salmon habitat by about 22% by 2090 in Washington State; (2) Variations in precipitation that may alter the seasonal hydrograph and modify shallow mainstem rearing habitat; and (3) Earlier snowmelt and higher spring flows with warmer temperatures that may cause spring Chinook and steelhead yearlings to smolt and emigrate to the ocean earlier in the spring (ISAB 2007).

To mitigate for the effects of climate change on listed salmonids, the ISAB (2007) recommends planning now for future climate conditions by implementing protective tributary, mainstem, and estuarine habitat measures, as well as protective hydropower mitigation measures. In particular, the ISAB (2007) suggests increased summer flow augmentation from cool/cold storage reservoirs to reduce water temperatures or to create cool water refugia in mainstem reservoirs and the estuary. The ISAB (2007) also calls for the protection and restoration of riparian buffers, wetlands, and floodplains. Although there were no specific recommendations for hatchery programs, the ISAB recommends managing to accommodate uncertainty (ISAB 2007). Hatchery programs could help with this uncertainty by serving as reserves for ESA-listed species. These will be most effective if hatchery programs make an effort to propagate populations with large phenotypic and genetic diversity to provide the greatest potential for adaptation.

Only global strategies for reducing the emission of greenhouse gases will completely address climate change impacts on all habitats in the Columbia Basin (ISAB 2007). In many cases, impacts of climate change on fish at one life history stage contribute to increased mortality at later stages; the impacts of climate change can propagate cumulatively through the life of the fish (ISAB 2007). For example, survival of migrating and spawning adults, and fry emergence of UCR spring Chinook salmon and rearing of UCR steelhead, may suffer during years of extreme low summer flows (Ward et al. 2015). The frequency of fall and winter storms in the Pacific Northwest is expected to increase and the trend in increased variation in winter flows is likely to continue (Mote & Salathe, 2010), potentially decreasing productivity through increased mortality during the egg incubation stage. Later peak flows during winter have the potential to affect UCR steelhead productivity by the scouring of eggs from the gravel (DeVries, 1997) as do the effects of increased flooding events. Expected behavioral responses include shifts in seasonal timing of important life history events, such as the adult migration, spawn timing, fry emergence timing, and the juvenile migration (Ford et al. 2011). Climate effects tend to be negative across multiple life stages (Healey 2011; Wade et al. 2013; Wainwright & Weitkamp 2013).

Conversely, the effect of increased flows may not be entirely negative. Ward et al. (2015) estimated a positive relationship between mean winter flow and Chinook salmon productivity. Positive effects include reduced predation on juveniles in more turbid environments (Gregory and Levings 1998) or benefits to juveniles that overwinter by creating greater access to habitat for foraging and sheltering (Sommer et al. 2005). These beneficial effects would extend to UCR juvenile steelhead as well. Increased late winter and spring instream flows would assist adult summer steelhead migration to spawning grounds.

BPA 2017

In 2017, NMFS staff attended the BPA RMJOC-II climate change study workshop that examined reservoir capacity within the Columbia River Basin. Although the final report is not yet available, climate outputs predicted increased winter flows, decreased summer flows, earlier spring peak flows, and less accumulation of snow pack (less precipitation falling as snow/more falling as rain) in the UCR Basin (BPA 2017). Furthermore, the BPA study predicts temperature increases between 1.3 to 2.8 °C by 2040, which are more modest estimates compared to other scientifically valid scenarios. The dataset reasonably captures the uncertainty in future Pacific Northwest precipitation levels predicting – 5 percent to +10 percent by the 2040s. BPA also mentions that the new IPCC models are trending warmer than previous forecasts but with a slightly larger range of uncertainty. Recent IPCC study results still show a large range of possible annual precipitation outcomes with somewhat drier summers compared to previous studies (BPA 2017). The BPA study results were consistent with other climate change outputs that demonstrate both beneficial and negative effects (as described above) during all life stages of salmon and steelhead.

2.4.2.8.2. Climate Change Effects for Icicle Creek Watershed

Unlike the studies discussed above, USFS flow modeling provides climate change flow predictions specific to Icicle Creek, though with limited data points (Table 34). These predictions are for flow at the USGS Gage #12458000 on Icicle Creek for years 2040 and 2080. In addition, the “historic” flows, which are model predictions based on historical data from 1977 to 2006, are used as representations of present-day flow. As discussed below, we find that mean August, mean summer, and mean annual flows are appropriate outputs to use for our analysis.

Table 34. Predicted mean flows using USFS flow modeling (in cfs).

	Historic	**2040**	**2080**
Mean August	280	102	59
Mean Summer[1]	845	513	271
Mean Annual	690	723	739

Source: (Kondo 2017w; USDA 2015)

[1] Mean summer flow is the average of daily flow between June 1 and September 30 (USDA 2015).

The IPCC presents four Representative Concentration Pathways (RCPs) to assess future climate changes, risk, and impacts (IPCC 2014). The IPCC did not identify any scenario as being more likely to occur than any other. For the purpose of evaluating potential climate effects on resource management, and for the specific purpose of the present analysis of the LNFH program, NMFS considers it appropriate to assume conditions similar to the *status quo* when analyzing climate effects (Weiting 2016). "Status quo" is one of the less optimistic climate change scenarios; it includes not only current temperatures, flows, and other climate factors, but also the assumption that no more than moderate adjustments to anthropogenic factors would occur. NMFS evaluates climate change effects as projected under RCP 8.5 when data are available to allow such evaluation (Weiting 2016) and, when sufficient data are not available, evaluates conditions as close to representing RCP 8.5 as possible.

The USFS flow model used underlying simulations (i.e., Variable Infiltration Capacity (VIC) macroscale hydrological model) that used a climate change scenario called A1B emissions scenario, which is analogous to RCP 6.0 (CIG 2013; USDA 2015). Because modeling specific to Icicle Creek based on RCP 8.5 is unavailable, NMFS relies on the A1B emissions scenario (CIG 2013). (CIG 2013). Though we cannot quantify the exact differences in the model outcomes, the climate change effects are likely to be greater to some unknown extent under conditions described in RCP 8.5 than this USFS flow model because RCP 8.5 assumes a higher level of GHG emissions than RCP 6.0 (CIG 2013).

Uncertainty surrounding the model

Climate futures are inherently uncertain, and most vulnerability assessments are based upon only one plausible climate and hydrologic change scenario – different inputs would lead to different outputs (Wade et al. 2013; Crozier et al. 2008). Crozier et al. (2008) stated that, despite the challenges involved in experimental manipulation of species with complex life histories, such research is essential for full appreciation of the biological effects of climate change.

The USFS flow model is no exception, and much uncertainty surrounds this climate change modeling. We note that while these modeled flow levels represent regionally consistent projections using available data, they are based on relatively coarse scaled functional relationships that may not fully reflect watershed specific considerations. For example, the sources of uncertainty in modeled flow include, but are not limited to, how the modeling included non-normative (i.e., not naturally occurring) water input, such as releases from irrigation and reservoirs. The model used for this analysis does not account for irrigation and reservoir releases, although it uses a refined approach to including other groundwater parameters (Luce et al. 2017). However, the model projected flow for present day (280 cfs) is fairly close to the actual USGS gage #12458000 reading on Icicle Creek (252 cfs) for August, lending support to the efficacy of the assumptions and inputs driving the model results. In addition, the model estimates increased precipitation (Table 34), but another literature predicts decreases in future precipitation for areas near the Cascades (e.g., Icicle Creek), though the magnitude is unknown (Luce et al. 2013).

We also note that the underlying simulations used for the modeling (i.e., VIC model) is known to have trouble simulating base flow and some snowpack dynamics, leading to underestimates of August flow. Thus, the model developers recommend not using this metric, or using it only in basins without significant groundwater contributions or drifting snow[95] (USDA 2015). The proposed action area (Icicle Creek) is not known to have significant groundwater contributions or drifting snow. It is also the only local dataset available to assess future climate change effects of the proposed action. Thus, NMFS determined the August flow depicted in USFS flow modeling is appropriate to use for the purpose of this opinion.

Mean annual flows

Mean annual flows are expected to increase over time (Table 34). Presumably, this increase is a result of change in Icicle Creek from a snowpack to a precipitation-dominated system and because of increase in precipitation. As discussed in Section 2.4.2.8.1, such shift in Icicle Creek is consistent with the overall expected change in the Wenatchee Basin. However, while we have no reason to doubt that Icicle Creek would also follow the predicted pattern of earlier snow melt in other areas, the shift in the timing of snow melt cannot be extrapolated from this dataset.

Mean summer flows

Mean summer flows are expected to decrease over time (Table 34). We note that the model outputs for summer flows are not designed to be used as an indication for flow level predictions of any particular month. However, because mean summer flow is the average of daily flow between June 1 and September 30, we consider these data a representation of June and July (when the proposed action would not be supplementing from the reservoirs), though such representation is only for illustrative purposes of the flows that *could* occur; because mean August flows are substantially lower than the mean summer flows of corresponding years, June and July flows could be higher than what is noted in Table 34.

Table 35 summarizes the likely flow downstream of Structure 1 under the climate scenarios.

Table 35. Predicted mean summer flows below S1 under climate change scenarios (in cfs).

	USFS flow metric predictions	Withdrawal before S1 (non-hatchery)[1]	Flow above S1[2]	S1 max withdrawal	COIC withdrawal at S1	Flows below S1
Historic	845	101	744	42	6	696
2040	513	101	412	42	6	364
2080	271	101	170	42	6	122

Source: (Kondo 2017b; Kondo 2017w; USDA 2015)
[1] Actual July withdrawal values for IPID and City of Leavenworth from Table 39.
[2] These values were calculated by subtracting the non-hatchery withdrawal before S1 from the USFS flow metric predictions.
[3] These value were calculated by subtracting all the non-hatchery withdrawals and maximum withdrawal at S1.

To calculate these values, we assumed the largest amount of monthly withdrawals (i.e., in July; Table 39) that has historically been used by all non-hatchery entities to understand the minimum flow that could occur downstream of Structure 1. In addition, we used 42 cfs as the withdrawal value at Structure 1 because the proposed action allows removal of up to 42 cfs. Although NMFS recognizes that actual water withdrawals are less than 42 cfs during most months of the year (USFWS 2014, Appendix XI, Table 3), we consider the largest amount of water withdrawal

[95] Drifting snow is the meteorological term for any loose snow that is lifted from the ground surface and suspended by strong winds to a height of less than 2 meters (6 feet) or more that creeps, rolls, or bounces above the surface.

scenario that is likely to occur based on data about actual use in our analysis of local climate change effects.

For the purpose of this opinion, the following analysis is performed with the assumption that these model prediction values are the likely flow at USGS Gage #2458000, though we note the high degree of uncertainty associated with any climate change modeling, as discussed above. Under the “historic” scenario (present-day representation), the flow below Structure 1, after all assumed withdrawals, is predicted to be 696 cfs. For 2040, the flow is likely to be around 364 cfs. For 2080, the flow is likely to be around 122 cfs. In all three circumstances, the flows below Structure 1 are likely to be higher than 100 cfs, which is the collective instream flow goal for the hatchery operation, as described in Section 2.4.2.6.

Mean August flows

Mean August flows are also expected to decrease over time (Table 34). Table 36 summarizes the likely flow in Icicle Creek under the climate scenarios in August, assuming that all withdrawals remain the same as current use.

Table 36. Predicted mean August flows in Icicle Creek under climate change scenarios (in cfs).

	USFS flow metric predictions	**Withdrawal before S1 (non-hatchery)[1]**	**Flow above Snow Creek[2]**	**Snow/Nada Lakes suppl. (proposed action)**	**Flow between Snow Creek and S1[3]**	**S1 max withdrawal (proposed action)**	**COIC withdrawal at S1 (non-hatchery)**	**Flow below S1 (all uses)[4]**	**Flow below S1 (without proposed action)[5]**
Historic	280	100	180	50	230	42	6	182	174
2040	102	100	2	50	52	42	6	4	0
2080	59	59	0	50	50	42	6	2	0

Source: (Kondo 2017b; Kondo 2017w; USDA 2015)

[1] Actual August withdrawal values for IPID and City of Leavenworth from Table 39, with the exception of 2080. 59 was used for 2080 because IPID and City of Leavenworth would only be able to withdraw the amount that is in Icicle Creek (i.e., 59 cfs at gage).

[2] These values were calculated by subtracting the non-hatchery withdrawal before S1 from the USFS flow metric predictions.

[3] These values were calculated by adding the Snow/Nada Lake supplementation flow (assuming 50 cfs release) to the values for flow above Snow Creek.

[4] These values were calculated by subtracting both withdrawals at S1 from the flow between Snow Creek and S1.

[5] These values were calculated by subtracting all non-hatchery withdrawals from the USFS flow metric predictions.

Using these predictions for the purpose of this opinion, Icicle Creek above the confluence with Snow Creek is anticipated to be nearly dry in 2040 (2 cfs) and completely dry by 2080 (0 cfs) as a result of baseline conditions under upstream non-hatchery withdrawals. However, the proposed action supplements the flow in Icicle Creek by providing up to 50 cfs from the Snow and Nada Lakes reservoirs. That is, Icicle Creek would have at least 50 cfs of flow (assuming 50 cfs is released from the reservoir) between the confluence with Snow Creek and Structure 1, and would have 4 cfs or 2 cfs for 2040 and 2080 respectively, even if COIC withdraws its current monthly use of 6 cfs. Under these predicted future climate change scenarios, negative effects would occur to all life stages of the Wenatchee spring Chinook salmon and steelhead populations such as severely limiting migration and spawning of adults, fry emergence, upstream and downstream passage of juveniles, and degrading rearing habitat for juveniles, particularly between Structure 1 and Structure 5. Of note, Icicle Creek is predicted to not have any flow at

Structure 1 (i.e., 0 cfs) in 2040 and 2080 without supplementation from Snow and Nada Lake reservoirs, assuming all non-hatchery entities continue to withdraw the same amount as they currently do. Therefore, the proposed action increases the stream flow in Icicle Creek below Snow Creek.[96]

We find that the specific flow predictions for Snow Creek, while available, are not appropriate to use for analyzing the effects of climate change because they do not account for the ongoing accumulated storage in Upper Snow Lake leading up to the low flow summer period and its subsequent use to supplement summer/fall low flows that is part of the proposed action. This lack of consideration is apparent because the proposed action includes up to 50 cfs flow supplementation through Snow Creek in August, while the model predictions show very low flow (9 cfs for current, 4 cfs for 2040, and 3 cfs for 2080 (Kondo 2017w)).

Though we do not have numeric predictions for the amount of water storage in the Snow and Nada Lakes reservoirs under climate change, we find that the reservoirs are likely to be able to maintain storage at a level similar to current levels, if not more. We come to this conclusion because the mean annual flow is predicted to increase over time in Icicle Creek (Table 34), meaning that there will be an increase in water contributions to the watershed (likely from a shift from snowpack to precipitation-dominated system and from increased precipitation). Lake reservoirs are designed to capture and store snow pack melt or rain water, so the increase in flow contribution to the watershed allows the reservoir to continue storing an amount of water similar to current conditions even if the hydrologic regime under climate change patterns decreases flow during summer, unless a severe drought occurs. For example, supplementation occurred at 50 cfs from July 28 to October 2 in 2015 despite it being a low flow year (USFWS 2016). USFS flow modeling predicts significantly higher mean annual flows than historical (current) instream flows (Table 34). Therefore, Snow and Nada Lakes reservoirs are likely to be able to continue supplementing the flow in Icicle Creek, as described in the proposed action, even under these climate change scenarios[97].

Other monthly flows

Monthly predictions for months other than August are not available for this model (USDA 2015). However, the hatchery operation would continue to aim to meet the daily average instream flow goals of 40 cfs in October, 60 cfs from November – February, 80 cfs in March, and 100 cfs from April through July to meet hatchery production targets resulting in reduced negative effects on spring Chinook salmon and steelhead juvenile rearing in Icicle Creek. For spring to early-summer months, the instream flow goals are likely to be met with increasing probability because Icicle Creek is likely to shift to a precipitation-dominated system with early

[96] Though we have no predictions for September flow, this conclusion also applies to September flows under climate change scenarios because supplementation would occur in September under the proposed action.

