UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OR 97232-1274

Refer to NMFS No:
WCRO-2020-01439

May 3, 2022

Melanie Vance
Environmental Manager
310 Maple Park Avenue SE
Olympia, Washington 98504

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for 88th Street NE Corridor Improvement Project (HUC: 171100110203 and 171100110204 – Marysville)

Dear Ms. Vance:

Thank you for your letter of June 30, 2020, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for 88th Street NE Corridor Improvement Project. This consultation was conducted in accordance with the 2019 revised regulations that implement section 7 of the ESA (50 CFR 402, 84 FR 45016).

Thank you, also, for your request for consultation pursuant to the essential fish habitat (EFH) provisions in Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA)(16 U.S.C. 1855(b)) for this action.

The enclosed document contains the biological opinion (opinion) prepared by the NMFS pursuant to section 7 of the ESA on the effects of the proposed action. In this opinion, the NMFS concludes that the proposed action would adversely affect but is not likely to jeopardize the continued existence of Puget Sound (PS) Chinook salmon and PS steelhead. The NMFS also concludes that the proposed action is likely to adversely affect designated critical habitat for PS Chinook salmon but is not likely to result in the destruction or adverse modification of PS Chinook salmon designated critical habitat. This opinion also documents our conclusion that the proposed action is not likely to adversely affect southern resident (SR) killer whales and their designated critical habitat.

This opinion includes an incidental take statement (ITS) that describes reasonable and prudent measures (RPMs) the NMFS considers necessary or appropriate to minimize the incidental take associated with this action, and sets forth nondiscretionary terms and conditions that the Federal Highway Administration (FHWA) must comply with to meet those measures. Incidental take from actions that meet these terms and conditions will be exempt from the ESA's prohibition against the take of listed species.

Section 3 of this document includes our analysis of the action's likely effects on EFH pursuant to Section 305(b) of the MSA. Based on that analysis, the NMFS concluded that the action would adversely affect designated freshwater EFH for Pacific Coast Salmon. Therefore, we have provided 3 conservation recommendations that can be taken by the FHWA to avoid, minimize, or otherwise offset potential adverse effects on EFH. We also concluded that the action would not adversely affect EFH for Pacific Coast groundfish and coastal pelagic species. Therefore, consultation under the MSA is not required for EFH for Pacific Coast groundfish and coastal pelagic species.

Section 305(b) (4) (B) of the MSA requires Federal agencies to provide a detailed written response to NMFS within 30 days after receiving this recommendation. If the response is inconsistent with the EFH conservation recommendations, the FHWA must explain why the recommendations will not be followed, including the scientific justification for any disagreements over the effects of the action and recommendations. In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we request that in your statutory reply to the EFH portion of this consultation you clearly identify the number of conservation recommendations accepted.

Please contact Elizabeth Babcock in the North Puget Sound Branch of the Oregon/Washington Coastal Office at, or by electronic mail at Elizabeth.Babcock@noaa.gov if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

Kim W. Kratz, Ph.D
Assistant Regional Administrator
Oregon Washington Coastal Office

cc: Melanie Vance, WSDOT
Cindy Callahan, FHWA

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

88th Street NE Corridor Improvement Project
(HUC: 171100110203 and 171100110204 – Marysville)

NMFS Consultation Number: WCRO-2020-01439

Action Agency: Federal Highway Administration

Affected Species and Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action	Is Action	Is Action Likely
Chinook salmon (*Oncorhynchus tshawytscha*) Puget Sound (PS)	Threatened	Yes	No	Yes	No
Steelhead (*O. mykiss*) PS	Threatened	Yes	No	N/A	N/A
Killer whales (*Orcinus orca*) Southern resident (SR)	Endangere d	No	No	No	No

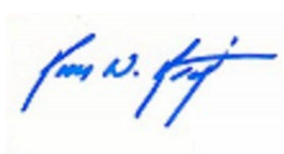
N/A = not applicable. The action area is outside designated critical habitat, or critical habitat has not been designated.

Affected Essential Fish Habitat (EFH) and NMFS' Determinations:

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

Consultation Conducted By: National Marine Fisheries Service
West Coast Region

Issued By:



dministrator
Oregon Washington Coastal Office

Date: May 3, 2022

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LIST OF ABBREVIATIONS

BA – Biological Assessment
BMP – Best Management Practices
CFR – Code of Federal Regulations
cfs – cubic feet per second
USACE – Corps of Engineers, U.S. Army
dB – Decibel (common unit of measure for sound intensity)
DIP – Demographically Independent Population
DPS – Distinct Population Segment
DQA – Data Quality Act
EF – Essential Feature
EFH – Essential Fish Habitat
ESA – Endangered Species Act
ESU – Evolutionarily Significant Unit
FR – Federal Register
HAPC – Habitat Area of Particular Concern
HUC – Hydrologic Unit Code
HPA – Hydraulic Project Approval
ITS – Incidental Take Statement
JARPA – Joint Aquatic Resources Permit Application
mg/L – Milligrams per Liter
MPG – Major Population Group
MSA – Magnuson-Stevens Fishery Conservation and Management Act
NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
PAH – Polycyclic Aromatic Hydrocarbons
PBF – Physical or Biological Feature
PCE – Primary Constituent Element
PFMC – Pacific Fishery Management Council
PS – Puget Sound
PSTRT – Puget Sound Technical Recovery Team
PSSTRT – Puget Sound Steelhead Technical Recovery Team
RPA – Reasonable and Prudent Alternative
RPM – Reasonable and Prudent Measure
SEL – Sound Exposure Level
SL – Source Level
SR – Southern Resident (Killer Whales)
VSP – Viable Salmonid Population
WCR – West Coast Region (NMFS)
WDFW – Washington State Department of Fish and Wildlife
WDOE – Washington State Department of Ecology