[97] Even if the precipitation decreases in the future, as predicted by (Luce, C. H., J. T. Abatzoglou, and Z. A. Holden. 2013. The missing mountain water: Slower westerlies decrease orographic enhancement in the Pacific Northwest USA. Science 342:1360-1364.), the degree of such decrease is not known. Because Snow and Nada Lakes have the capacity to capture and store precipitation, precipitation would have to decrease substantially before these reservoirs no longer have the capacity to supplement the flow. However, a drought for more than two consecutive years, which is unlikely, could require a reduction in supplemental flow from Snow and Nada Lakes (Cappellini 2014). The amount of reduction is unknown and would be largely dependent on the environmental conditions at the time.

snow melt and increased precipitation. However, instream flow goals are likely to become more difficult to meet in the late-summer months when supplementation is not occurring.

2.4.2.8.3. Summary of Climate Change Effects

Overall, broad geographic and long-term climate change impacts include increased winter flows, decreased summer flows and winter snowpack, and a change in peak flow timing. All of these impacts are likely to have a variety of beneficial and negative effects on the Wenatchee spring Chinook salmon and steelhead populations in Icicle Creek for all life stages (Section 2.4.2.8.1). Due to the wide-ranging uncertainty and variability in climate change outputs, NMFS can only determine that these effects are likely to occur if the climate models accurately predict future conditions.

In the action area, the proposed action is likely to improve future habitat conditions for the Wenatchee spring Chinook salmon and steelhead populations in Icicle Creek because it allows for additional supplementation of up to 50 cfs during critical low flow summer periods, particularly in August. Icicle Creek is predicted to be dry in 2040 and 2080 without supplementation from Snow and Nada Lake reservoirs, assuming all non-hatchery withdrawals continue at the same rate. Therefore, the proposed action increases stream flows in Icicle Creek under future climate change scenarios (Section 2.4.2.8.2) for months when supplementation occurs.

As previously mentioned, only global strategies for reducing greenhouse gas emissions will fully address climate change impacts. Any number of stressors in combination with one another or with climate impacts will present pressures of much greater concern than they would individually, but they also offer potential solutions (Ford et al. 2011). Habitat actions can address some of the adverse impacts of climate change on fish in the future. Reducing water diversions and using supplementation from cold water reservoirs, as described under the proposed action (Section 1.3), can help alleviate increasingly adverse future climate change effects on flows and temperatures both in the short-term (5 to 20 years) and long-term (20 to 80+ years). The Icicle Creek Restoration Project, which removed Structures 3 and 4 from the stream, allowed for improvements in the Icicle Creek Historical Channel by transitioning from wetland to riverine habitat such that the condition of spawning fish habitat may further improve (Section 2.3.2). Habitat restoration actions like these are likely to ameliorate future climate change effects by increasing habitat diversity and population resilience (Beechie et al. 2013; Honea et al. 2016) for UCR spring Chinook salmon and steelhead. Thus, the activities described in the proposed action (Section 1.3) and the Environmental Baseline (Section 2.3), coupled with instream flow supplementation (Section 2.4.2.8.2), assist in offsetting negative effects by allowing these species to better adapt to future environmental conditions.

Finally, the Icicle Creek watershed is fed predominantly by high-elevation mountain crests, alpine lakes, and glaciers (Section 1.4). Due to the geographical features of the predominantly narrow canyon and hydrological sources of Icicle Creek, water temperatures remain colder than broader rivers with wider stream width and shallower depths located at lower elevations in the UCR Basin. For this reason, predicted climate change is less likely to have negative effects in Icicle Creek than in other streams within the UCR Basin that have different geographical features. Nonetheless, NMFS recognizes the importance of restoring habitat in Icicle Creek through the proposed action, coupled with instream flow supplementation (Section 1.3; Section 2.3; Section 2.4.2.8.2) to ameliorate the predicted increasing temperatures, decreased snowpack, and variability of instream flow regimes under future climate change scenarios, even in an area that overall would be less prone to climate change affects.

We note that our understanding of what is likely to occur under current predicted climate change models is limited; climate change predictions are updated frequently, and the analysis in this opinion used models that have many assumptions and uncertainties. However, for the purpose of this consultation, the use of such models is the best available projection of what might happen into the future and is therefore appropriate to use.

2.4.2.9. Effects of the Action on Critical Habitat

Negligible for UCR spring Chinook salmon, negative effect for UCR steelhead: Critical habitat is not designated for UCR spring Chinook salmon in Icicle Creek so a determination of effects on designated critical habitat is not applicable. However, the action area also includes the lower Wenatchee River where effects are determined negligible. Critical habitat is designated in the Entiat River for UCR spring Chinook salmon; because the only effect of the proposed action in the Entiat River involves adult strays and potential genetic effects, there would be negligible effect on critical habitat in the Entiat River.

Critical habitat is designated for ESA-listed steelhead in Icicle Creek. Operation of the proposed action would have a negative effect on designated critical habitat for UCR steelhead in Icicle Creek and the lower Wenatchee River.

Variations in streamflow can affect water quality (Ebersole et al. 2009; Ebersole et al. 2006; May and Lee 2004; NMFS 2002b; Poole and Berman 2001), amount of drifting invertebrates (Carlisle et al. 2010; Elliott 2002; Townsend and Hildrew 1994), refugia available for rearing salmonids (Hardy et al. 2006), riparian vegetation (Lake 2003; Ritcher and Ritche 2000), condition of substrates (Wilcock et al. 1996), and fish passage (Cragg-Hine 1985; Mitchell and Cunjak 2007; Thompson 1972). The proposed action would negatively affect primary constituent elements (PCEs) for UCR steelhead associated with freshwater spawning, migration, and rearing (Table 31); however, the majority of effects would be on water quantity. Negative effects from sediment on streams associated with diversion maintenance and use also occur. Sediment can reduce water quality and quality of substrate, including spawning gravel.

2.4.2.9.1. UCR Spring Chinook Salmon

As mentioned above, Icicle Creek does not contain habitat for UCR spring Chinook salmon designated as critical. Critical habitat for UCR spring Chinook salmon was designated in the Wenatchee River mainstem only; Icicle Creek and its tributaries were excluded from the critical habitat listing (70 FR 170, September 2, 2005). Designated critical habitat for UCR spring Chinook salmon affected by the proposed action would occur in the lower Wenatchee River from the mouth of Icicle Creek to the confluence of the Columbia River in the action area. ESA-listed UCR spring Chinook salmon occupy the lower Wenatchee River mainstem where designated critical habitat is rated as having a medium conservation value (Section 2.2.2.1). The LNFH is a non-consumptive water user and all water is returned (along with additional groundwater used by the hatchery) to Icicle Creek, minus any leakage or evaporation, before the confluence of the Wenatchee River. The effects of LNFH-effluent in the mainstem Wenatchee River is trivial because of the Wenatchee River's assimilative capacity and the location of Icicle Creek relative to other sources of phosphorus load, as discussed in Section 2.4.1.6. Therefore, effects of the proposed action are likely to be negligible and are not anticipated to reduce the conservation value of designated critical habitat for UCR spring Chinook salmon in the lower Wenatchee River.

2.4.2.9.2. UCR Steelhead

Designated critical habitat for UCR steelhead exists in the entire action area including Icicle Creek from RM 5.7 to the confluence of the lower Wenatchee River as well as in the lower Wenatchee River to the confluence of the Columbia River. For the reasons described above regarding critical habitat designated for UCR spring Chinook salmon (Section 2.4.2.8.2), effects of the proposed action on UCR steelhead critical habitat outside of Icicle Creek are likely to be negligible and are not anticipated to reduce the conservation value of designated critical habitat for UCR steelhead in the lower Wenatchee River.

The remainder of this critical habitat analysis will apply to designated critical habitat for UCR steelhead in Icicle Creek. Fulton (1970) identified Icicle Creek as historical steelhead habitat and these fish are part of the ESA-listed Wenatchee steelhead population. Critical habitat for steelhead was designated in Icicle Creek (e.g. Icicle/Chumstick watershed).

The Icicle/Chumstick Creek HUC was identified as having a medium conservation value at the time critical habitat was designated (Section 2.2.2.2). At that time, operations at the hatchery were severely limiting upstream steelhead passage in Icicle Creek above the hatchery. In addition, flow manipulations at Structure 2 were causing very low levels in the Icicle Creek historical channel. The LNFH storage releases from the Snow/Nada Lakes Supplementation Reservoirs (Section 2.4.2.6.4) were also not being managed to offset the effects of hatchery diversions at Structure 1 from the onset of base flow through the end of the irrigation season. In addition, a number of culverts[98] complicated passage into Chumstick Creek that reduced the conservation value of the Icicle/Chumstick Creek HUC. In addition, the Icicle Creek mainstem and upriver tributaries contain habitat with high intrinsic potential (UCSRB 2007; Figure 9; NWFSC 2004) for ESA-listed steelhead above the LNFH to RM 5.7 (NMFS 2005). Icicle Creek steelhead spawners are part of the Wenatchee steelhead population, which is one of four extant populations supporting the overall viability of the UCR Steelhead DPS. Each of the four populations is particularly important considering that approximately half of the historical habitat within the DPS is blocked by Federal dams (Grand Coulee and Chief Joseph Dams) and Icicle Creek steelhead are particularly important to the extant Wenatchee population, especially in terms of its contribution to population abundance, productivity, spatial structure, and diversity (UCSRB 2007).

As previously mentioned in the environmental baseline (Section 2.3), steelhead have consistently spawned in the lower 2 miles of Icicle Creek, as shown by presence of redds, but extensive surveys have not been conducted within the upper spawning reaches identified by the intrinsic

[98] These culverts have since been removed in Chumstick Creek.

habitat analysis for the UCR recovery plan (NWFSC 2004). Icicle Creek continues to contain important habitat for ESA-listed steelhead despite the fact that access to upriver spawning areas is limited by instream flows at the LNFH or naturally impaired at almost all flows by the boulder field (Dominguez et al. 2013). Approximately one mile of the Icicle Creek historical channel has been blocked until recently, and the majority of adult spawning and juvenile steelhead rearing are limited to degraded habitat in the lower Icicle Creek mainstem (with limited spawning in the Icicle Creek historical channel) downstream of the LNFH (Section 1.3). Despite these obstacles, Icicle Creek currently supports a high proportion of UCR steelhead in the Wenatchee Basin. Icicle Creek represented 10.2% (fourth largest) of all the steelhead redds in the Wenatchee River Basin in 2013 (Section 2.2.2.2) even though the action area contains a small proportion of critical habitat in the basin.

The USFWS Upper Columbia River Hatchery Review Team recognized the demographic risk to upstream migration of ESA-listed steelhead from inadequate fish passage at the LNFH and the impediment of natural stream functions associated with low stream flows, gravel recruitment, and deposition of large woody debris (USFWS 2007). Beginning in 2011, changes made at the LNFH improved the quantity and complexity of habitat in the Icicle Creek historical channel, and allowed greater frequency of adult steelhead passage, and improved the efficiency of ground water usage. Spawning data indicate that ESA-listed UCR steelhead are not only reproducing in Icicle Creek but also showing an increase in the number of redds in since 2012, with the exception of 2016 (Kondo 2017y), both in the lower mainstem and historical channel (Section 1.3). NMFS believes this is due to favorable environmental conditions developing as the historical channel recovers and the incremental operational changes to the LNFH water delivery system that reduce impacts on ESA-listed species.

Table 37 describes the effects of the LNFH water delivery operations on various life stages of ESA-listed UCR steelhead. Steelhead spawning migration in Icicle Creek occurs March through June. Adult steelhead spawning occurs April through June. A conservative estimate of fry emergence is no earlier than June 24th and no later than August 8th (Gale and Cooper 2014). Juvenile steelhead rearing occurs year-round. Life history stages affected by the proposed operation of Structures 1, 2 & 5 are identified both during an average water year (50th exceedance) and a dry water year (90% exceedance) combined (Table 37).

Table 37. Steelhead use and general effects of LNFH water delivery system operations on instream flows in Icicle Creek by calendar month (adapted from USFWS 2014).
A = no to negligible effect; B = negative effect[1]

Month	Adult Migration	Spawning	Fry Emergence[2]	Juvenile Rearing
January				B
February				B
March	A			B
April	A	A		A,B
May	A	A		A
June	A	A	A	A
July			A	A,B
August			A	A
September				B
October				B
November				A,B
December				B

[1] Analysis includes effects during an average (50th exceedance flow) and dry (90th exceedance flow) water year as reflected by two entries. For example: A,B would represent no to negligible effects in an average water year and negative effects in a dry water year. One entry (i.e., A or B) describes effects in both an average and dry water year when the effects are identical.
[2] A conservative estimate of fry emergence is no earlier than June 24th and no later than August 8th (Gale and Cooper 2014).

Table 38. LNFH effects on Primary Constituent Elements (PCEs) of critical habitat designated for ESA-listed steelhead in Icicle Creek.

Effects = neutral, negligible, or negative; N/A = not applicable

PCEs		Species Life History Event	Effect on Critical Habitat & Species Life History Event
Site Type	**Site Attribute**		
Freshwater spawning	Substrate Water quality Water quantity	Adult spawning Embryo to incubation Alevin growth and development	**Negative:** inadequate diversion screening; temporary migrational delay during spring Chinook broodstock collection occurs for adult steelhead spawning impeding access to the Icicle Creek historical channel and upriver spawning habitat when S5 is operated.
Freshwater rearing	Floodplain connectivity Forage Natural cover Water quality Water quantity	Fry emergence from gravel Fry/parr/smolt growth and development	**Negative:** degraded water quantity during fry emergence in August during a dry water year, and fry/parr/smolt growth and development August-October during an average water year, and all months of the year except July during a dry water year; juvenile upstream passage in September during an average water year and in August-October during a dry water year; lack of diversion screening to prevent entrainment of juveniles; and loss of connectivity to freshwater rearing habitat from RM 2.8 to RM 5.7
Freshwater migration	Free of artificial obstruction Natural cover Water quality Water quantity	Adult sexual maturation Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration	**Negative:** temporary migrational delay during spring Chinook broodstock collection occurs for adult steelhead spawning impeding access to the Icicle Creek historical channel and upriver spawning habitat when S5 is operated; temporary loss of connectivity to freshwater rearing habitat from RM 2.8 to RM 5.7; reduced water quantity during fry/parr/smolt growth development, and seaward migration and sexual maturation
Estuarine areas	Forage Free of artificial obstruction Natural cover Salinity Water quality Water quantity	Adult sexual maturation and "reverse smoltification" Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration	N/A
Nearshore marine areas	Forage Free of artificial obstruction Natural cover Water quantity Water quality	Adult growth and sexual maturation Adult spawning migration Nearshore juvenile rearing	N/A
Offshore marine areas	Forage Water quality	Adult growth and sexual maturation Adult spawning migration Subadult rearing	N/A

The specific attributes of designated critical habitat likely to be affected by the proposed action are temperature, nutrients, sediment, physical barriers, large woody debris (LWD), pool frequency, pool quality, width/depth ratio, and change in base/peak flows. These attributes are discussed in more detail below.

The proposed action is not likely to affect specific attributes of designated critical habitat such as substrate, chemical contamination, off-channel habitat, refugia, streambank condition, floodplain connectivity, and increase in drainage network. The proposed action is also not likely to affect watershed habitat conditions such as road density/location, disturbance history, or riparian reserves. Thus, these indicators are likely to be maintained.