1. INTRODUCTION

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

1.1 Background

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

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

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

1.2 Consultation History

On June 3, 2020, NMFS received a letter from the Federal Highway Administration (FHWA) that requested formal consultation for the proposed action. The FHWA would be providing funding for the proposed action and is the lead federal agency for this consultation, with Washington Department of Transportation (WSDOT) acting as the non-federal representative. The consultation was assigned the tracking number WCRO-2020-01439. On June 30, 2021, the NMFS requested more information regarding the culvert design, stormwater treatment plan, and riparian revegetation plan (NMFS 2021a). That information was provided by WSDOT via email, with 5 attachments, on October 29, 2021 (WSDOT 2021a) and formal consultation was initiated that day. On November 4, 2021, NMFS requested via email the Joint Aquatic Resources Permit Application (JARPA) and Hydraulic Project Approval (HPA) for this consultation (NMFS 2021b).

This opinion is based on the information in the applicant's BA and additional information and construction plan drawings provided by the applicant's agent; recovery plans, status reviews, and critical habitat designations for ESA-listed PS Chinook salmon and PS steelhead; published and unpublished scientific information on the biology and ecology of those species; and relevant scientific and gray literature (see Literature Cited).

1.3 Proposed Federal Action

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

The FHWA proposes to fund the City of Marysville's repair and maintenance work at along the 88th Street NE corridor in Snohomish County, Washington (Figure 1).

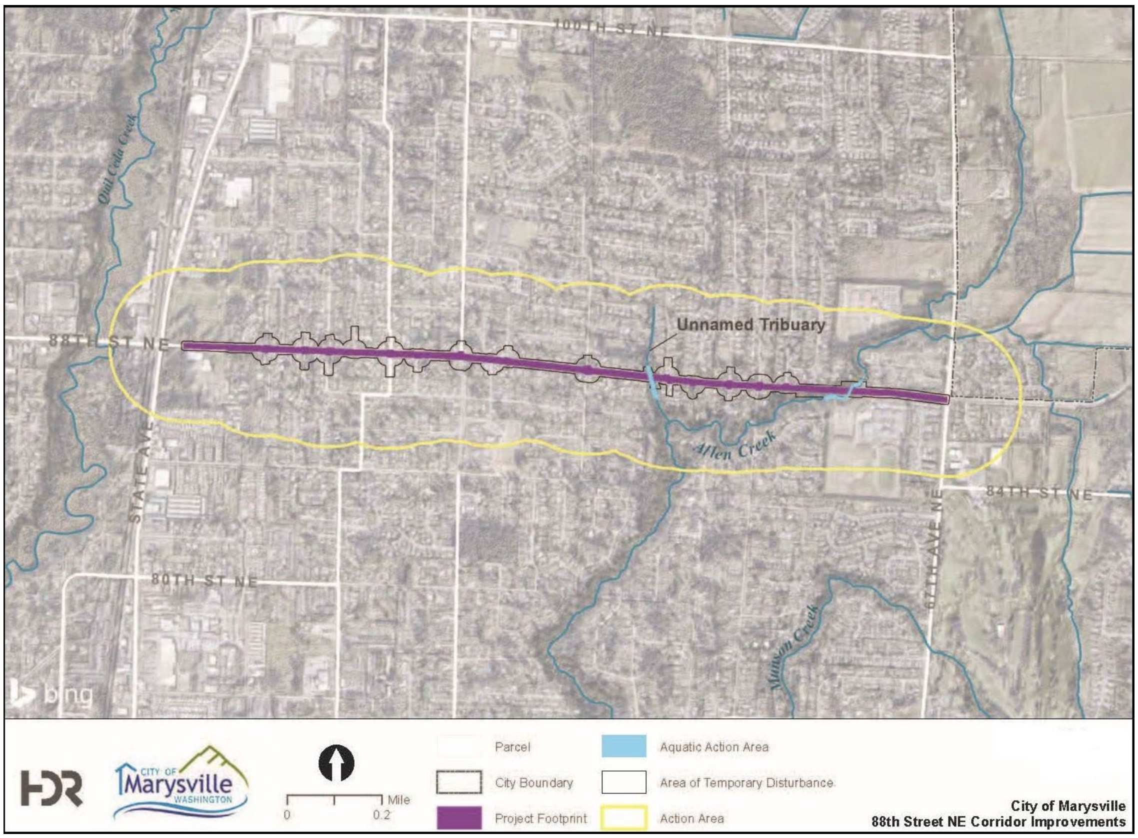

Figure 1. Map of the project corridor (in red), stretching along 88th Street NE from State Street to the west (east of I-5) and 67th Avenue to the east.

The 88th Street NE Corridor Improvement Project would improve a 1.6 mile-long section of 88th Street NE between State Avenue and 67th Avenue NE to provide a consistent 3-lane roadway comprised of two travel lanes, by adding a center turn lane, a sidewalk, and right of way improvements for non-motorized access along this stretch of roadway. The improvements include the installation of curb, gutter, planter strips, utility replacements, bike facilities, and illumination. The purpose of the project is to improve traffic flow and safety. The project is located within the City of Marysville, Washington, in Water Resources Inventory Area (WRIA) 7, Snohomish watershed. The proposed action is located between State Avenue and 67th Avenue (Figure 1; HDR 2020). The project will replace the existing stream crossing culverts on Allen

Creek and an unnamed tributary to Allen Creek. The proposed action includes clearing and grubbing the project footprint, construction of two fish passable culverts, building retaining walls, and the construction of stormwater management facilities and bioswales (HDR 2020). A complete description of the proposed action can be found in Section 2 of the FHWA's Biological Assessment (BA) and is incorporated in this Opinion by reference.