Water Quality

Temperature: High temperatures decrease salmonid production; as temperatures increase past certain temperatures, salmonid growth decreases (Bjornn and Reiser 1991). High water temperatures can reduce the biotic potential of a stream by reducing the amount of dissolved oxygen and increasing metabolic reactions (Horne and Goldman 1994). The optimum temperatures for steelhead are 4-9 °C for incubation, 14-15 °C for rearing, 13.3-14.3 °C for smoltification, 16-17 °C for adult migration, and 10-12.8 for spawning (Richter and Kolmes 2005), with 20-22 °C being lethal for adults (Wade et al. 2013). Icicle Creek temperatures in summer months can exceed 15 °C (59 °F) and during the winter temperatures can fall below 10 °C (34 °F) (WRWSC 1998). Temperatures as high as 21 °C (70 °F) have been recorded in Icicle Creek (Mullan et al. 1992a). (Hall 2013) reported that Icicle Creek experienced downstream warming in the action area with a high of 18.7 °C (65.6 °F) in 2012. With climate change, the temperature in Icicle Creek is likely to rise (August mean predicted to be 16.5 °C in 2040 and 17.5 °C in 2080 (Kondo 2017x)), though the exact amount of change is difficult to predict, as discussed in Section 2.4.2.6.1. The current indicator is functioning at risk.

The proposed action would have a slight beneficial effect on UCR steelhead designated critical habitat in the Icicle Creek action area (RM 5.7 to RM 2.8), including alleviating climate change effects. WDOE (2002) concluded that daily temperatures of 21 – 24 °C (69.8 – 75.2 °F) are associated with avoidance behavior and migration blockage in steelhead. Daily maximum water temperatures should not exceed 21 – 22 °C (69.8 – 71.6 °F) to be protective of adult steelhead migration (Carter and Region 2005). Current conditions are functioning at risk for temperature criteria and the proposed action would likely aid in maintaining this indicator between RM 2.8 and RM 4.5, particularly during low flow periods and in dry water years (90^{th} Exceedance). Snow/Nada Lakes supplementation in August and September, have cooled instream water temperature by an average of 0.6 °C (range 0.2 °C to 1.0 °C) for the years 2005 – 2001 (Hall 2012) (Section 2.4.2.6.1). The LNFH operation as proposed by the USFWS would continue to have slight beneficial effects as a result of supplying supplementation flows in August and September. The LNFH operation is not likely to have beneficial effects on water temperatures from RM 5.7 to RM 4.5 during the remaining months of the year. The current LNFH operation is not likely to affect water temperatures below RM 2.8. The proposed action would not alter the PCEs essential to the conservation of the species, and is not likely to preclude or significantly delay development of such features—as discussed here, there is some likelihood that the proposed action would assist in delaying deterioration in some features, such as the increase in stream temperature due to other actions in the Icicle Creek watershed and incipient effects of climate change. In the event USFWS implements changes, such as implementation of a pRAS system[99], a pump-back system, and exploration of additional well resources or infiltration gallery (Section 1.3), habitat conditions are likely to improve. Overall, excluding beneficial effects that may occur from long-term improvements to the LNFH water delivery system, this indicator is likely to be maintained as functioning at risk.

Nutrients. Phosphorus, an important nutrient for primary production, is a limiting nutrient in Icicle Creek. Increase in phosphorus in streams can increase the algal activity, which decreases the carbon dioxide in the water through photosynthesis. As a result, the pH in the water increases, and the water becomes more alkaline. In particular, the summer months are considered critical for pH because the water is warm and flow is low, so algal activity is likely to be higher and is likely to affect pH more than during other high or average flow months. Increased pH has been shown to have lethal effects in extreme circumstances that are not likely to be present under the proposed action. In addition, increased pH can also have sublethal effects, such as reduced ammonia and urea efflux on many salmonid species (Groot. C. et al. 1995). The current indicator is functioning at risk (i.e., one reach below LNFH is CWA 303d designated for pH). This indicator is likely to be maintained at risk.

Sediment. Information on fine sediments is not available for Icicle Creek. High sediment loads historically occurred and currently occur in Icicle Creek. Icicle Creek watershed dominant land types have high sediment delivery hazards, and background hill slope erosion rates for the watershed are high (estimated to total over 4,500 tons/year) (USDA 1995). The current indicator is functioning at risk.

Sediment typically moves through the Icicle Creek watershed during high flows. The LNFH intake system and withdrawal of 42 cfs year round is not likely to increase the sediment input into Icicle Creek or affect factors that contribute to sedimentation. Reducing flows or conducting maintenance activities on the water delivery system may temporarily increase the amount of sediment in the action area. Conversely, the primary intake may decrease the amount of sediment that would contribute to the action area below RM 4.5 by entering the sand settling basin, and potentially a pollution abatement pond, and settling out before the water is returned to Icicle Creek resulting in a potential benefit.

The proposed action is likely to have no effect on the action area above the intake at RM 4.5. Overall, this indicator is likely to be maintained as functioning at risk.

Habitat Access (Safe Passage)

Physical Barriers: Operation of structures 2 and 5 can temporarily block or limit upstream and downstream fish passage at all flows from RM 2.8 to RM 4.5. Migration can also be temporarily blocked or limited at the LNFH's Structure 1 low head dam during low flows. The proposed action contains measures to capture and release UCR steelhead when structures 2 and 5 are operated. The proposed action also contains instream flow goals to allow for increased fish passage at structures 1, 2, and 5. This indicator is likely to be maintained.

[99] A re-circulating aquaculture system could reduce LNFH water needs by up to 20 cfs.

Habitat Elements

Large Wood Debris (LWD): LWD plays an important role in defining stream habitat characteristics and supporting UCR steelhead during all life stages. LWD provides cover, refuge, and deep-water areas. It also serves to dissipate energy, protect stream banks, reduces erosion, provides nutrients, and slow the movement of organic matter. Sources for short and long-term recruitment of LWD are lacking. Urbanization, livestock grazing, and road building in the lower part of Icicle Creek has reduced the riparian zone. Below the LNFH, 11% of the riparian vegetation along lower Icicle Creek has been removed for housing developments (WRWSC 1998). The current indicator is functioning at risk.

Structure 5 may capture LWD from the Icicle Creek channel itself. During maintenance activities, LWD is placed downstream of the structure. Therefore, this indicator is likely to be maintained.

Pool Frequency: Because of their larger body size, adult steelhead are limited to using depth for in-stream cover. Deep pools are important over-wintering habitats for adult fish. The amount and complexity of winter habitat in a stream determines its carrying capacity for fish populations. USFS (1994) stated that pool frequency and quality in the upper Icicle Creek does not meet USFS Standards. The wetted width of lower Icicle Creek is within the range of 40 to 65 feet and recommended pools per mile for streams this wide is 23 to 26; Icicle Creek does not meet this criteria. Icicle Creek lacks LWD and boulders that create pools. Existing pools are deep (> 1 meter) but there is no cover for fish other than depth. Pool volume has been reduced by fine sediment accumulation. The current indicator is not properly functioning.

Removal of up to 42 cfs year round at Structure 1 and additional hatchery aquifer well recharge at Structure 2 up to five times a year, in addition to many other factors such as climate change, is likely to reduce the number of pools in the action area from RM 2.8 to RM 4.5, except during the months of supplementation. From RM 3.8 to RM 4.5, Icicle Creek is confined by a road and a canyon. The proposed action would likely maintain the current baseline particularly during low flow periods and in dry water years (90th Exceedance). In the long-term, with the implementation of a pRAS system, a pump back system, and/or exploration of additional well resources or infiltration gallery (Section 1.3), habitat conditions are likely to improve. Overall, excluding beneficial effects the may occur from long-term improvements to the LNFH water delivery system, the status of this indicator (i.e., not properly functioning) is likely to be maintained.

Pool Quality: As described above, Icicle Creek does not meet pool frequency standards but the available data shows that all reaches of Icicle Creek contain a few large pools with residual depths > 1 meter deep. The current indicator is functioning at risk.

Removal of up to 42 cfs year round at Structure 1 and additional hatchery aquifer well recharge at Structure 2 up to five times a year, in addition to many other factors, is likely to reduce the quality[100] of pools in the action area between RM 2.8 and RM 4.5, except during the months of supplementation. From RM 3.8 to RM 4.5, Icicle Creek is confined by a road and a canyon. The

[100] Pool quality includes parameters such as depth, temperature, and size.

proposed action would likely maintain the current trend, particularly during low flow periods and in dry water years (90th Exceedance). In the long-term, with the implementation of a pRAS system, a pump back system, and/or exploration of additional well resources or infiltration gallery (Section 1.3), habitat conditions are likely to improve. Overall, excluding beneficial effects that may occur from long-term improvements to the LNFH water delivery system, the status of this indicator (i.e., at risk) is likely to be maintained.

Channel Condition/Dynamics

Width/depth Ratio: Data on Icicle Creek width/depth ratio has not been well documented. In the lower reach of Icicle Creek, channel features are not being maintained over time and deposition and erosion are occurring causing it to be in a state of flux (USFWS 2004a). Channel width/depth ratios in lower Icicle Creek are increasing and entrenchment ratios are decreasing in response to increases in sediment supply and bank instability, decreases in riparian vegetation structure and function, and changes in flow regime (USFWS 2004). As a result, Icicle Creek is becoming shallower and wider (USFWS 2004). Upper Icicle Creek reaches above the boulder field are functioning adequately except in areas where roads, bridges, and riprap affect the natural stream channel (USFWS 2004). This indicator is functioning at risk.

Removal of up to 42 cfs year round at Structure 1 and operation of Structure 2 as described in Section 1.3, in addition to many other factors such as climate change, may contribute to Icicle Creek becoming shallower and wider in the action area from RM 2.8 to RM 4.5. From RM 3.8 to 4.5, Icicle Creek is confined by a road and canyon. The proposed action may maintain the current trend, particularly during low flow periods and in dry water years (90th Exceedance). In the long-term, with the implementation of a pRAS system, a pump back system, and/or exploration of additional well resources or infiltration gallery (Section 1.3), habitat conditions are likely to improve. Overall, excluding beneficial effects that may occur from long-term improvements to the LNFH water delivery system, this indicator is likely to be maintained.

Flow/Hydrology

Change in Peak/Base Flows: Icicle Creek is listed under the Washington state 303(d) Clean Water Act for not meeting in-stream flow standards (WRWSC 1998). A Watershed Ranking Project showed that measured flows did not meet surface water quality standards contained in Chapter 173-201A of the Washington Administrative Code (WAC) almost 45% of the time (USFWS 2004a). The assessment found that WAC instream flow levels are not met for 66 days on average from August to October in Icicle Creek. These flow standards were set in 1983 and priority water right holders[101] are not constrained by these requirements (USFWS 2004a). The WAC in-stream flow standards were established as the basis from which future water acquisition request would be evaluated (USFWS 2004a). Icicle Creek mean flows below all diversions are calculated at 100 cfs (USFWS 2004a). Icicle Creek is subject to potential changes in peak/base flows due to increases in surface runoff from residential development, roads, landslides, logging, trails, and fires. With climate change, summer instream flow in Icicle Creek is likely to decrease,

[101] Priority water right holders include the LNFH, Cascade Orchard Irrigation Company (COIC), the City of Leavenworth, and the Icicle/Peshastin Irrigation District (IPID).

though the exact amount of change is difficult to predict, as discussed in Section 2.4.2.6.1. This indicator is not properly functioning.

Operation of the proposed action has a direct and additive effect on base flows in Icicle Creek in the action area from RM 2.8 to RM 4.5. Year-round, the LNFH removes up to 42 cfs at Structure 1 resulting in a 1.3% to 31.1% reduction in instream flows during an average water year and a 1.8% to 46.6% reduction in instream flows during a dry water year (Section 2.4.2.6.2; Table 29). The proposed action (continuation of the LNFH spring Chinook salmon program) would maintain this ongoing negative effect. Cumulative effects of other Icicle Creek water users include the IPID, City of Leavenworth, and the COIC. In April – July, average water withdrawals total ~126 cfs. In August – September average withdrawals total ~88 cfs. In October – March, average water withdrawals[102] total ~42 cfs (Section 2.5; Table 39). In April – July, instream flows would be sufficient to maintain the collective instream flow goals of 100 cfs. The greatest effects on Icicle Creek instream flow occur in August and September during the irrigation season. However, during August and September, the LNFH supplements Icicle Creek instream flows up to 50 cfs at RM 5.7 offsetting water diversions at Structure 1 in August and September.

Up to five times a year, the LNFH re-directs instream flows at Structure 2 for aquifer recharge. During an average water year, this results in removal of an additional 13 to 80 cfs or 25% to 40% of instream flow in the Icicle Creek historical channel during average and dry water years combined (Section 2.4.2.6.2; Table 31). Structure 2 can also be operated for other uses, as described in Section 1.3. In April – July instream flows would be sufficient to maintain the collective instream flow goals of 100 cfs. Under the proposed action, Structure 2 would not be operated in August. In September, supplemented instream flows of up to 50 cfs is intended to offset water use at Structure 2. During all other months of the year, instream flows would be below the collective instream flow goal of 100 cfs.

Due to stream flow limitations through Structure 2, the Icicle Creek historical channel has not benefited from channel forming base/peak flows (Skalicky et al. 2013). The proposed action may contribute to maintaining current base flows particularly during low flow periods and in dry water years (90th exceedance) and help alleviate climate change effects. In the long-term, with the implementation of a pRAS system, a pump-back system, and/or exploration of additional well resources or infiltration gallery (Section 1.3), habitat conditions are likely to improve. Overall, excluding beneficial effects the may occur from long-term improvements to the LNFH water delivery system, this indicator is likely to be maintained.

Relevance of Effects on Primary Constituent Elements to Conservation Value

As described above, the proposed action is likely to have both short-term and long-term effects regarding temperature, sediment, physical barriers, LWD, pool frequency, pool quality, width/depth ratio, and base/peak flows of freshwater spawning, rearing, and migration PCEs of designated critical habitat. The instream structures and year round operations are not likely to negatively affect spawning and migration PCEs for adult and steelhead but likely to negatively affect the rearing and migration PCEs for juvenile steelhead in the action area. Icicle Creek

[102] This includes the 42 cfs water withdrawal from the LNFH.

represents a high proportion of the UCR steelhead redd production contained in critical habitat of the Wenatchee Basin (2.2.2.2). Although negligible to negative effects on UCR spring Chinook salmon and steelhead designated critical habitat are likely to continue under the proposed action, short-term actions are also likely to improve habitat conditions in the action area as compared to the baseline during specific months of the year and types of years (average/dry water year) (Section 2.4.2.6.2). Thus, the proposed action would not alter the PCEs essential to the conservation of the species, and is not likely to preclude or significantly delay development of such features; in fact, it is likely that the conservation value of Icicle Creek designated critical habitat would likely be improved under the proposed action.

Long-term actions include infrastructure improvements that may reduce overall LNFH water diversions in Icicle Creek, with the potential to reduce water diversions by up to 20 cfs year round. Long-term actions also include finding alternative water sources that may obviate the need for operation of Structure 2 for hatchery aquifer recharge. These long-term actions have designated periods for completion (between one and eight years; Section 1.3, Figure 2) and would result in habitat improvements that, if implemented, are likely to aid in the recovery of ESA-listed UCR spring Chinook salmon and steelhead. However, implementation of these long-term actions have a high degree of uncertainty because regulatory procedures, permitting, and funding must be established prior to implementation. Although some actions are currently underway, many of the procedures associated with the implementation of long-term actions have yet to occur. NMFS recognizes and supports the LNFH's infrastructure upgrades and instream flow improvements (i.e., long-term actions) described in the proposed action while meeting their production targets. However, NMFS only relies on our analysis of the short-term actions (i.e., water delivery system operational changes and instream flow improvements) described in Section 1.3 in making our effects determinations. Assuming the proposed action (e.g., flow regime, fish salvage procedures) is carried forward into the future, the proposed action would not alter the PCEs essential to the conservation of the species, and some PCEs would likely demonstrate further improvement.

2.5. 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). 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 *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions anticipated in the action area are included in the environmental baseline description (Section 2.3) and considered in the effects analysis (Section 2.4.2).