Construction Schedule

The City of Marysville would complete the project in two phases: 1) construction of the roadway section from 55th Avenue NE eastward and include the culvert replacements on Allen Creek and the unnamed tributary; and 2) the remainder of the corridor to the west of 55th Avenue NE. All work to remove the existing culverts and construct the two new ones would be conducted within the in-water work window for Allen Creek and its tributaries (July 1 to October 1), with all in-water work completed within four to six weeks, anticipated to begin on July 1. Construction would be scheduled to occur only during daylight hours.

Vegetation Clearing

To reduce the potential for, and intensity of impacts on listed species and their habitat resources, the City's contractors would be required to comply with the Impact Avoidance and Minimization Measures, EFH Conservation Measures, and Fish Removal Protocol and Standards that are identified in Sections 1 and 2 of the project BA (HDR 2020). Those measures include compliance with a Spill Prevention, Control, and Countermeasure (SPCC) plan for work area isolation and in-water construction work. The first stage of construction involves site preparation that would include marking the construction boundaries, installing temporary erosion and sediment controls, mobilizing and staging equipment, and clearing vegetation. Construction would include the use of heavy equipment and various handheld power tools, standard construction practices, and required compliance with appropriate best management practices (BMPs). At the end of the project, workers would remove work area isolation structures, and restore disturbed areas to preconstruction conditions, including re-vegetation with a native seed mix and/or planting of native trees and shrubs identified in the planting plan for the project that would be largely identical in type and number to those that were removed for construction (HDR 2021a, b).

The proposed action would include approximately 2.8 acres of temporary clearing and grubbing outside the permanent footprint of the project. Vegetation and ground cover to be removed includes roadside mowed grass, shrubs, and some trees during demolition of the existing culverts and during roadway repair. Riparian vegetation at the stream crossings of Allen Creek and the unnamed tributary would be removed during construction of the new culverts, retaining walls, and grading to tie in to the existing stream channel. At Allen Creek approximately 0.5 acre of trees and riparian vegetation would be removed for construction, including 36 trees in the riparian corridor, 31 of which are deciduous trees comprised of black cottonwood (*Populus balsamifera*) and red alder (*Alnus rubra*), and five of which are western hemlock (*Tsuga heterophylla*; HDR 2021a, b). Scrub-shrub and emergent vegetation in the riparian corridor that would be removed mainly includes Himalayan blackberry (*Rubus procerus*), reed canarygrass (*Phalaris arundinacea*), and salmonberry (*Rubus spectabilis*). Riparian vegetation in the permanent footprint is mainly black cottonwood, Himalayan blackberry, reed canarygrass, and salmonberry. At the unnamed tributary, the project would remove approximately 0.35 acre of trees and riparian vegetation, including 10 trees in the riparian corridor, 9 of which are deciduous trees comprised of black locust (*Robinia pseudoacacia*), red alder, black cottonwood, and western red cedar (HDR 2021a, b). Scrub-shrub and emergent vegetation in the riparian corridor that would be removed mainly includes Himalayan blackberry and grasses and forbs. Riparian vegetation in the permanent footprint is mainly black locust, red alder, Himalayan blackberry and grasses and forbs.

Culvert Replacement

Stream Isolation

Prior to demolition, the contractors would install temporary work area isolation barriers with clean sandbags to divert stream flows. The isolated work area would be within approximately 60 feet upstream and downstream of the existing culverts. This would encompass an area of approximately 4,500 square feet on Allen Creek including the culvert footprint, and approximately 2,000 square feet on the unnamed tributary that would be isolated and dewatered. Upstream and downstream cofferdams would be installed at each of the stream crossing sites to divert stream flow through temporary bypass pipes and discharged downstream of the work area. This would isolate the area of construction while diverting and maintaining stream flow around the project and back into the stream channel downstream. These bypass pipes would be removed when the culvert replacement work is complete and stream flows would resume through the new culvert. For a more complete description of the stream isolation protocol, see Section 1.4.2 of the applicant's BA (HDR 2020).

The proposed action would incorporate several BMPs during construction to minimize sedimentation into the creeks, including installation of barriers to prevent sediment from reaching streams via runoff, and stabilization of exposed soils during and after construction. Debris removal, bank excavation, and culvert construction could mobilize large amounts of sediments. However, that work would be done behind dewatered work area isolation barriers that would contain the vast majority of mobilized sediments. Further, the project includes required turbidity monitoring, with shut-down and correction required if turbidity exceeds State standards. The City's contractors would be required to comply with the Water Quality Management Plan (WQMP) for this project, and to monitor and limit turbidity such that at 150 feet from the culvert turbidity would not exceed 5 NTU (~5 mg/L) above background levels of 50 NTU or less, and to 10% above background for background levels above 50 NTU.

Fish Salvage

Prior to and during installation of the diversion and dewatering of the in-water work area, a qualified fish biologist will perform fish salvage activities to remove any fish that may become trapped behind barriers or stranded in dewatered areas. Upstream of the cofferdam site, block nets would be installed prior to any dewatering activities to prevent fish from moving downstream into the cofferdam site and into the bypass pipe entrance area. Once the upstream block net is in place, seine nets, and, if necessary, potentially electrofishing equipment, would be used to flush fish downstream past the cofferdam installation site. Once the upstream cofferdam is in place, the stream channel would be monitored downstream of the cofferdam as the water recedes to ensure no fish are stranded in the dewatered area. Fish remaining in any residual pools and backwater areas would be salvaged following methods described in the WSDOT Fish Exclusion Protocols and Standards (WSDOT 2016). Qualified fish biologists with fish salvage experience would ensure that all fish are removed and handled safely following National Marine Fisheries Service (NMFS) electrofishing guidelines (2000). Seining or electrofishing would not be used if water temperatures exceed 18 °C. Captured fish would be released back into the stream channel a safe distance (approximately 100 feet) from the work area. Fish biologists would record species and lengths of any fish mortalities encountered, in compliance with permit terms and conditions.