For the purpose of this analysis, the action area is that part of the Columbia River Basin described in the Section 1.4. To the extent ongoing activities have occurred in the past and are currently occurring, their effects are included in the environmental baseline (whether they are federal, state, tribal, or private). To the extent those same activities are reasonably certain to occur in the future (and will not be subject to future section 7 consultation), their future effects are included in the cumulative effects analysis. This is the case even if the ongoing tribal, state, or private activities may become the subject of section 10(a)(1)(B) incidental take permits in the future. The effects of such activities are treated as cumulative effects unless and until an opinion for the take permit has been issued.

A full discussion of cumulative effects more generally in the Columbia River Basin can be found in the FCRPS opinions (NMFS 2008c; NMFS 2014b) and in the Mitchell Act opinion (NMFS 2017a), many of which are relevant to this discussion and incorporated by reference. State, tribal, and local governments have developed plans and initiatives to benefit listed species and these plans must be implemented and sustained in a comprehensive manner for NMFS to consider them "reasonably certain to occur" in its analysis of cumulative effects. Although the federally approved recovery plan for UCR spring chinook salmon and steelhead (UCSRB 2007) describes, in detail, the on-going and proposed Federal, state, tribal, and local government actions that are targeted to reduce known threats to listed species in the Wenatchee River, we are not aware of any plans or initiatives to recover listed species in Icicle Creek from state, tribal, and local government entities at this time.

The Final Bull Trout Recovery Plan (USFWS 2015b) identified a number of recovery actions related to Icicle Creek, such as the improvement of low flow conditions, screening irrigation diversions, correcting irrigation passage barriers, protecting high quality habitats, improving various water quality parameters, reconnecting floodplains, and enforcing placer mining regulations. Future recommendations also included assessing/correcting various road impacts, fish passage at LNFH, and non-native fish impacts. Some actions have been implemented to certain levels and others are likely to occur in the foreseeable future. NMFS acknowledges, however, that such future state, tribal, and local government actions would likely be in the form of legislation, administrative rules, or policy initiatives, and land use and other types of permits, and that government actions are subject to political, legislative, and fiscal uncertainties.

As described in Section 2.2.2, many stream reaches designated as critical habitat in the Interior Columbia Recovery Domain have more allocated water rights than existing streamflow conditions can support. Withdrawals of water, particularly during low-flow periods that commonly overlap with agricultural withdrawals, often increase summer stream temperatures, block fish migration, strand fish, and alter sediment transport (Spence et al. 1996). Reduced tributary stream flow has been identified as a major limiting factor for all ESA-listed salmon and steelhead species in this area (NMFS 2007c; NMFS 2011c). This is likely to result in negative effects on ESA-listed species by reducing stream flow that impedes or blocks adult spring Chinook salmon and steelhead as well as reducing and degrading the quantity and quality of juvenile salmonid rearing and migration habitat. Icicle Creek water rights by entity are described in Table 39.

Table 39. Icicle Creek and Snow/Nada Lake water users, water rights (WR)[1], and estimated use (cfs) (USFWS 2014).

Month	IPID (WR)	City of Leavenworth (WR)	CIOC (WR)	LNFH (WR)	LNFH Snow/Nada Lakes (WR)	Total Withdrawals (WR)
January	0 (0)	2 (3)	0 (0)	39 (42)	0 (0)	41 (45)
February	0 (0)	2 (3)	0 (0)	41 (42)	0 (0)	43(45)
March	0 (0)	2 (3)	0 (0)	42 (42)	0 (0)	44 (45)
April	69 (117.7)	2 (3)	0 (0)	42 (42)	0 (0)	113 (162.7)
May	88 (117.7)	2 (3)	6 (12.4)	21 (42)	0 (0)	117 (175.1)
June	96 (117.7)	2 (3)	6 (12.4)	27 (42)	0 (0)	131 (175.1)
July	99 (117.7)	2 (3)	6 (12.4)	34 (42)	0 (0)	141 (175.1)
August[2]	98 (117.7)	2 (3)	6 (12.4)	41 (42)	(50+)	97 (125.1)
September	79 (117.7)	2 (3)	6 (12.4)	41 (42)	(50+)	78 (125.1)
October[3]	0 (0)	2 (3)	0 (0)	38 (42)	0 (0)	40 (45)
November	0 (0)	2 (3)	0 (0)	40 (42)	0 (0)	42 (45)
December	0 (0)	2 (3)	0 (0)	41 (42)	0 (0)	43 (45)

[1] Full water rights are listed in parenthesis. Actual water usage is listed without parenthesis.
[2] LNFH would supplement in August and September.
[3] Irrigation water withdrawals typically end within the first few days of October.

Icicle Creek stream flows downstream from the USGS gage located at RM 5.8 are reduced by several water diversions. The City of Leavenworth and the IPID water diversion is located above the Snow Lakes trailhead at RM 5.7. The LNFH and COIC water diversion is located below the trailhead at RM 4.5. These water diversions occur downstream of major irrigation withdrawal of Icicle Creek water (USFWS 2007). Water withdrawals can remove up to 48% and 79% of the mean monthly August and September stream flows, respectively (Mullan et al. 1992b), resulting in ecological risk from dewatering of Icicle Creek in low flow conditions in the stream reach between the hatchery water intake and discharge to meet hatchery program needs (USFWS 2007). No to negligible effects on ESA-listed adult spring Chinook salmon and steelhead and negative effects on ESA-listed juvenile spring Chinook salmon and steelhead are likely to occur by reducing instream flows through water withdrawals during average and dry water years (Section 2.4.2.6.2). As described in Section 2.4.6.2.6.1, D, to assure adequate water for the LNFH, a supplementary water supply was developed in Upper Snow and Nada Lakes. Without the water release of approximately 50 cfs from the Snow/Nada Lake Supplementation Reservoirs in August and September, the downstream reaches of Icicle Creek could go dry in some years (Skalicky et al. 2013). Under climate change scenarios, Icicle Creek could also go dry above the hatchery in August (Table 36). The USFWS Columbia River Basin Hatchery Review Team was concerned that the need to maintain instream flows in Icicle Creek was not addressing the potentially large water withdrawals—up to 117.7 cfs monthly April – September; Table 39) (USFWS 2007)—by the IPID. To better manage water use cooperatively, IPID works with the IWG. For example, the USBR's contract with IPID allows IPID to divert up to 30 cfs from Upper Snow Lake until their annual allowance of 750 AF is exhausted; however, IPID is not likely to withdraw at its maximum diversion rate even during a drought year, as discussed in Section 2.3.2, and its water withdrawal from Snow Creek (if any) is likely to allow the hatchery to fully supplement for the hatchery intake into Icicle Creek (e.g., 5 cfs withdrawal from Snow Creek by IPID in 2015 allowed the proposed action to supplement 45 cfs into Icicle Creek, which is 3 cfs more than the hatchery intake). In addition, many future upgrades in the water delivery system (including the valve replacement at the reservoir to accommodate both water users by the end of 2019) are likely to be able to allow increases in the amount of water released from the reservoir in the future to better accommodate for all water users; however, the valve replacement is a future federal action.

2.6. Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the benefits and risks posed to ESA-listed species and critical habitat as a result of implementing the Proposed Action. In this section, NMFS add the effects of the Proposed Action (Section 2.4.2) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5) 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 diminishes the value of designated critical habitat for the conservation of a listed species. This assessment is made in full consideration of the status of the species and critical habitat and the status and role of the affected populations in recovery (Sections 2.2.1, 2.2.2, and 2.2.3).

In assessing the overall risk of the Proposed Action on each species, NMFS considers the benefits and risks of each factor discussed in Section 2.4.2, above, in combination, considering their potential additive effects with each other and with other actions in the area (environmental baseline and cumulative effects). This combination serves to translate the positive and negative effects posed by the Proposed Action into a determination as to whether the Proposed Action as a whole would appreciably reduce the likelihood of survival and recovery of the ESA-listed species or result in the destruction or adverse modification of designated critical habitat. To do this, NMFS considers how all of the effects impact individuals within the different populations and how these impacts on individuals affect the VSP parameters for those populations. If there are changes to the VSP parameters from the Proposed Action, NMFS then determines whether the changes in VSP parameters affects the overall status of the population, and then determines if the resulting change in the overall status of the population affects the likelihood of survival and recovery of the entire ESA-listed ESU/DPS (i.e., the species). Similarly, NMFS considers how all these impacts affect critical habitat in the Action Area and whether these impacts adversely modify or destroy the habitat.

2.6.1. UCR Spring-run Chinook Salmon ESU and Critical Habitat

NMFS analyzed seven factors for their effects, beneficial, negligible, and negative, on ESA-listed UCR spring Chinook salmon at the population level. For these seven factors, one had no effect, three had negligible effects, two had negative effects, and the seventh factor (fisheries) was analyzed under a separate ESA consultation and found to have negligible effects (NMFS 2008b) (Section 2.4.2; Table 17). Overall, the effect of the proposed action in combination with the environmental baseline and cumulative effects was negative but it would not result in the appreciable reduction in the likelihood of the survival and recovery of the UCR Spring-run Chinook Salmon ESU.

The UCR Spring-run Chinook Salmon ESU is at high risk of extinction in a 100-year time period and remains at endangered status. All three populations within the ESU (i.e., Wenatchee River, Entiat River, and Methow River populations) are at high risk for abundance, productivity, spatial structure, and diversity (Table 3). Because Icicle Creek is within the Wenatchee Basin, the Wenatchee River population is most likely to be affected by the proposed action. Within the Wenatchee Basin, Icicle Creek has not been an important production area for UCR spring Chinook salmon in the past, in the present, or as anticipated into the future. The watershed supports some spring Chinook salmon spawning, rearing, and migration with some features similar to PCEs for other designated habitat. However, critical habitat is not designated in the watershed. Effects of the proposed action in Icicle Creek would not diminish or limit the abundance, productivity, diversity, or spatial structure of the UCR Spring-Run Chinook Salmon ESU.

After the Wenatchee and Methow Basins, the Entiat Basin is the next most important production area for spring Chinook salmon in the UCR. The proposed action would have a negative but low adverse effect on diversity and productivity due to straying of hatchery-origin fish from LNFH. Considered in combination with the environmental baseline and cumulative effects, particularly considering the recent termination of the spring Chinook salmon hatchery program at the ENFH that also used Carson-stock spring Chinook salmon, and the actions taken by the Chiwawa River spring Chinook hatchery program to reduce straying, the effects of hatchery fish on diversity and productivity are certain to diminish to very low levels and would not limit abundance, productivity, diversity, or spatial structure of the UCR Spring-Run Chinook Salmon ESU.

The proposed action is likely to have a negligible effect on natural-origin juvenile spring Chinook salmon when LNFH fish travel down to the Columbia River (i.e., mouth of Wenatchee River) after release. No measureable interactions are expected in rearing areas because the hatchery releases are not likely to residualize. However, the LNFH fish may compete with or prey upon natural-origin juvenile spring Chinook salmon as they travel downstream prior to reaching the Columbia River. As a result of such ecological interactions, we expect the equivalent of 21 returning adult spring Chinook salmon to be affected, resulting in a reduction of 1.9 percent loss of potential adult natural-origin spawners from the UCR Spring Chinook Salmon ESU, though such effect may be overestimated for reasons described in Section 2.4.2.3.

Juvenile spring Chinook salmon may encounter the water intake structure operated by LNFH and be entrained into the sand settling basin until they are released back to Icicle Creek. Negative effects on juvenile spring Chinook salmon are likely to continue when instream flows in Icicle

Creek are reduced below 100 cfs. The LNFH would operate (including operating Structure 2 for purposes of aquifer recharge) in a manner intended to maintain daily average instream flow goals of 40 cfs in October, 60 cfs in November - February, 80 cfs in March, and 100 cfs from April through July in the Icicle Creek historical channel. Those negative effects may include reduced habitat area and water depth, increased summer water temperature, increased exposure to predators and crowding into reduced available rearing and migratory habitat. However, the proposed action includes actions that are also likely to benefit UCR spring Chinook salmon, such as adult screening at the intake, improved fish salvage procedures, and no operation of Structure 2 in August. In addition, the proposed action potentially provides for additional flow in Icicle Creek through releasing up to 50 cfs of water from Snow and Nada Lakes reservoirs; even if IPID withdraws the maximum it has in the past during these months (5 cfs in 2015), additional 45 cfs of water would enter Icicle Creek, up to 42 of which could be withdrawn by the hatchery. In September, if the natural flow remaining after subtracting the amount of water diverted by the LNFH and all water users is less than 60 cfs, the LNFH would not route more water into the hatchery channel than the volume of its Snow/Nada Lake storage release (up to 50 cfs) minus the withdrawal from Snow Creek by IPID and diversion at Structure 1 (up to 42 cfs)..

The effluent from current operation and operation under the NPDES permit interim limit may also have a small negative effect on spring Chinook salmon adults and juveniles because the phosphorus loading may cause temporary sublethal effects in the lower portion of Icicle Creek (up to 2.8 RM) with elevated pH. However, the temporary nature of the effect, the small amount of affected portion of Icicle Creek, the likelihood that fish could readily swim to areas of lower pH, and the added flow of up to 50 cfs during the critical months, resulting in dilution, are likely to reduce the negative effects.

The proposed action includes immediate beneficial actions from increased instream flows, a commitment to not operate Structure 2 during critical steelhead rearing periods, and a reduction in operational effects (Section 2.4.2.6). These actions directly relate to those identified in the UCR recovery plan by addressing passage barriers and diversion screens (UCSRB 2007). The proposed action also increases spatial structure by improving fish passage above LNFH structures and using practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) in lower Icicle Creek (UCSRB 2007). Considering all of the information in this opinion, NMFS concludes that the proposed action does not appreciably reduce the likelihood of the survival of the UCR Spring-Run Chinook Salmon ESU in part because the operational effects of the proposed action occur in a minor spawning area. Additionally, NMFS concludes that the proposed action does not appreciably reduce the likelihood of the recovery of the UCR Spring-run Chinook Salmon ESU because the proposed action minimizes the adverse effect on spring Chinook salmon and would not preclude improvements necessary for recovery into the future. We specifically examined the governing recovery plan (including recovery goals and identified recovery actions within the action area), status of the affected population as well as overall status of the species, the anticipated impacts of the proposed action on the prospects of the species recovery, and the other relevant factors discussed in the effects of the action, environmental baseline, cumulative effects sections. NMFS came to its conclusion because the negative effects did not rise to the level where they would be expected to appreciably reduce the likelihood of survival, and the beneficial actions described in the proposed action directly relate to those identified in the recovery plan to improve population viability and recovery of the UCR spring Chinook salmon population, even though Icicle Creek is not a watershed known to support a large number of spring Chinook salmon. Outside of Icicle Creek, the negative effects are minimized by ensuring that pHOS is no greater than 3.2%.

The proposed action would not affect critical habitat for UCR spring Chinook salmon in Icicle Creek since none is designated there (NMFS 2005b), but it would affect habitat features similar to PCEs of other critical habitat used by ESA-listed natural and hatchery-origin spring Chinook salmon. Effects from operating the hatchery would be negative but there is likely to be some improvement in habitat condition following implementation of the proposed action. LNFH intends to increase stream flows in Icicle Creek, starting immediately, and to work toward achieving an instream flow of 100 cfs during all months of the year (including dry water years). (Section 2.4.2.6). Critical habitat is designated in the Lower Wenatchee River but not in Icicle Creek; effects on UCR spring Chinook salmon critical habitat in the Lower Wenatchee River from the proposed action would be negligible because the facilities effects, which are the component of the proposed action that would contribute most to effects on critical habitat, only occur in Icicle Creek. Thus, NMFS concludes that the proposed action does not appreciably diminish the value of designated critical habitat (e.g., Lower Wenatchee River mainstem) for the conservation of the Wenatchee spring Chinook salmon population or the UCR Spring-Run Chinook Salmon ESU.