Culvert Construction

The larger of the two existing culvert crossings is located on Allen Creek and is a combination of a precast concrete culvert segment and a timber arch structure. The smaller culvert is located on the unnamed tributary to Allen Creek. The existing culvert is a corrugated metal pipe that crosses 88th Street NE at about a 25-degree angle measured to the roadway centerline. The Allen Creek culvert is degraded and is likely obstructing fish passage, which is one of the main reasons for replacement. The existing undersized 6-foot-diameter culvert on the unnamed tributary is considered fish passable but does not meet stream simulation requirements due to backwatering within the channel. Both culverts would be removed and replaced with larger culverts as part of the project and would be designed using the Stream Simulation approach, which is used to create and maintain natural stream processes within the designed culvert based on the needs of a specific reference reach within the project area.

The City is proposing to use four-sided segmental pre-cast re-enforced box culverts. The proposed structure at Allen Creek would be a 102-footlong, four-sided box-culvert with a 19.5-foot span by 10-foot rise (Figure 2; HDR 2021c). For the unnamed tributary, the proposed structure would be a 80.5-foot long culvert that has a 10-foot span by 8-foot rise (HDR 2021c). The culvert entrance to the unnamed tributary will be realigned to eliminate the current 90-degree channel bend into the culvert which is causing localized erosion. Both culverts would include cast-in-place concrete wingwalls that are angled at the stream inlets and outlets, 8-10.5 feet for the unnamed tributary and between 11 and 19 feet for the culvert on Allen Creek (Figure 2; HDR 2021c). The wingwalls would be constructed when the box culverts are installed, and within the dewatered work area and embankment. The stream channel at both the upstream and downstream ends of the new culverts will be realigned to tie into the existing channels. For Allen Creek, this includes realigning the channel approximately 25 feet upstream and 45 feet downstream of the proposed culvert. For the unnamed tributary, the stream channel will be realigned to tie into the existing channel approximately 40 feet upstream and 30 feet downstream of the proposed culvert, with each designed developed to mimic the existing channel sections in the reference reaches identified in the field (HDR 2020; HDR 2021c).

Permanent retaining walls would be required along several sections of the 88th Street NE corridor to retain grades, act as headwalls and wingwalls for the culverts, and allow for construction of the road embankment and road improvements in as narrow a footprint as possible to minimize the length of culverted stream to cross under the widened roadway (HDR 2020). Temporary retaining walls would be used to accommodate staging of the project and to support excavation work when removing the existing culverts and constructing new walls, and would be removed following project completion. Retaining walls would be designed as outlined in the project BA and supplementary documents (HDR 2020; HDR 2021c).

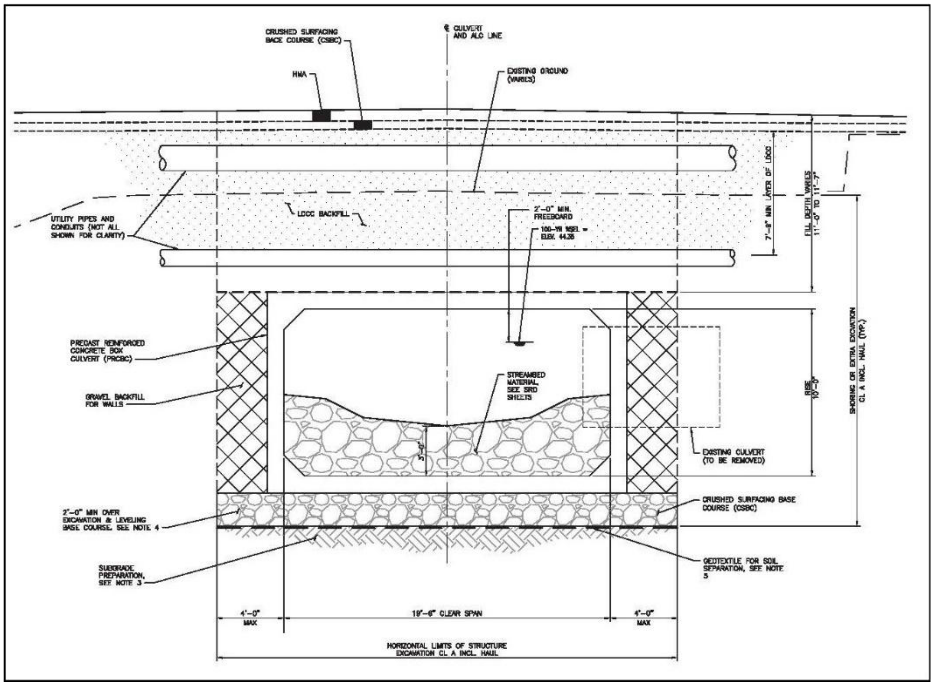

Figure 2. Cut-away drawing of the culvert proposed for Allen Creek (adapted from sheet 7 of HDR 2021a).

Roadway and Stormwater Improvements

The proposed action would add approximately 0.62 acre of new pollution generating impervious surface (PGIS), 0.34 acres in threshold discharge area (TDA)-1 and 0.28 acres in TDA-2 (HDR 2021d). Much of the existing roadway within the corridor would also be replaced, with 2.01 acres of replaced PGIS in TDA-1 and 2.01 acres in TDA-2, for a total of 4.67 acres of new and replaced PGIS along 88th Street NE between State Avenue and 67th Avenue NE (Figure 1; HDR 2021d). For most of the 88th Street corridor within the project limits, there is no curb and gutter and stormwater primarily sheet flows off the roadway and infiltrates within vegetated areas at the side of the roadway. There is an existing municipal stormwater system on the western edge of the project area, adjacent to 44th Avenue NE that connects to detention pipes across State Avenue. A smaller, disconnected network of detention pipes is present along 88th Street throughout the project area, which transfer roadway runoff to catch basin. However, those catch basins do not include treatment or infiltration, but mainly control flood volume, and in some cases, discharge directly to Allen Creek.