2.6.2. UCR Steelhead DPS and Critical Habitat

Best available information indicates that the species, in this case the UCR Steelhead DPS, is at high risk of extinction in the next 100 years and remains at threatened status (NWFSC 2015). As set out in the Environmental Baseline (Section 2.3), habitat conditions in Icicle Creek may have a negative effect on ESA-listed summer steelhead. Although land and water management activities have improved, factors such as dams, diversions, roads and railways, agriculture (including livestock grazing), residential development, and historical forest management continue to threaten UCR steelhead (UCSRB 2007).

NMFS analyzed seven factors for their effects, beneficial, negligible, and negative on ESA-listed UCR steelhead at the population level. For these seven factors, four had negligible effects, one had negative effects, two factors did not apply, and the seventh factor (fisheries) was analyzed under a separate ESA consultation and found to have negligible effects (NMFS 2008b) (Section 2.4.2; Table 17). Overall, the effect of the proposed action in combination with the environmental baseline and cumulative effects was negative but it would not result in the appreciable reduction in likelihood of the survival and recovery of the UCR Steelhead DPS.

For UCR steelhead, the proposed action may limit further development of spatial structure, productivity, and abundance in the fourth most important production area in the Wenatchee River Basin. The proposed action would have negligible effects outside of Icicle Creek (i.e., Lower Wenatchee River). Water diversions would continue to limit Icicle Creek from reaching its production potential for UCR steelhead, though the proposed action, through the collective instream flow goal, could reduce such limit on production potential. Mitigation actions included in the proposed action would also alleviate some of the other negative effects on the Wenatchee steelhead population, which is at low risk for abundance and productivity and high risk for spatial structure and diversity (Table 5), and in turn, the UCR Steelhead DPS.

The proposed action is likely to have a negligible effect on natural-origin juvenile steelhead when LNFH fish travel down to the Columbia River (i.e., mouth of Wenatchee River) after release. As mentioned above, LNFH spring Chinook salmon juveniles are not expected to residualize, but the LNFH fish can compete with or prey upon natural-origin juvenile steelhead during outmigration. As a result of such ecological interactions, we expect 6 adult steelhead to be lost, resulting in a reduction of 0.3 percent loss of potential adult natural-origin spawners from the UCR Steelhead DPS.

Steelhead adults are likely to be delayed when migrating upstream when Structure 5 is operated to trap adult salmonids until such steelhead are released upstream to continue their migration to spawn. Similarly, adult and juvenile steelhead would likely encounter the water intake structure operated by LNFH and be entrained into the sand settling basin until they are released back to Icicle Creek. Juvenile steelhead are likely to experience negative effects when instream flows in Icicle Creek are reduced below 100 cfs. The LNFH would operate (including operating Structure 2 for purposes of aquifer recharge) in a manner intended to maintain daily average instream flow goals of 40 cfs in October, 60 cfs in November - February, 80 cfs in March, and 100 cfs from April through July in the Icicle Creek historical channel. Those negative effects may include reduced habitat area and water depth, increased summer water temperature, increased exposure to predators and crowding into reduced available rearing and migratory habitat. Despite these negative effects under the proposed action, the Wenatchee steelhead population component of the UCR Steelhead DPS exceeded both its ICTRT minimum threshold required of 1,000 fish (e.g., 1,025; range 385-2,235) and productivity threshold of 1.1 (i.e., 1.2) for the most recent time period from 2005 to 2014 (NWFSC 2016). The abundance and productivity viability rating for the Wenatchee River population, of which Icicle Creek is a component, exceeds the minimum threshold for 5% extinction risk (NWFSC 2016). The proposed action includes activities that are likely to minimize risks to or actually benefit UCR steelhead, such as improved fish salvage procedures, a requirement to not operate Structure 2 in March if steelhead are present, and no operation of Structure 2 in August. In September, if the natural flow remaining after subtracting the amount of water diverted by the LNFH and all water users is less than 60 cfs, the LNFH would not route more water into the hatchery channel than the volume of its Snow/Nada Lake storage release (up to 50 cfs) minus the withdrawal from Snow Creek by IPID and diversion at Structure 1 (up to 42 cfs).

The effluent from current operation and operation under the NPDES permit interim limit may also have a small negative effect on steelhead juveniles because the phosphorus loading may cause temporary sublethal effects in the lower portion of Icicle Creek (up to 2.8 RM) with elevated pH. However, the temporary nature of the effect, the fact that only a small distance of Icicle Creek is affected, likelihood of the fish swimming to an area with lower pH, and the added flow during the critical months are likely to reduce the negative effects. In addition, the proposed action includes hatchery operation that supplements up to 50 cfs during these critical months, reducing the likelihood of increasing the pH in Icicle Creek by ensuring additional water for dilution.

The proposed action includes immediate activities that benefit steelhead or minimize risks to them, from increased instream flows, a commitment to not operate Structure 2 during critical adult steelhead spawning and juvenile rearing periods, and a reduction in operational effects (Section 2.4.2.6). These actions directly relate to those identified in the UCR recovery plan by addressing passage barriers and diversion screens (UCSRB 2007). The proposed action also improves spatial structure by increasing fish passage over LNFH structures and using practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) in the lower Icicle Creek assessment unit (UCSRB 2007). In addition, the proposed action potentially provides for additional flow in Icicle Creek through releasing up to 50 cfs of water from Snow and Nada Lakes reservoirs; even if IPID withdraws the maximum it has in the past during these months (5 cfs in 2015), an additional 45 cfs of water would enter Icicle Creek, up to 42 of which could be withdrawn by the hatchery.

Considering all of the information in this opinion, NMFS concludes that the proposed action does not appreciably reduce the likelihood of the survival of the UCR Steelhead DPS because the proposed action would have negligible effects outside of Icicle Creek and negative effects are small in Icicle Creek. Similarly, NMFS concludes that the proposed action does not appreciably reduce the likelihood of the recovery of the UCR Steelhead DPS because the proposed action includes beneficial activities, as well as activities that minimize risks to steelhead in Icicle Creek. In reaching this determination, we specifically examined the governing recovery plan (including recovery goals and identified recovery actions within the action area), status of the affected population, the overall status of the species, the anticipated impacts of the proposed action on the prospects of the species recovery, and the other relevant factors discussed in the effects of the action, environmental baseline, cumulative effects sections. By examining this information, we conclude that the proposed action, when considered in the context of the status of the species in the current and anticipated future environment, does not appreciably reduce the likelihood of survival and recovery of the UCR Steelhead DPS.

Designated critical habitat for this species is located in Icicle Creek and the Lower Wenatchee River mainstem. UCR steelhead habitat in the Icicle/Chumstick HUC designated as critical has a medium conservation value. However, it is important to consider that only half of the habitat for this DPS is still accessible to fish, and, consequently, the DPS is at high risk because of decreased spatial structure. The proposed action recognizes that the condition of the habitat still accessible to steelhead is important and includes immediate improvements to designated critical habitat in Icicle Creek (Section 2.4). Recent actions taken by LNFH have improved steelhead access into the Icicle Creek historical channel and are beginning to reverse some negative effects on UCR steelhead critical habitat previously caused by past hatchery operations. Specifically, the recovery plan calls for improving stream flows as short-term restoration actions (Section 2.3.3). The proposed action includes immediate actions to supplement flows in August and September (critical periods for steelhead rearing) and cease operation of Structure 2 during August. The remaining effects of Structure 2 operations, to the extent negative effects are occurring, would be short and temporary (not all months of the year) and in many years (particularly average or high water years) may not occur at all (Section 2.4.2.6). Although operation of Structure 2 has been negatively affecting habitat in Icicle Creek for more than 50 years, the proposed action is likely to reduce these negative effects.

Steelhead differ from other salmon by preferring smaller, higher-gradient streams and tend to spawn further upstream than Chinook salmon. Additionally, climate change is likely to warm and change the hydrology of the entire critical habitat for this species, increasing the importance of restoring habitat in Icicle Creek, an area that would likely be less prone to climate change effects. The proposed action is not likely to appreciably diminish the function and conservation value of the habitat designated as critical for the UCR Steelhead DPS. The proposed action is not expected to alter PCEs essential to the conservation of the DPS, nor preclude or significantly delay development of such PCEs. The proposed action would often result in instream flows that meet or exceed the 100 cfs. Recent changes at LNFH have improved fish access and designated habitat in Icicle Creek compared to historical management, and steelhead continue to access and spawn in the area under existing operations.

Another reason why Icicle Creek is an attractive and important target for steelhead rehabilitation is that it does not have a hatchery steelhead program. As previously explained in Section 2.3, the widespread and increasing number of hatchery steelhead on the spawning grounds is a contributing factor to the viability risk rating for Wenatchee River steelhead spatial structure and diversity in other parts of the basin. Steelhead production areas where the proportion of hatchery-origin fish among all natural spawners is low can reduce this risk factor and are very important for DPS recovery. Icicle Creek is one of these places.

The proposed action is likely to have negligible effects on 55.5 river miles of critical habitat PCEs in the Lower Wenatchee River (NMFS 2005a; Appendix H). The proposed action is also likely to have negligible to negative effects in 5.7 river miles of designated critical habitat in Icicle Creek (out of 61.2 miles of total designated critical habitat PCEs[103]) (NMFS 2005a; Appendix H). In total, negligible to negative effects would occur in 5.5% of designated critical habitat for UCR steelhead. The proposed action would not alter the PCEs essential to the conservation of a species or preclude or significantly delay development of such features. Considering all the information above, NMFS concludes that the proposed action would not diminish the conservation value of this critical habitat (e.g., Icicle Creek and Lower mainstem Wenatchee River) for the Wenatchee steelhead population or the UCR Steelhead DPS.

2.6.3. Issuance of NPDES permit

The NPDES permit that the EPA proposes to issue would permit the levels of pollutants analyzed in section 2.4.2.6.1 and described above, particularly the same assumed levels of temperature and phosphorus in the effluent. NMFS determined the effluent discharge would only have a small negative effect on UCR steelhead and Chinook salmon within the action area. The effects of issuance of the permit, taken together with cumulative effects, are subsumed within the analysis above. Therefore, the issuance of the NPDES permit would also not appreciably reduce the likelihood of their survival and recovery, nor alter the PCEs essential to the conservation of the species or preclude or significantly delay development of such features.

2.6.4. Climate Change

Upper Columbia spring Chinook salmon and steelhead may be adversely affected by climate change (see section 2.2.3). A decrease in winter snow pack would be expected to reduce spring

[103] This estimate includes designated critical habitat PCEs in Icicle Creek and the Lower Wenatchee River included in the action area.

and summer flows and increase water temperatures in the Upper Columbia River basin, including the Wenatchee and Entiat Basins; Icicle Creek may experience spring runoffs earlier than presently, with increased early summer flows, with lower flows than currently occurring during late summer (i.e., August and September). This could lead to reductions in spawning and rearing habitat and may result in earlier fry emergence times and emigration. Returning adults may become stressed or die due to warmer temperatures.

Reduced flow and higher temperature in Icicle Creek could also exacerbate the effect resulting from the hatchery effluent. For example, the phosphorus load in the effluent could contribute to an increase in pH because the flow in the stream could decrease in the future, resulting in a higher concentration of phosphorus in the stream. Similarly, DO, which currently is not having a negative effect in Icicle Creek, could decrease enough to start negatively affecting salmon and steelhead. However, monitoring of the effluent and downstream surface water would be in place in the near future before any such change is likely to occur, allowing consideration of potential changes in the action.

The proposed action is designed to provide, at a minimum, enough supplemental flow from the Snow/Nada Lake reservoirs in August and September (i.e., for those months without a daily instream flow goal) to replace (prior to withdrawal) the amount of water removed by the hatchery during those months, ensuring no hatchery-related flow reductions and somewhat cooler water temperature between the intake and the outfall. Thus, the programs may serve as a buffer for habitat conditions in years under these climate change scenarios where low water flow and high temperatures make spawning and rearing in the natural environment difficult, by providing additional, cooler water into Icicle Creek.

Although they provided no specific recommendations for hatchery programs, the ISAB recommends managing to accommodate uncertainty (ISAB 2007), which, in the case of LNFH, is managed through various monitoring requirements, such as for instream flow. In tandem with such monitoring requirements, the hatchery operates with a flow goal that provides sufficient flow for various life stages of ESA-listed salmon and steelhead, with multiple mechanisms to minimize negative effects on the species (e.g., not operating Structure 2; providing Snow/Nada Lake reservoirs supplementation). In addition, meeting the flow goals also prevents any increase in the adverse effects of the hatchery effluent on the listed species by providing enough flow to dilute the effluent. Thus, the monitoring requirement and the flow goals work together to adapt to the potential decrease in flow because of climate change.

Given the supplemental flow from the Snow/Nada Lake reservoirs, the proposed action is expected to provide a beneficial effect during August and September, with or without climate-change related effects. Because the addition of water from the reservoirs via Snow Creek is key to this beneficial effect, it is important to consider the likelihood of such supplementation water being available even under conditions that might be expected to prevail in the future. Because the climate change scenarios predict an increase in precipitation and because the supplementation occurs using reservoirs that could store water throughout the year, the reservoirs are likely to continue to refill sufficiently to provide the necessary flow, and Snow/Nada Lake reservoirs supplementation is likely to continue to provide beneficial effect even under conditions predicted under the climate change scenarios. In addition, Snow Creek is expected to remain cooler than

Icicle Creek, thereby allowing the supplementation to continue providing cooler water into Icicle Creek to mitigate the increase in stream temperature from climate change.

2.7. 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, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of the UCR Spring-Run Chinook Salmon ESU and the UCR Steelhead DPS or destroy or adversely modify their designated critical habitat.

2.8. Incidental Take Statement

Section 9 of the ESA and Federal regulation 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 results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (50 CFR 17.3). "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). For purposes of this consultation, we interpret "harass" to mean an intentional or negligent action that has the potential to injure an animal or disrupt its normal behaviors to a point where such behaviors are abandoned or significantly altered. 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.

2.8.1. Amount or Extent of Take

NMFS analyzed seven factors and identified three that are reasonably certain to result in some level of incidental take for listed spring Chinook salmon: *(1) hatchery fish and their progeny on spawning grounds and at adult collection facilities; (2) hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas;* and *(3) construction, operation, and maintenance.* NMFS also determined that the same three factors are reasonably certain to result in some level of incidental take of steelhead. Most of the incidental take can be quantified annually as numbers of fish or the proportion of the adult return, but a surrogate for genetic effects will be used to quantify incidental take resulting from the straying and natural spawning of LNFH origin spring Chinook salmon. A metric for gene flow (e.g., stray rate) will be used in this ITS to prescribe an acceptable take level associated with straying.

Though the incidental take levels of juveniles and adults often cannot be measured directly, the magnitude and scope of possible impacts may be understood through sampling and monitoring and evaluation activities identified in the terms and conditions (Section 2.8.4). The following describes amount or extent of take by species.

2.8.1.1. UCR Spring Chinook Salmon

Hatchery fish and their progeny on spawning grounds and at adult collection facilities (Factor 2): In the course of collecting LNFH spring Chinook salmon for hatchery broodstock, the proposed action is expected to handle, annually, approximately three ESA-listed, adipose-present adult natural-origin UCR spring Chinook salmon with an incidental take mortality of no more than three natural-origin adults annually. All natural-origin fish handled during broodstock collection would be released immediately into Icicle Creek after determination of origin (through scale pattern analysis to ensure that mis-clipped LNFH adults are removed).

In addition, in the course of collecting LNFH spring Chinook salmon for broodstock, the proposed action is expected to handle, annually, up to 170 ESA-listed adult UCR spring Chinook salmon from other hatchery programs that operate inside and outside of the Wenatchee Basin. All of the above fish would be intercepted exclusively as volunteers into LNFH. When encounters with other hatchery spring Chinook salmon occur, the USFWS would hold those fish up to three days in order to identify and coordinate with the associated hatchery program operators to determine the appropriate disposition of those fish (e.g., return to supplementation programs for broodstock, release in downstream areas, surplus, etc.). In addition, we anticipate up to 1,000 juvenile spring Chinook salmon would be encountered in the water delivery system with up to 50 mortalities annually (Table 40).