The proposed action would include water quality treatment designed to treat stormwater runoff from the new PGIS created by the project through the use of 5-foot wide bioretention swales to infiltrate runoff. The bioretention swales, located between 52th Ave NE and 60th Drive NE, would treat approximately 0.73 acre of PGIS within TDA-1 and 0.71 acre of PGIS in TDA-2, more than the total amount of new PGIS, but less than the overall footprint of new and replaced PGIS (Figure 3; HDR 2021d). The addition of curb cuts would allow a flow path for the bioretention swales to overflow back into the gutter and flow to the next swale. Twelve-inch piping would also link bioretention swales together in a series that would be the typical flow path if not all runoff is infiltrated (instead of overflow back into the gutter). In order to minimize effects on slope stability, stormwater would be collected in a BioPod treatment vault within a 100-foot buffer of Allen Creek and the unnamed tributary, with engineered media to remove pollutants such as suspended solids, hydrocarbons, nutrients, and dissolved metals prior to discharge to the creek. The project would also include a water quality vault and detention pipes which would treat stormwater from TDA-2 that could not be treated by the bioswales.

The project also includes the following avoidance and minimization measures identified in the project BA (HDR 2020) to reduce effects of roadway construction on creeks within the project area: 1) temporary erosion and sediment controls (TESC) measures; 2) maintain a Spill Prevention Control and Countermeasures Plan (SPCC) to manage toxic materials associated with construction activities; and 3) follow a Stormwater Pollution Prevention Plan (SWPPP) to minimize erosion of sediments due to rainfall runoff at construction sites.

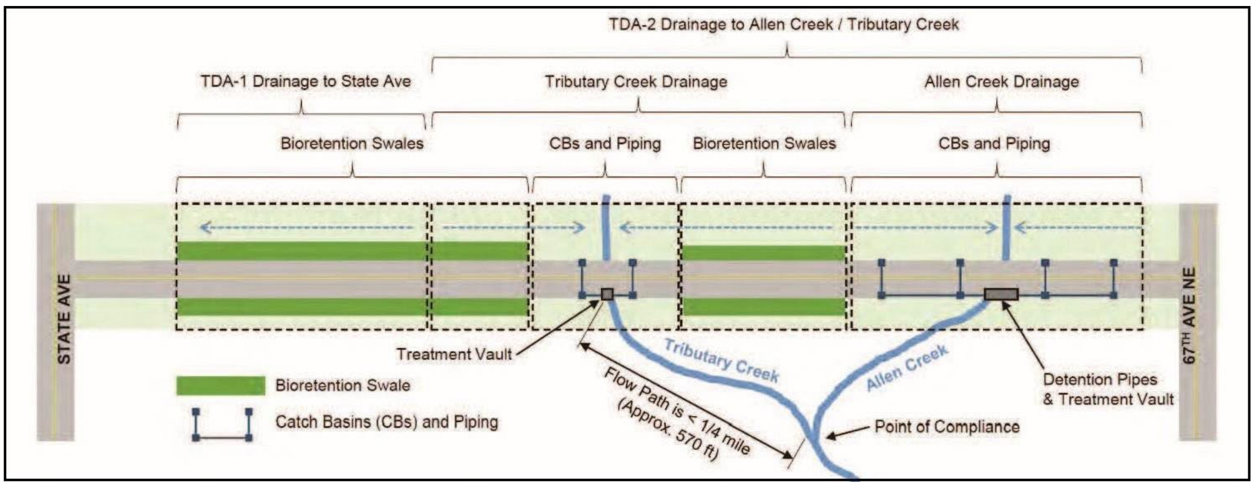

Figure 3. Draft schematic of the proposed stormwater treatment system (adapted from page 16 of HDR 2020).

The NMFS also considered whether or not the proposed action would cause any other activities and determined that the project supports increasing use of and stormwater discharge from roads.

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

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, each Federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with

NMFS and section 7(b)(3) requires that, at the conclusion of consultation, the NMFS provide an opinion stating how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

The FHWA determined that the proposed action is likely to adversely affect PS Chinook salmon, PS steelhead, and designated critical habitat for PS Chinook salmon. They did not address Southern Resident (SR) killer whales or their designated critical habitat (Table 1). Additionally, because of the trophic relationship between PS Chinook salmon and SR killer whales, the NMFS analyzed the action's potential effects on SR killer whales and their designated critical habitat in the "Not Likely to Adversely Affect" Determinations section (2.12).

Table 1. ESA-listed species and critical habitat that may be affected by the proposed action.

ESA-listed species and critical habitat likely to be adversely affected (LAA)				
Species	**Status**	**Species**	**Critical Habitat**	**Listed / CH Designated**
Chinook salmon (*Oncorhynchus tshawytscha*) Puget Sound	Threatened	LAA	LAA	06/28/05 (70 FR 37160) / 09/02/05 (70 FR 52630)
steelhead (*O. mykiss*) Puget Sound	Threatened	LAA	N/A	05/11/07 (72 FR 26722) / 02/24/16 (81 FR 9252)
ESA-listed species and critical habitat not likely to be adversely affected (NLAA)				
Species	**Status**	**Species**	**Critical Habitat**	**Listed / CH Designated**
Killer whales (*Orcinus orca*) Southern resident (SR)	Endangered	NLAA	NLAA	11/18/05 (70 FR 57565) / 11/29/06 (71 FR 69054)

LAA = likely to adversely affect NLAA = not likely to adversely affect
N/A = not applicable. The action area is outside designated critical habitat, or critical habitat has not been designated.