Table 40. UCR ESA-listed natural (NO) and hatchery-origin (HO) spring Chinook salmon handling and incidental mortality associated with annual broodstock collection and the water delivery system for the proposed action.
NO = natural-origin fish; ESN HO = ESA-listed safety-net program hatchery-origin fish; EC HO = ESA-listed conservation program hatchery-origin fish

	Maximum Handled & Released	**Maximum Incidental Mortality**
ESA-listed spring Chinook salmon	**Annually**	
Broodstock collection		
NO adult[1]	3	Up to 3
ESN HO adult[2]	120	Up to 120
EC HO adult[3]	50	Up to 50
Water delivery system		
Adult	10	0
Juvenile	1,000	50

[1] All natural-origin spring Chinook salmon handled during broodstock collection are released immediately into Icicle Creek by verifying adipose fin is present and reading scale pattern to determine natural origin.
[2] ESA-listed hatchery-origin safety-net fish are identified by the absence of an adipose fin with a CWT. Fish may be inadvertently incorporated into LNFH broodstock because a proportion of ESA-listed supplementation safety-net and LNFH fish are identically marked (i.e., adipose fin-clipped).
[3] ESA-listed hatchery-origin conservation fish are determined as adipose present with a CWT. All hatchery fish are scanned for CWTs or other identifying tags/marks and the USFWS coordinates with other hatchery programs to determine disposition of fish.

Straying of LNFH spring Chinook salmon to spawning grounds in the UCR is considered a take due to genetic (i.e., outbreeding) and ecological (i.e., competition for spawning sites or redd superimposition) effects. It is not possible to ascertain the exact amount of such take, because it is not possible to meaningfully measure the number of interactions, nor their precise effects. NMFS will, therefore, rely on a surrogate take indicator for LNFH spring Chinook salmon that stray into natural spawning areas in the upper Wenatchee and Entiat watersheds, measured by LNFH contribution to pHOS, obtained through CWT recovery of carcasses on spawning ground surveys; LNFH contribution to pHOS should not be higher than 3.2%. The LNFH contribution to pHOS has a rational connection to the amount of take resulting from genetic effects because LNFH contribution to pHOS measures the proportion of LNFH-origin fish that could be breeding with natural-origin spring Chinook salmon. For the purpose of this surrogate measure, it is assumed that LNFH spring Chinook salmon have the same chance to spawn as do the local natural-origin fish; this is a protective metric, since substantial data indicate that out-of-basin origin fish have a reduced likelihood of contributing to natural spawning (Section 2.4.1.2.1). However, because it is difficult to measure the likely degree of reduced reproductive success for hatchery fish, NMFS will assume equal likelihoods for this purpose.

Similarly, NMFS will also use pHOS to serve as a surrogate measure of take resulting from ecological effects, specifically spawning ground interactions and redd superimposition. This surrogate has a rational connection to the amount of take because LNFH contribution to pHOS is an indicator of the proportion of LNFH-origin fish present on the spawning grounds to compete for spawning sites or superimpose redds. For the purpose of this surrogate measure, it is assumed that LNFH spring Chinook salmon have the same chance to compete with or have redd superimposition over natural-origin fish. Therefore, LNFH contribution to pHOS is an indicator of how LNFH-origin fish are contributing to competition or redd superimposition on the spawning grounds.

The LNFH is required to limit within basin and out-of-basin gene flow between the LNFH hatchery-origin fish and fish from natural populations, particularly because it uses fish that are not derived from a local population within the UCR Spring-Run Chinook Salmon ESU (NOAA 2008). Because of the origin of broodstock used (i.e., out-of-basin Carson stock), NMFS considered the most recent HSRG recommendations for isolated programs (HSRG 2009a; HSRG 2014). Based on these considerations, the LNFH will limit straying to the existing levels evaluated in this opinion (i.e., no higher than 3.2% pHOS) for LNFH spring Chinook salmon in the Upper Wenatchee and Entiat Basins.

A new marking strategy has been implemented to help distinguish LNFH-origin fish from other hatchery-origin spring Chinook salmon and assist in the identification and removal of LNFH adult spring Chinook salmon at Tumwater Dam in the Wenatchee Basin. The method for determining LNFH pHOS (in the Wenatchee and Entiat Basins) has only been recently implemented, so the marking strategy and pHOS monitoring for the LNFH spring Chinook salmon program would continue indefinitely to determine if the recent method implemented continues to be efficient in removing LNFH-origin strays. Monitoring would also be required to ensure efficacy and compliance with this LNFH spring Chinook salmon pHOS level.

Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas (Factor 3): Competition with and predation by hatchery-origin spring Chinook salmon, as they travel down to the Columbia River, could result in take of natural-origin spring Chinook salmon. However, it is difficult to quantify this take because ecological interactions cannot be directly observed or counted. Thus, NMFS will rely on median travel rate as a surrogate take variable.

This is a reasonable, reliable, and measurable surrogate for incidental take because, if travel rate falls much below 14.2 RM/day (e.g., 9.4 RM/day would indicate that smolts are taking 1 extra day to travel out of the Wenatchee Basin), it is a sign that fish are not exiting the action area as quickly as expected, the amount of time during which adverse interactions can occur would have increased, and, therefore, the expected take from interactions would be larger than expected as a result of greater overlap between hatchery and natural-origin fish. This threshold will be monitored using emigration estimates from PIT tag detections.

Construction, operation, and maintenance (Factor 6): Adult spring Chinook salmon are rarely encountered during water withdrawals at the primary intake. However, juveniles may be encountered, with the total incidental encounters not to exceed 1,000 juvenile spring Chinook salmon with a total incidental mortality of 50 juvenile spring Chinook salmon annually. Total take includes fish salvage activities associated with water withdrawals until the LNFH water delivery system is upgraded. NMFS recognizes that little production of native spring Chinook salmon occurs in Icicle Creek so the majority of spring Chinook salmon juveniles are likely of LNFH-origin—because it is not feasible to determine what the proportion of affected fish is from this form of take, we will assume for the purpose of this statement that all are of natural origin.

Information to measure and determine adult and juvenile take (encounters and direct or latent mortality) associated with water diversions at structures 1 and 2 is unavailable at this time. Instream flows will be used as a surrogate for take because the effect of low flow on adult and juvenile spring Chinook salmon cannot be directly measured due to uncertainty in the number of spring Chinook salmon that would be present when the flow becomes low and in the degree of effect on spring Chinook salmon spawning, rearing, and migration. We find that measuring the instream flow has a rational connection to the effect of low flow on spring Chinook salmon because decrease in instream flow could lead to a flow level low enough to result in take of spring Chinook salmon.

Maintaining an instream flow of 100 cfs in the Icicle Creek would provide adequate ESA-listed adult and juvenile spring Chinook upstream and downstream passage and rearing conditions. However, there may be times when the LNFH may need to deviate from the collective instream goal of 100 cfs to meet production needs. Thus, the LNFH would operate the hatchery with a collective instream flow goal of 100 cfs year round. From April through July, instream flows of 100 cfs would be achieved in average and dry water years combined. In August, Structure 2 would not be operated. In September, if the natural flow remaining after subtracting the amount of water diverted by the LNFH and all water users is less than 60 cfs, the LNFH will not route more water into the hatchery channel than the volume of its Snow/Nada Lake storage release (up to 50 cfs) minus the withdrawal from Snow Creek by IPID and hatchery diversion at Structure 1 (up to 42 cfs). In dry water years (90^{th} exceedance), when the LNFH would deviate from the 100 cfs instream flow, they would operate in a manner intended to maintain daily average instream flows of 40 cfs in October, 60 cfs November - February, and 80 cfs in March in the Icicle Creek historical channel as described in Section 2.4.2.6.2. Under the future effects of climate change, these daily instream flow goals are likely to become more difficult to meet in the late-summer months when supplementation is not occurring; however, flows below the daily instream flow goals would result in exceeding the amount or extent of take described in this incidental take statement.

Additional operation of Structures 2 or 5 may also occur through discussion with and consensus of the adaptive management group, with prior notification to NMFS SFD, only to improve flow or increase fish passage opportunities.

The effluent from the hatchery's current operation and operation under the NPDES permit interim phosphorus limit is expected to result in take of adult and juvenile ESA-listed spring Chinook salmon due to harm resulting from sublethal effects of elevated pH, which is possible below the discharge point in Icicle Creek during the critical, low-flow months. It is not possible to accurately quantify this take because meaningful measurements cannot be made of such factors or their effects. NMFS will therefore rely on the end-of-the-pipe phosphorus concentrations in the effluent as a surrogate take indicator because the amount of phosphorus directly affects the shift in pH such that it serves as a reasonable and reliable indicator of incidental take that would result from an increased pH. Exceedance of end-of-the-pipe phosphorus interim limits would result in exceeding the amount or extent described in this incidental take statement. Until monitoring is implemented to measure end-of-the-pipe phosphorus levels, NMFS considers the amount of feed used to be a sufficient indicator of phosphorus levels, as noted in Table 18 of USFWS (2011c).

2.8.1.2. UCR Steelhead

Hatchery fish and their progeny on spawning grounds and at adult collection facilities (Factor 2): Hatchery fish and their progeny on the spawning grounds are likely to have immeasurable negligible ecological effects since Chinook salmon and steelhead have differences in spawn timing and utilize different spawning and rearing habitat. In addition, LNFH fish are removed during collection activities and not allowed to spawn naturally (i.e., not returned to Icicle Creek).

In the course of collecting LNFH spring Chinook salmon for hatchery broodstock, the proposed action is expected to handle, annually, fewer than 10 ESA-listed, natural and hatchery-origin adult steelhead and up to 50 juvenile *O. mykiss,* with no mortalities associated with either life stage (Table 41, which also includes encounters anticipated from Factor 6). All steelhead handled during broodstock collection would be released, immediately, back into Icicle Creek.

The LNFH program is not likely to result in increased local competition for spawning sites, redd superimposition, and removal of fine sediments from spawning gravels due to differences in spawn timing between UCR spring Chinook salmon and steelhead. The vast majority of LNFH spring Chinook salmon returning to Icicle Creek are removed at the fish collection ladder and are not allowed to spawn naturally. Staff survey below the hatchery barrier to determine if any adults are present after the collection ladder is closed to maximize hatchery-origin adult removal.

Table 41. UCR ESA-listed adult and juvenile steelhead (natural and hatchery combined) handling and incidental mortality associated with annual broodstock collection and the water delivery system for the proposed action.

Activity	Maximum Handled & Released[1]		Maximum Incidental Mortality[1]
	Adult	Juvenile	Juvenile
Broodstock collection	< 10	50	0
Water delivery system	10	500	5

[1] This includes all ESA-listed steelhead, natural or hatchery fish.

Of note, Icicle Creek also contains a resident rainbow trout population. Since juvenile steelhead are indistinguishable from juvenile rainbow trout during the first few years of their life, the juvenile take listed in Table 41 is likely to include fish from both life history strategies.

The LNFH staff relies on data from CPUD and WDFW to monitor and report the number, location, and timing of naturally-spawning hatchery fish in order to achieve best management practices at the hatchery and minimize the risk of ecological effects. The USFWS would continue to coordinate with these parties through the HCP HC process.

The LNFH program was not analyzed for genetic effects on ESA-listed steelhead because spring Chinook salmon and steelhead do not interbreed.

Hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas (Factor 3): Competition with and predation by hatchery-origin spring Chinook salmon, as they travel down to the Columbia River, could result in take of natural-origin steelhead. However, it is difficult to quantify this take because ecological interactions cannot be directly observed or counted. Thus, NMFS will rely on median travel rate as a surrogate take variable.

This is a reasonable, reliable, and measurable surrogate for incidental take because if travel rate falls much below 14.2 RM/day (e.g., 9.4 RM/day would indicate that smolts are taking 1 extra day to travel out of the Wenatchee Basin), it is a sign that fish are not exiting the action area as quickly as expected, the amount of time during which adverse interactions can occur would have increased, and therefore the expected take from interactions would be larger than expected as a result of greater overlap between hatchery and natural-origin fish. This threshold will be monitored using emigration estimates from PIT tag detections.

Construction, operation, and maintenance (Factor 6): During water withdrawals and flow management activities, the proposed action is expected to handle 10 ESA-listed adult steelhead and 500 juvenile *O. mykiss* (likely to include some rainbow trout, as discussed above) with an incidental take mortality of no more than 5 juvenile *O. mykiss* (Table 41)..

Information to measure and determine adult and juvenile take (encounters and direct or latent mortality) associated with water diversions at structures 1 and 2 is unavailable at this time.

Instream flows will be used as a surrogate for take. Maintaining an instream flow of 100 cfs in the Icicle Creek would provide adequate ESA-listed adult and juvenile steelhead upstream and downstream passage and rearing conditions. However, there may be times when the LNFH would need to deviate from the collective instream goal of 100 cfs to meet production needs. Thus, the LNFH would operate the hatchery with a collective instream flow goal of 100 cfs year round. From April through July, instream flows of 100 cfs would be achieved in average and dry water years combined. In August, Structure 2 would not be operated. In September, if the natural flow remaining after subtracting the amount of water diverted by the LNFH and all water users is less than 60 cfs, the LNFH will not route more water into the hatchery channel than the volume of its Snow/Nada Lake storage release (up to 50 cfs) minus the withdrawal from Snow Creek by IPID and diversion at Structure 1 (up to 42 cfs). In dry water years (90th exceedance), when the LNFH would deviate from the 100 cfs instream flow, they would operate in a manner intended to maintain daily average instream flows of 40 cfs in October, 60 cfs November - February, and 80 cfs in March in the Icicle Creek historical channel as described in Section 2.4.2.6.2. Under the future effects of climate change, these daily instream flow goals are likely to become more difficult to meet in the late-summer months when supplementation is not occurring; however, flows below the daily instream flow goals would result in exceeding the amount or extent of take described in this incidental take statement.

Additional operation of Structures 2 or 5 may also occur through discussion with and consensus of the adaptive management group, with prior notification to NMFS SFD, only to improve flow or increase fish passage opportunities.

The effluent from the hatchery's current operation and operation under the NPDES permit interim phosphorus limit is expected to result in take of juvenile ESA-listed steelhead due to harm resulting from sublethal effects of elevated pH, which is possible below the discharge point in Icicle Creek during the critical, low-flow months. It is not possible to accurately quantify this take because meaningful measurements cannot be made of such factors or their effects. NMFS will therefore rely on the end-of-the-pipe phosphorus concentrations in the effluent as a surrogate take indicator because the amount of phosphorus directly affects the shift in pH such that it serves as a reasonable and reliable indicator of incidental take that would result from an increased pH. Exceedance of end-of-the-pipe phosphorus interim limits (Table 27) will constitute an exceedance of authorized take and act as a reinitiation trigger. Until monitoring is implemented to measure end-of-the-pipe phosphorus levels, NMFS considers the amount of feed used to be a sufficient indicator of phosphorus levels (Table 18 of USFWS 2011c).

2.8.2. Effect of the Take

In Section 2.7, NMFS determined that the level of anticipated take, coupled with other effects of the proposed action, is not likely to jeopardize the continued existence of the UCR Spring-Run Chinook Salmon ESU and the UCR Steelhead DPS or result in the destruction or adverse modification of their designated critical habitat.

2.8.3. Reasonable and Prudent Measures

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

NMFS concludes that the following reasonable and prudent measures are necessary and appropriate to minimize incidental take.

USFWS and USBR shall:

1. Limit the number of stray LNFH spring Chinook salmon that spawn in the Upper Wenatchee and Entiat Basins;
2. Limit and reduce take and the effect of take of salmon and steelhead in Icicle Creek and lower Wenatchee River associated with the hatchery program, including operation of the LNFH broodstock collection facilities, water delivery system, and instream structures; and
3. Monitor and report on operation of the LNFH and its effects on ESA-listed species.

The EPA shall:

4. Monitor LNFH's compliance with the daily maximum and monthly average phosphorus limits through reporting it receives on the LNFH operation.

2.8.4. Terms and Conditions

The terms and conditions described below are non-discretionary, and the Action Agencies must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). The Action Agencies have 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 incidental take statement (50 CFR 402.14). If the following terms and conditions are not complied with, the protective coverage of section 7(o)(2) would likely lapse.

1a. NMFS is using LNFH contribution to pHOS as a surrogate for gene flow, with a limit of 3.2% annually on the LNFH contribution to pHOS for the Upper Wenatchee and Entiat Basins. The LNFH will continue their marking strategy for the spring Chinook salmon hatchery program to help identity LNFH spring Chinook salmon, request removal of them at Tumwater Dam, and validate that the surrogate for gene flow—i.e., pHOS—is no higher than the rates evaluated in this opinion (up to 3.2%) annually for the Upper Wenatchee and Entiat Basins. Monitoring and escapement estimates shall be reported to NMFS SFD annually (see 3b).

2a. The disposition by USFWS of all natural-origin and hatchery-origin spring Chinook salmon and steelhead that enter the LNFH fish collection ladder and water delivery system will be addressed as follows:

   i. All ESA-listed natural-origin spring Chinook salmon (up to 3 adults) (i.e., identified by presence of adipose fin and verified with scale pattern as appropriate) and steelhead (up to 10 adults) shall be monitored, documented, and returned to Icicle Creek during broodstock collection activities, of which no more than three spring Chinook salmon would die annually. In addition, up to 50 juvenile steelhead (with no mortality) may be encountered during broodstock collection.

ii. Annually, up to 120 ESA-listed adult hatchery-origin spring Chinook salmon (identified retrospectively through agency/program specific CWT code; safety-net program) may be encountered[104] during broodstock collection with no more than 120 annual mortalities through use as broodstock, for tribal consumption, or other disposal.

iii. Annually, up to 50 ESA-listed adult hatchery-origin spring Chinook salmon (i.e., identified by presence of adipose fin and CWT; conservation program) may be encountered during broodstock collection and shall be returned to Icicle Creek or transferred to the appropriate hatchery operator (e.g., WDFW) for use as broodstock with no more than 50 annual mortalities.

iv. Annually, up to 1,000 naturally spawned spring Chinook salmon juveniles would be encountered through the water delivery system, of which no more than 50 would result in mortalities.

v. Annually, 10 adult ESA-listed spring Chinook salmon, 10 adult ESA-listed steelhead, and 500 juvenile ESA-listed steelhead may be encountered through the water delivery system and shall be returned to Icicle Creek, of which no more than five juvenile steelhead would die. Icicle Creek also contains a resident rainbow trout population. Since juvenile steelhead are indistinguishable from juvenile rainbow trout during the first few years of their life, this take is likely to include fish from both life history strategies.

2b. Ensure that the gates at Structure 2 are open from March 1 through May 31 to allow for unimpeded steelhead adult migration with the following exception. In March, Structure 2 will only be operated if adult steelhead have not been detected recently (within the last 30 calendar days) in Icicle Creek. Structure 2 may be operated in May for the purpose of installing the DIDSON™ fish counter for monitoring the 50-fish trigger and to block upstream passage of LNFH-origin spring Chinook salmon after reaching the 50-fish trigger, as long as the flow in the historical channel remains above 300 cfs at all times. Structure 2 will not be operated in August.

If Structure 5 is closed during LNFH-origin spring Chinook salmon broodstock collection (i.e., due to reaching 50-fish trigger), traps would be checked twice daily and ESA-listed spring Chinook salmon and steelhead would be released upstream or downstream of Structure 5 (depending on marking for spring Chinook salmon and spawning status for steelhead).

[104] As described in sections 1.3, 2.3, and 2.4.2.2, LNFH spring Chinook salmon and hatchery-origin spring Chinook salmon from the Wenatchee supplementation safety-net programs are difficult to distinguish due to an identical marking strategy for a proportion of these fish.

2c. From August 1 through September 30, release up to 50 cfs of supplemental flow from the Snow/Nada Lake Basin Supplementation Water Supply Reservoirs, to ensure access to LNFH's surface water withdrawal and improve instream flow conditions to the extent possible during the irrigation season in cooperation with IPID as described in this opinion.

2d. In September, if the natural flow remaining after subtracting the amount of water diverted by the LNFH and all water users is less than 60 cfs, the LNFH will not route more water into the hatchery channel than the volume of its Snow/Nada Lake storage release (up to 50 cfs) minus the IPID's withdrawal from Snow Creek and diversion at Structure 1 (up to 42 cfs).

2e. If USFWS and USBR become aware that the amount of supplementation reaching Icicle Creek from Snow Creek in August and September is less than the amount of water diverted at Structure 1, USFWS and USBR shall notify NMFS within 3 business days. USFWS and USBR shall also confer with IPID and seek permission to include the volume of IPID's withdrawal from Snow Creek in August and September in the annual report to NMFS.

2f. The circumstances under which the LNFH would need to deviate from a 100 cfs collective minimum flow goal in the Icicle Creek historical channel are described and analyzed in Section 2.4.2.6.2, Table 30. Under these circumstances, the LNFH would operate (including operating Structure 2 for purposes of aquifer recharge) in a manner intended to maintain daily average instream flow goals of 40 cfs in October, 60 cfs in November - February, and 80 cfs in March in the Icicle Creek historical channel.

2g. By May 2023, USBR and USFWS shall have a water delivery system in place and operating that complies with NMFS current screening and fish passage criteria for anadromous fish passage facilities (NMFS 2011c). All holding areas and intake structures incidentally take listed species. Because water withdrawals at the LNFH facility do not currently meet or exceed NMFS current water intake screening criteria, to minimize injury or death of listed species, the USFWS shall evaluate such withdrawals and effects by regularly surveying the sand settling basin and capturing and releasing listed species as follows:

i. Protocol for detecting listed species:
   a. Visual observation through snorkeling[105] (to determine if fish are present and capture and release is required) as long as the entire sand settling basin can be viewed.

[105] The snorkeling is performed by a minimum of two USFWS personnel, at least one being an experienced snorkeler, for the presence of ESA-listed fish. These snorkelers are trained by USFWS (e.g., to accurately identify the species of fish) and tend to have biology degrees. The snorkelers swim parallel and in tandem for a minimum of one pass through the sand settling basin to determine fish presence and identify fish species.

i. If any *O. mykiss* or spring Chinook salmon are present or if the fish identification is inconclusive, the sand settling basin is drawn down.[106]

b. If the entire sand settling basin cannot be viewed, or if the snorkeler determines that visual detection through snorkeling is not effective, the sand settling basin is drawn down.

c. Any time the sand settling basin is drawn down, all fish in the basin shall be promptly captured and released unharmed into Icicle Creek near the LNFH spillway pool (RM 2.8). If a steelhead is in pre-spawn condition, it shall be released upstream of Structure 1.

d. If less than 2 staff is available to snorkel during the timeframe described below, USFWS will confer with NMFS to assess the benefits and risks associated with performing this protocol understaffed (e.g., risks to the listed species, efficiency of snorkeling, human safety concerns).

ii. Frequency of monitoring for detection:

a. On a weekly basis, as defined by every 7 calendar days to the extent feasible[107] and no less frequently than every calendar week, starting on April 1 through October (particularly during the UCR steelhead smolt migration in spring and again during the first onset of cold weather during the fall).

b. Starting on April 1 through October, if, after three weeks, no *O. mykiss* or spring Chinook salmon are encountered (other than during the spring steelhead smolt migration in fall as described above), survey the sand settling basin for the presence of listed species every 31 calendar days. If more than five steelhead were detected during one survey effort, then the monitoring interval would change back to weekly.

c. During the November through mid-April period, after the onset of cold weather, survey the sand settling basin and remove listed species every 31 calendar days. If more than five *O. mykiss* were detected during one survey effort, then the monitoring interval would change back to weekly.

d. If surveying the sand settling basin is ineffective (e.g., high sediment loads, typically lasting 3 to 4 days) and/or removing fish from the basin is not possible (e.g., presence of ice covering basin pool, potentially up to a month), confer with NMFS to determine the best method of detection, immediately survey basin and remove ESA-listed species as soon as possible, and return to regular survey schedule as stated above.

iii. If no ESA-listed fish is present in the sand settling basin (e.g., if the sand settling basin has no water) and no fish could enter the water delivery system (e.g., if the hatchery is not withdrawing water from Structure 1), no monitoring of the sand settling basin is necessary.

[106] Drawing down the sand settling basin to capture the fish is more preferable than capturing the fish without drawing down the sand settling basin for a couple of reasons. First, it allows for better visual of the fish in the sand settling basin, which eliminates human error. It also increases the likelihood of capturing all the fish in the sand settling basin through better detection.

[107] Feasibility determined by staff availability.

Include results of spring Chinook salmon or *O. mykiss* detection from the above actions and monitoring in annual reports submitted to NMFS (see 3b).

2h. The USFWS will monitor and report monthly average instream flows in Icicle Creek, using current monitoring systems at Structures 1 and 2 and the USGS and Ecology stream gauging systems on Icicle Creek until real-time instream flow monitoring becomes available; when real-time instream flow monitoring becomes available, USFWS will use real-time instream flow monitoring to monitor and report monthly average instream flows in Icicle Creek. USFWS will also monitor for daily flows and will notify NMFS within 3 business days if daily average flow in the Icicle Creek historical channel drops below 40 cfs in October, 60 cfs from November – February, 80 cfs in March, or 100 cfs from April through July. USFWS will not operate Structure 2 without real-time instream flow monitoring. By November 30, 2017, the USFWS will install real-time instream flow monitoring stations with the intent of measuring flows upstream of the intake at RM 4.5 (Structure 1) and with the intent of measuring flows in the Icicle Creek historical channel between RM 3.8 and 2.8 (Structure 2) in order to monitor instream flows in Icicle Creek. USFWS will notify NMFS by October 31, 2017, if real-time instream flow monitoring cannot be installed by November 30, 2017. Instream flow reporting can be combined with other hatchery reporting requirements and submitted to NMFS by March 1st (see 3b).

2i. Disturbing natural-origin spawning salmon and steelhead during hatchery maintenance activities of diversions and instream structures shall be avoided, as shall disturbing salmon and steelhead redds.

2j. The USBR shall replace the valve at Snow Lake to allow accommodating for multiple water users by the end of calendar year 2019, or USBR will notify NMFS, by October 31, 2019, if the valve cannot be installed by the end of 2019.

2k. The USFWS shall monitor the time it takes LNFH juveniles to migrate out of the system, using methods adequate to identify LNFH juveniles, such as PIT tag detections or observations in screw traps. The USFWS shall annually report to NMFS the hatchery fish post-release out-of-basin migration timing (in mean and median travel time) to McNary Dam and travel rate of juvenile hatchery-origin fish. The USFWS shall notify NMFS if the running 3-year average of travel rate (using mean travel time) is at or below 9.4 RM/day, including instances where it is apparent, from numbers observed in years prior to the third year, that the average of 9.4 RM/day would not be achieved after 3 years.

3a. NMFS' SFD must be notified, in advance, of any change in hatchery program operation and implementation that would potentially result in increased take of ESA-listed species or a change in the manner of that taking.

3b. NMFS' SFD must be notified as soon as possible, but no later than two days, after any authorized level of take is exceeded. A written report shall be provided to SFD detailing why the authorized take level was exceeded or is likely to be exceeded.

NMFS prefers communication via phone and electronic submission of reporting documents. The current point of contact for document submission is Craig Busack (*craig.busack@noaa.gov*), but this may change during the life of the permits. All reports, as well as all other notifications required in the permits, can also be submitted to NMFS at:

Craig Busack
Anadromous Production and Inland Fisheries
NMFS – Sustainable Fisheries Division
National Marine Fisheries Service, West Coast Region
1201 NE Lloyd Blvd, Suite 1100
Portland, Oregon 97232
Phone: (503) 230-5412
Fax: (503) 872-2737

3c. Apply measures to ensure that, before their release into Icicle Creek, LNFH-origin spring Chinook salmon juveniles are ready to actively migrate to the ocean. To meet this condition, fish shall be released at a uniform size and demonstrate signs of smoltification that ensure that the fish will migrate seaward without delay.

i. Variance from this release requirement is only approved, per best management practice, in the event of an emergency, such as flooding, water loss to raceways, or vandalism, which necessitates early release to prevent catastrophic mortality.

ii. Any emergency releases must be reported as soon as reasonably possible to SFD.

3d. Post-release survival of LNFH-spring Chinook salmon smolts shall be monitored and evaluated to determine the speed of emigration and level of residualism.

3e. To the extent possible without imposing increased risk to ESA-listed species, USFWS shall enumerate and identify marks and tags on all anadromous species encountered at adult collection and water intake sites. This information shall be included in the broodstock protocol or LNFH monitoring report submitted to NMFS annually.

3f. If water temperature in the adult holding ponds or sand settling chamber exceeds 21 °C (69.8 °F), fish collection shall cease pending further consultation with NMFS to determine if continued collection poses substantial risk to ESA-listed species that may be incidentally encountered.

3g. The USFWS shall update and provide SFD, by March 1st of each year, the projected hatchery releases by age class and location for the upcoming year (see 3b).

3h. The USFWS shall provide annual report(s) that summarize numbers, fish weights, dates, tag/mark information, locations of artificially propagated fish releases, and monitoring and evaluation activities that occur within the hatchery environment, and adult return numbers (specifying the program of origin) to the UCR basin. Ensure collection and reporting of the coefficient of variation around the average (target) release size for LNFH spring Chinook salmon immediately prior to their liberation from the rearing ponds to serve as an indicator of population size uniformity and smoltification status. Reports must include any preliminary analyses of scientific research data, identification of any problems that arise during conduct of the authorized activities, a statement as to whether or not the activities had any unforeseen effects, and steps that have been and will be taken to coordinate the research or monitoring with that of other researchers. Unless otherwise noted in the specific terms and conditions, the reports will be submitted by March 1st, of the year following release to NMFS (i.e., brood year 2016, release year 2017, report due March 2018, see 3b).

3i. Provide plans in advance of any future projects and/or changes in collection locations for NMFS concurrence through the UCR annual broodstock protocol memorandum.

3j. Adult return information shall include available annual estimates of pHOS for LNFH spring Chinook salmon in the Wenatchee and Entiat basins, including the number, location, and timing of recoveries. Adult return information and results from monitoring and evaluation activities outside the hatchery environment shall be included in the annual report or a separate report. If a separate report on monitoring and evaluation activities conducted outside the hatchery environment is prepared, it will be submitted by March 1st, of the year following the monitoring and evaluation activities (i.e., surveys conducted on 2014, report due March 2015, see 3b).

4a. EPA will notify NMFS' SFD if the terms of the NPDES permit (including monitoring requirements) pertaining to phosphorus will change from what is currently proposed prior to issuance of the final permit.

4b. EPA will include terms in its final NPDES permit that require LNFH to also notify NMFS' SFD for non-compliance with the daily maximum and monthly average phosphorus limits using the same method as reporting to the EPA.

4c. Until monitoring is implemented for phosphorus in the effluent, USFWS and USBR will use feed only up to the levels of the feeding regimen for the spring Chinook salmon program described in Table 18 of USFWS (2011c).

4d. If monitoring is implemented before the issuance of a final NPDES permit, USFWS and USBR will notify NMFS' SFD if LNFH operation exceeds the amount of phosphorus in the effluent described in the draft NPDES permit until final permit issuance. Upon final permit issuance, USFWS and USBR will notify NMFS' SFD if LNFH operation exceeds the amount of phosphorus in the effluent described in the final NPDES permit, per conditions indicated in the final NPDES permit.