2.1 Analytical Approach

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

This biological opinion relies on the definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species" (50 CFR 402.02).

The designation(s) of critical habitat for (species) use(s) the term primary constituent element (PCE) or essential features. The 2016 critical habitat regulations (50 CFR 424.12) replaced this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

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

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

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

2.2 Rangewide Status of the Species and Critical Habitat

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

One factor affecting the status of ESA-listed species considered in this opinion, and aquatic habitat at large, is climate change. Climate change is likely to play an increasingly important role in determining the abundance and distribution of ESA-listed species, and the conservation value of designated critical habitats, in the Pacific Northwest. These changes will not be spatially homogeneous across the Pacific Northwest. The largest hydrologic responses are expected to occur in basins with significant snow accumulation, where warming decreases snow pack, increases winter flows, and advances the timing of spring melt (Mote et al. 2014; Mote et al 2016). Rain-dominated watersheds and those with significant contributions from groundwater may be less sensitive to predicted changes in climate (Tague et al. 2013; Mote et al. 2014).

During the last century, average regional air temperatures in the Pacific Northwest increased by 1-1.4 °F as an annual average, and up to 2 °F in some seasons (based on average linear increase per decade; Abatzoglou et al. 2014; Kunkel et al. 2013). Recent temperatures in all but two years since 1998 ranked above the 20th century average (Mote et al. 2014). Warming is likely to continue during the next century as average temperatures are projected to increase another 3 to 10 °F, with the largest increases predicted to occur in the summer (Mote et al. 2014).

Decreases in summer precipitation of as much as 30 percent by the end of the century are consistently predicted across climate models (Mote et al. 2014). Precipitation is more likely to occur during October through March, less during summer months, and more winter precipitation will be rain than snow (ISAB 2007; Mote et al. 2013). Earlier snowmelt will cause lower stream flows in late spring, summer, and fall, and water temperatures will be warmer (ISAB 2007; Mote et al. 2014). Models consistently predict increases in the frequency of severe winter precipitation events (i.e., 20-year and 50-year events), in the western United States (Dominguez et al. 2012). The largest increases in winter flood frequency and magnitude are predicted in mixed rain-snow watersheds (Mote et al. 2014).

The combined effects of increasing air temperatures and decreasing spring through fall flows are expected to cause increasing stream temperatures; in 2015 this resulted in 3.5-5.3 ºC increases in Columbia Basin streams and a peak temperature of 26 ºC in the Willamette (NWFSC 2015). Overall, about one-third of the current cold-water salmonid habitat in the Pacific Northwest is likely to exceed key water temperature thresholds by the end of this century (Mantua et al. 2009).

Higher temperatures will reduce the quality of available salmonid habitat for most freshwater life stages (ISAB 2007). Reduced flows will make it more difficult for migrating fish to pass physical and thermal obstructions, limiting their access to available habitat (Mantua et al. 2010; Isaak et al. 2012). Temperature increases shift timing of key life cycle events for salmonids and species forming the base of their aquatic foodwebs (Crozier et al. 2011; Tillmann and Siemann 2011; Winder and Schindler 2004). Higher stream temperatures will also cause decreases in dissolved oxygen and may also cause earlier onset of stratification and reduced mixing between layers in lakes and reservoirs, which can also result in reduced oxygen (Meyer et al. 1999; Winder and Schindler 2004; Raymondi et al. 2013). Higher temperatures are likely to cause several species to become more susceptible to parasites, disease, and higher predation rates (Crozier et al. 2008; Wainwright & Weitkamp 2013; Raymondi et al. 2013).

As more basins become rain-dominated and prone to more severe winter storms, higher winter stream flows may increase the risk that winter or spring floods in sensitive watersheds will damage spawning redds and wash away incubating eggs (Goode et al. 2013). Earlier peak stream flows will also alter migration timing for salmon smolts, and may flush some young salmon and steelhead from rivers to estuaries before they are physically mature, increasing stress and reducing smolt survival (McMahon and Hartman 1989; Lawson et al. 2004).

In addition to changes in freshwater conditions, predicted changes for coastal waters in the Pacific Northwest as a result of climate change include increasing surface water temperature, increasing but highly variable acidity, and increasing storm frequency and magnitude (Mote et al. 2014). Elevated ocean temperatures already documented for the Pacific Northwest are highly likely to continue during the next century, with sea surface temperature projected to increase by 1.0-3.7 ºC by the end of the century (IPCC 2014). Habitat loss, shifts in species' ranges and abundances, and altered marine food webs could have substantial consequences to anadromous, coastal, and marine species in the Pacific Northwest (Tillmann and Siemann 2011; Reeder et al. 2013).

Moreover, as atmospheric carbon emissions increase, increasing levels of carbon are absorbed by the oceans, changing the pH of the water. A 38 percent to 109 percent increase in acidity is projected by the end of this century in all but the most stringent CO_2 mitigation scenarios, and is essentially irreversible over a time scale of centuries (IPCC 2014). Regional factors appear to be amplifying acidification in Northwest ocean waters, which is occurring earlier and more acutely than in other regions and is already impacting important local marine species (Barton et al. 2012; Feely et al. 2012). Acidification also affects sensitive estuary habitats, where organic matter and nutrient inputs further reduce pH and produce conditions more corrosive than those in offshore waters (Feely et al. 2012; Sunda and Cai 2012).