2.9. 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 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 (50 CFR 402.02). NMFS has identified three conservation recommendations to minimize take of ESA-listed steelhead or spring Chinook salmon proposed action:

C1. NMFS recommends the USFWS and USBR continue to improve instream flows in Icicle Creek. To the extent feasible:

(a) Stream flows would be ~200 cfs during adult spawning and migration of ESA-listed steelhead (March through June) and spring Chinook salmon (May through July) with < 260 cfs for adult salmonid passage through Structure 5;

(b) Stream flows would be ~64 cfs for upstream passage of ESA-listed juvenile salmonids at Structures 1 and 2, and ~125 cfs for ESA-listed juvenile salmonids upstream passage over Structure 5, year-round;

(c) Stream flows would be ~40 cfs for downstream passage of ESA-listed juvenile steelhead at Structures 1, 2 and 5, year-round; and

(d) Stream flows would be ~250 cfs for rearing of ESA-listed juvenile steelhead at Structures 1, 2, and 5, during the months of July through February.

C2. NMFS recommends the USFWS, in cooperation with NMFS, continue to investigate and implement additional methods to externally mark and/or internally tag hatchery-produced salmon to determine the extent of straying by hatchery adults from this program into tributaries outside of Icicle Creek in the Wenatchee and Entiat Basins. The USFWS, in cooperation with NMFS, would also continue to investigate and, if practicable, implement best management practices that reduce stray rates of LNFH spring Chinook salmon.

C3. NMFS recommends the USFWS, in cooperation with NMFS, continue to investigate the level of ecological interactions between hatchery-produced spring Chinook salmon and listed steelhead and spring Chinook salmon within Icicle Creek and the Wenatchee and Entiat River Basins to identify additional methods to minimize these interactions.

C4. NMFS recommends the USFWS work with the adaptive management group to operate Structure 2 and/or 5 to increase stream flow and fish passage opportunities (e.g., partial closure of Structure 5 in a manner that leaves the two middle bays open during broodstock collection (before the 50 spring Chinook salmon trigger is met)), to allow for responsive management.

C5. NMFS recommends the USFWS and USBR work toward achieving the final temperature and phosphorus limit described in the NPDES permit for the hatchery effluent.

C6. NMFS recommends the USFWS and USBR use low phosphorus feed, whenever commercially available.

C7. NMFS recommends the USFWS and USBR continue working with the Icicle Creek Work Group and with Icicle Creek water users to improve stream flow to support healthy habitat for ESA-listed species into the future. This adaptive management approach will be increasingly important in the future, as most climate change models predict warmer stream temperatures and decreased summer instream flows, which habitat improvements could ameliorate (Honea et al. 2016).

2.10. Reinitiation of Consultation

As provided in 50 CFR 402.16, reinitiation 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 take 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 CONSULTATION

The consultation requirement of section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or Proposed Actions that may adversely affect EFH. The MSA (section 3) defines EFH as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” Adverse effects include the direct or indirect physical, chemical, or biological alterations 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 EFH, and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based, in part, on descriptions of EFH for Pacific coast salmon (Pacific Fishery Management Council 2003a) contained in the fishery management plans developed by the Pacific Fishery Management Council (PFMC) and approved by the Secretary of Commerce.

3.1. Essential Fish Habitat Affected by the Project

The Proposed Action is the implementation of one hatchery program in the Wenatchee River basin, as described in detail in Section 1.3, above. The action area of the proposed action includes habitat described as EFH for Chinook and coho salmon, which includes Icicle Creek to the confluence of the Wenatchee River at RM 25.6, and the lower Wenatchee downstream from that point to the confluence of the Columbia River at Columbia RM 468. Because EFH has not been described for steelhead, the analysis is restricted to the effects of the Proposed Action on EFH for Chinook and coho salmon.

Freshwater EFH for Chinook and coho salmon consists of four major components: (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors and holding habitat (Pacific Fishery Management Council 2003a). Based on these components, the PFMC designated five Habitat Areas of Particular Concern: (1) complex channels and floodplain habitats; (2) thermal refugia; (3) spawning habitat; (4) estuaries; and (5) marine and estuarine submerged aquatic vegetation (PFMC 2014). The aspects of EFH that might be affected by the Proposed Action include effects of hatchery operations on ecological interactions on natural-origin Chinook and coho salmon in spawning and rearing areas and adult migration corridors and adult holding habitat, and genetic effects on natural-origin Chinook salmon in spawning areas.

3.2. Adverse Effects on Essential Fish Habitat

Important features of essential habitat for spawning, rearing, and migration include adequate:

(1) Substrate composition;
(2) Water quality (e.g., dissolved oxygen, nutrients, temperature, etc.);
(3) Water quantity, depth, and velocity;
(4) Channel gradient and stability;
(5) Food;
(6) Cover and habitat complexity (e.g., large woody debris, pools, channel complexity, aquatic vegetation, etc.);
(7) Space;
(8) Access and passage; and
(9) Flood plain and habitat connectivity.

Water withdrawal and flow management activities for hatchery operations can adversely affect salmon by reducing streamflow, impeding migration, or reducing other stream-dwelling organisms that could serve as prey for juvenile salmonids. Water withdrawals can also kill or injure juvenile salmonids through impingement upon inadequately designed intake screens or by entrainment of juvenile fish into the water diversion structures.

The Proposed Action generally has effects on the major components of EFH. Potential effects on EFH by the proposed action are primarily directed at habitat features in Icicle Creek, including adult migration corridors and adult holding habitat and water quantity and water quality associated with water withdrawals. These risk factors are similar to those considered in the effects analysis in Section 2.4, Effects of the Action on the Species and Designated Critical Habitat.

The PFMC (2003) recognized concerns regarding the “genetic and ecological interactions of hatchery and wild fish… [which have] been identified as risk factors for wild populations.” The biological opinion describes in considerable detail the impacts hatchery programs might have on natural populations (Section 2.4.1). Hatchery fish returning to Icicle Creek are expected to be removed from the river and, thus, interbreeding or competition for space with natural-origin spring Chinook salmon or steelhead is expected to be negligible. Some spring Chinook salmon from LNFH will stray into other rivers but not in numbers that would cause genetic effects or that would result in increased incidence of disease or increases in competition or predators.

Predation by adult hatchery salmon on juvenile natural Chinook salmon is not likely to occur since little natural production from the native spring Chinook population is thought to occur in Icicle Creek (UCSRB 2007) and adult salmon stop feeding by the time they reach spawning areas. Predation and competition by hatchery-origin juveniles on juvenile natural-origin Chinook salmon would occur at only minimal levels for reasons discussed in Section 2.4.2. Hatchery fish from LNFH and from other hatcheries that volunteer into LNFH would be removed and prevented from returning to the Wenatchee River in order to reduce adverse ecological and genetic effects on extant Wenatchee River natural populations.

The proposed hatchery program includes plans to minimize each potential effect on EFH. Criteria for surface water withdrawal and flow management are implemented to avoid impacts on water quality and quantity that could degrade the environment of listed species. The LNFH would be operated with a collective instream flow goal of 100 cfs when operating Structure 1 for water diversions and/or Structure 2 for hatchery aquifer recharge, thereby providing adequate water for adult spawning and juvenile salmonid passage and rearing. The conditions under which the LNFH may deviate from this goal are described in Section 2.4.2.6.2. Further, the amount of water to be removed would largely be returned to the river approximately 1.7 miles from the point of withdrawal, minus any leakage or evaporation. An updated water delivery system would be screened for compliance with NMFS criteria (NMFS 2011c) by May 2023. During this transition, USFWS has implemented updated fish salvage procedures to minimize risks to listed species that may become entrained in the current water delivery system.

NMFS has determined that the Proposed Action is likely to adversely affect EFH for Pacific salmon.

3.3. Essential Fish Habitat Conservation Recommendations

For each of the potential adverse effects by the Proposed Action on EFH for Chinook salmon, NMFS believes that the conditions described in the ITS (Section 2.8) include the best approaches to avoid or minimize those adverse effects. The Reasonable and Prudent Measures and Terms and Conditions included in the ITS constitute NMFS recommendations to address potential EFH effects. USFWS and USBR would ensure that the ITS, including Reasonable and Prudent Measures and implementing Terms and Conditions are carried out.

To address the potential effects on EFH of hatchery fish on natural fish in natural spawning and rearing areas, the PFMC (PFMC 2003) provided an overarching recommendation that hatchery programs:

> "[c]omply with current policies for release of hatchery fish to minimize impacts on native fish populations and their ecosystems and to minimize the percentage of nonlocal hatchery fish spawning in streams containing native stocks of salmonids."

NMFS adopts this recommendation as a specific conservation recommendation for this proposed action. Of particular importance are the terms and conditions that address water withdrawal, effluent discharge, and ESA-listed steelhead adult and juvenile rearing and migration:

1. Ensure that the gates at Structure 2 are open from March 1 through May 31 to allow for unimpeded steelhead adult migration with the following exception. In March, Structure 2 will only be operated if adult steelhead have not been detected recently (within the last 30 calendar days) in Icicle Creek. Structure 2 may be operated in May for the purpose of installing the DIDSON™ fish counter for monitoring the 50-fish trigger and to block upstream passage of LNFH-origin spring Chinook salmon after reaching the 50-fish trigger, as long as the flow in the historical channel remains above 300 cfs at all times. Structure 2 will not be operated in August.

   If Structure 5 is closed during LNFH-origin spring Chinook salmon broodstock collection (i.e., due to reaching 50-fish trigger), traps would be checked twice daily and ESA-listed spring Chinook salmon and steelhead would be released upstream or downstream of Structure 5 (depending on marking for spring Chinook salmon and spawning status for steelhead).

2. From August 1 through September 30, release up to 50 cfs of supplemental flow from the Snow/Nada Lake Basin Supplementation Water Supply Reservoirs, to ensure access to LNFH's surface water withdrawal and improve instream flow conditions to the extent possible during the irrigation season in cooperation with IPID as described in this opinion.

3. In September, if the natural flow remaining after subtracting the amount of water diverted by the LNFH and all water users is less than 60 cfs, the LNFH will not route more water into the hatchery channel than the volume of its Snow/Nada Lake storage release (up to 50 cfs) minus the IPID's withdrawal from Snow Creek and diversion at Structure 1 (up to 42 cfs).

4. If USFWS and USBR become aware that the amount of supplementation reaching Icicle Creek from Snow Creek in August and September is less than the amount of water diverted at Structure 1, USFWS and USBR shall notify NMFS within 3 business days. USFWS and USBR shall also confer with IPID and seek permission to include the volume of IPID's withdrawal from Snow Creek in August and September in the annual report to NMFS.

5. The circumstances under which the LNFH would need to deviate from a 100 cfs collective minimum flow goal in the Icicle Creek historical channel are described and analyzed in Section 2.4.2.6.2, Table 30. Under these circumstances, the LNFH would operate (including operating Structure 2 for purposes of aquifer recharge) in a manner intended to maintain daily average instream flow goals of 40 cfs in October, 60 cfs in November - February, and 80 cfs in March in the Icicle Creek historical channel.

6. By May 2023, USBR and USFWS shall have a water delivery system in place and operating that complies with NMFS current screening and fish passage criteria for anadromous fish passage facilities (NMFS 2011c). All holding areas and intake structures incidentally take listed species. Because water withdrawals at the LNFH facility do not currently meet or exceed NMFS current water intake screening criteria,

to minimize injury or death of listed species, the USFWS shall evaluate such withdrawals and effects by regularly surveying the sand settling basin and capturing and releasing listed species as follows:

iv. Protocol for detecting listed species:
   a. Visual observation through snorkeling[108] (to determine if fish are present and capture and release is required) as long as the entire sand settling basin can be viewed.
      i. If any *O. mykiss* or spring Chinook salmon are present or if the fish identification is inconclusive, the sand settling basin is drawn down.[109]
   b. If the entire sand settling basin cannot be viewed, or if the snorkeler determines that visual detection through snorkeling is not effective, the sand settling basin is drawn down.
   c. Any time the sand settling basin is drawn down, all fish in the basin shall be promptly captured and released unharmed into Icicle Creek near the LNFH spillway pool (RM 2.8). If a steelhead is in pre-spawn condition, it shall be released upstream of Structure 1.
   d. If less than 2 staff is available to snorkel during the timeframe described below, USFWS will confer with NMFS to assess the benefits and risks associated with performing this protocol understaffed (e.g., risks to the listed species, efficiency of snorkeling, human safety concerns).

v. Frequency of monitoring for detection:
   a. On a weekly basis, as defined by every 7 calendar days to the extent feasible[110] and no less frequently than every calendar week, starting on April 1 through October (particularly during the UCR steelhead smolt migration in spring and again during the first onset of cold weather during the fall).
   b. Starting on April 1 through October, if, after three weeks, no *O. mykiss* or spring Chinook salmon are encountered (other than during the spring steelhead smolt migration in fall as described above), survey the sand settling basin for the presence of listed species every 31 calendar days. If more than five steelhead were detected during one survey effort, then the monitoring interval would change back to weekly.
   c. During the November through mid-April period, after the onset of cold weather, survey the sand settling basin and remove listed species every 31 calendar days. If more than five *O. mykiss* were detected during one survey effort, then the monitoring interval would change back to weekly.

[108] The snorkeling is performed by a minimum of two USFWS personnel, at least one being an experienced snorkeler, for the presence of ESA-listed fish. These snorkelers are trained by USFWS (e.g., to accurately identify the species of fish) and tend to have biology degrees. The snorkelers swim parallel and in tandem for a minimum of one pass through the sand settling basin to determine fish presence and identify fish species.

[109] Drawing down the sand settling basin to capture the fish is more preferable than capturing the fish without drawing down the sand settling basin for a couple of reasons. First, it allows for better visual of the fish in the sand settling basin, which eliminates human error. It also increases the likelihood of capturing all the fish in the sand settling basin through better detection.

[110] Feasibility determined by staff availability.

d. If surveying the sand settling basin is ineffective (e.g., high sediment loads, typically lasting 3 to 4 days) and/or removing fish from the basin is not possible (e.g., presence of ice covering basin pool, potentially up to a month), confer with NMFS to determine the best method of detection, immediately survey basin and remove ESA-listed species as soon as possible, and return to regular survey schedule as stated above.

vi. If no ESA-listed fish is present in the sand settling basin (e.g., if the sand settling basin has no water) and no fish could enter the water delivery system (e.g., if the hatchery is not withdrawing water from Structure 1), no monitoring of the sand settling basin is necessary.

Include results of spring Chinook salmon or *O. mykiss* detection from the above actions and monitoring in annual reports submitted to NMFS (see 3b).

7. The USBR shall replace the valve at Snow Lake to allow accommodating for multiple water users by the end of calendar year 2019, or USBR will notify NMFS, by October 31, 2019, if the valve cannot be installed by the end of 2019.

8. Until monitoring is implemented for phosphorus in the effluent, USFWS and USBR will use feed only up to the levels of the feeding regimen for the spring Chinook salmon program described in Table 18 of USFWS (2011c).

3.4. Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, the Federal agency 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 time frames 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 USFWS and USBR 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

Section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-554) ("Data Quality Act") 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, document compliance with the Data Quality Act, 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. NMFS has determined, through this ESA section 7 consultation, that operation of the LNFH spring Chinook salmon program as proposed will not jeopardize ESA-listed species and will not destroy or adversely modify designated critical habitat. Therefore, NMFS can issue an ITS. The intended users of this opinion are the USFWS (as operating and funding entity) and USBR (as funding entity). The scientific community, resource managers, and stakeholders benefit from the consultation through the anticipated increase in returns of salmonids to the Columbia and Wenatchee Rivers, and through the collection of data indicating the potential effects of the operation on the viability of natural populations of UCR steelhead and spring Chinook salmon. This information will improve scientific understanding of hatchery-origin salmon effects that can be applied broadly within the Pacific Northwest area for managing benefits and risks associated with hatchery operations. This opinion will be posted on NMFS' West Coast Region web site (http://www.westcoast.fisheries.noaa.gov/). The format and naming adheres 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 600.920(j).

Best Available Information: This consultation and supporting documents use the best available information, as described in the references section. The analyses in this biological opinion/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.

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