Global sea levels are expected to continue rising throughout this century, reaching likely predicted increases of 10-32 inches by 2081-2100 (IPCC 2014). These changes will likely result in increased erosion and more frequent and severe coastal flooding, and shifts in the composition of nearshore habitats (Tillmann and Siemann 2011; Reeder et al. 2013). Estuarine-dependent salmonids such as chum and Chinook salmon are predicted to be impacted by significant reductions in rearing habitat in some Pacific Northwest coastal areas (Glick et al. 2007). Historically, warm periods in the coastal Pacific Ocean have coincided with relatively low abundances of salmon and steelhead, while cooler ocean periods have coincided with relatively high abundances, and therefore these species are predicted to fare poorly in warming ocean conditions (Scheuerell and Williams 2005; Zabel et al. 2006). This is supported by the recent observation that anomalously warm sea surface temperatures off the coast of Washington from 2013 to 2016 resulted in poor coho and Chinook salmon body condition for juveniles caught in those waters (NWFSC 2015). Changes to estuarine and coastal conditions, as well as the timing of seasonal shifts in these habitats, have the potential to impact a wide range of listed aquatic species (Tillmann and Siemann 2011; Reeder et al. 2013).

The adaptive ability of these threatened and endangered species is depressed due to reductions in population size, habitat quantity and diversity, and loss of behavioral and genetic variation. Without these natural sources of resilience, systematic changes in local and regional climatic conditions due to anthropogenic global climate change will likely reduce long-term viability and sustainability of populations in many of these ESUs (NWFSC 2015). New stressors generated by climate change, or existing stressors with effects that have been amplified by climate change, may also have synergistic impacts on species and ecosystems (Doney et al. 2012). These conditions will possibly intensify the climate change stressors inhibiting recovery of ESA-listed species in the future.

The summaries that follow describe the status of the ESA-listed species, and their designated critical habitats, that occur within the action area and are considered in this opinion. More detailed information on the biology, habitat, and conservation status and trend of these listed resources can be found in the listing regulations and critical habitat designations published in the Federal Register and in the recovery plans and other sources at: https://www.fisheries.noaa.gov/species-directory/threatened-endangered, and are incorporated here by reference.

Status of Listed Species

Viable Salmonid Population (VSP) Criteria: For Pacific salmonids, we commonly use four VSP criteria (McElhany et al. 2000) to assess the viability of the populations that constitute the species. These four criteria (spatial structure, diversity, abundance, and productivity) 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.

"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 on habitat quality and spatial configuration, 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 in single genes to complex life history traits.

"Abundance" generally refers to the number of naturally-produced adults that return to their natal spawning grounds.

"Productivity" refers to the number of naturally-spawning adults produced per parent. When progeny replace or exceed the number of parents, a population is stable or increasing. When progeny fail to replace the number of parents, the population is in decline.

For species with multiple populations, we assess the status of the entire species based on the biological status of the constituent populations, 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).

The summaries that follow describe the status of the ESA-listed species, and their designated critical habitats, that occur within the geographic area of this proposed action and are considered in this opinion. 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.

Puget Sound (PS) Chinook Salmon: The PS Chinook salmon evolutionarily significant unit (ESU) was listed as threatened on June 28, 2005 (70 FR 37160). We adopted the recovery plan for this ESU in January 2007. The recovery plan consists of two documents: the Puget Sound salmon recovery plan (SSPS 2007) and the final supplement to the Shared Strategy's Puget Sound salmon recovery plan (NMFS 2006). The recovery plan adopts ESU and population level viability criteria recommended by the Puget Sound Technical Recovery Team (PSTRT) (Ruckelshaus et al. 2002). The PSTRT's biological recovery criteria will be met when all of the following conditions are achieved:

- The viability status of all populations in the ESU is improved from current conditions, and when considered in the aggregate, persistence of the ESU is assured;
- Two to four Chinook salmon populations in each of the five biogeographical regions of the ESU achieve viability, depending on the historical biological characteristics and acceptable risk levels for populations within each region;
- At least one population from each major genetic and life history group historically present within each of the five biogeographical regions is viable;
- Tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations are functioning in a manner that is sufficient to support an ESU-wide recovery scenario; Production of Chinook salmon from tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations occurs in a manner consistent with ESU recovery; and
- Populations that do not meet all the Viable Salmon Population (VSP) parameters are sustained to provide ecological functions and preserve options for ESU recovery.

General Life History: Chinook salmon are anadromous fish that require well-oxygenated water that is typically less than 63 ºF (17 ºC), but some tolerance to higher temperatures is documented with acclimation. Adult Chinook salmon spawn in freshwater streams, depositing fertilized eggs in gravel "nests" called redds. The eggs incubate for three to five months before juveniles hatch and emerge from the gravel. Juveniles spend from three months to two years in freshwater before migrating to the ocean to feed and mature. Chinook salmon spend from one to six years in the ocean before returning to their natal freshwater streams where they spawn and then die.

Chinook salmon are divided into two races, stream-types and ocean-types, based on the major juvenile development strategies. Stream-type Chinook salmon tend to rear in freshwater for a year or more before entering marine waters. Conversely, ocean-type juveniles tend to leave their natal streams early during their first year of life, and rear in estuarine waters as they transition into their marine life stage. Both stream- and ocean-type Chinook salmon are present, but ocean-type Chinook salmon predominate in Puget Sound populations.

Chinook salmon are further grouped into "runs" that are based on the timing of adults that return to freshwater. Early- or spring-run chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and finally spawn in the late summer and early autumn. Late- or fall-run Chinook salmon enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas, and spawn within a few days or weeks. Summer-run fish show intermediate characteristics of spring and fall runs, without the extensive delay in maturation exhibited by spring-run Chinook salmon. In Puget Sound, spring-run Chinook salmon tend to enter their natal rivers as early as March, but do not spawn until mid-August through September. Returning summer- run (Skykomish population) to enter the rivers June through early-September, with and fall-runs (Snoqualmie population) August to late-October.

Yearling stream-type fish tend to leave their natal rivers late winter through spring, and move relatively directly to nearshore marine areas and pocket estuaries. Out-migrating ocean-type fry tend to migrate out of their natal streams beginning in early-March. Those fish rear in the tidal delta estuaries of their natal stream for about two weeks to two months before migrating to marine nearshore areas and pocket estuaries in late May to June. Out-migrating young of the year parr tend to move relatively directly into nearshore marine areas and pocket estuaries after leaving their natal streams between late spring and the end of summer.

Spatial Structure and Diversity: The PS Sound Chinook salmon ESU includes all naturally spawning populations of Chinook salmon from rivers and streams flowing into Puget Sound including the Straits of Juan De Fuca from the Elwha River, eastward, including rivers and streams flowing into Hood Canal, South Sound, North Sound and the Strait of Georgia in Washington. The ESU also includes the progeny of numerous artificial propagation programs (NWFSC 2015; Ford 2022). The PSTRT identified 22 extant populations, grouped into five major geographic regions, based on consideration of historical distribution, geographic isolation, dispersal rates, genetic data, life history information, population dynamics, and environmental and ecological diversity. The PSTRT distributed the 22 populations among five major biogeographical regions, or major population groups (MPGs), that are based on similarities in hydrographic, biogeographic, and geologic characteristics (Table 2).

Hatchery-origin spawners are present in high fractions in most populations within the ESU, with the Whidbey Basin the only MPG with consistently high fractions of natural-origin spawners. Between 1990 and 2014, the fraction of natural-origin spawners has declined in many of the populations outside of the Skagit watershed (NWFSC 2015; Ford 2022).

Abundance and Productivity: Available data on total abundance since 1980 indicate that abundance trends have fluctuated between positive and negative for individual populations, but productivity remains low in most populations, and hatchery-origin spawners are present in high fractions in most populations outside of the Skagit watershed. Further, escapement levels for all populations remain well below the PSTRT planning ranges for recovery, and most populations consistently show flat or negative trends in adult spawner populations and spawner-recruits, levels below those identified by the PSTRT as consistent with recovery (NWFSC 2015; Ford 2022). The current information on abundance, productivity, spatial structure and diversity suggest that the Whidbey Basin MPG is at relatively low risk of extinction. In recent years, only 5 populations have had productivities above zero (Lower Skagit, Upper Skagit, Lower Sauk, Upper Sauk, and Suiattle), all Skagit River populations in the Whidbey Basin MPG (Ford 2022). These data support our understanding of the continued decline of the ESU as described in the 2015 Status Review (NWFSC 2015; Ford 2022). The other four MPGs are considered to be at high risk of extinction due to low abundance and productivity (NWFSC 2015; Ford 2022). The most recent 5-year status review concluded that the ESU should remain listed as threatened (NMFS 2017a).

Table 2. Extant PS Chinook salmon populations in each biogeographic region (Ruckelshaus et al. 2002; Ford 2022).

Biogeographic Region	Population (Watershed)
Strait of Georgia	North Fork Nooksack River
	South Fork Nooksack River
Strait of Juan de Fuca	Elwha River
	Dungeness River
Hood Canal	Skokomish River
	Mid Hood Canal River
Whidbey Basin	Skykomish River
	Snoqualmie River
	North Fork Stillaguamish River
	South Fork Stillaguamish River
	Upper Skagit River
	Lower Skagit River
	Upper Sauk River
	Lower Sauk River
	Suiattle River
	Upper Cascade River
Central/South Puget Sound Basin	Cedar River
	North Lake Washington/ Sammamish River
	Green/Duwamish River
	Puyallup River
	White River
	Nisqually River

Limiting Factors: Factors limiting recovery for PS Chinook salmon include:

- Degraded floodplain and in-river channel structure
- Degraded estuarine conditions and loss of estuarine habitat
- Riparian area degradation and loss of in-river large woody debris
- Excessive fine-grained sediment in spawning gravel
- Degraded water quality and temperature
- Degraded nearshore conditions
- Impaired passage for migrating fish
- Severely altered flow regime

Puget Sound (PS) steelhead: The PS steelhead distinct population segment (DPS) was listed as threatened on May 11, 2007 (72 FR 26722). The NMFS adopted the recovery plan for this DPS in December 2019. In 2013, the Puget Sound Steelhead Technical Recovery Team (PSSTRT) identified 32 demographically independent populations (DIPs) within the DPS, based on genetic, environmental, and life history characteristics. Those DIPs are distributed among three geographically-based major population groups (MPGs); Northern Cascades, Central and South Puget Sound; and Hood Canal and Strait de Fuca (Myers et al. 2015) (Table 3).

Table 3. PS steelhead Major Population Groups (MPGs), Demographically Independent Populations (DIPs), and DIP Viability Estimates (Modified from Figure 58 in Hard et al. 2015).

Geographic Region (MPG)	Demographically Independent Population (DIP)	Viability
Northern Cascades	Drayton Harbor Tributaries Winter Run	Moderate
	Nooksack River Winter Run	Moderate
	South Fork Nooksack River Summer Run	Moderate
	Samish River/Bellingham Bay Tributaries Winter Run	Moderate
	Skagit River Summer Run and Winter Run	Moderate
	Nookachamps Creek Winter Run	Moderate
	Baker River Summer Run and Winter Run	Moderate
	Sauk River Summer Run and Winter Run	Moderate
	Stillaguamish River Winter Run	Low
	Deer Creek Summer Run	Moderate
	Canyon Creek Summer Run	Moderate
	Snohomish/Skykomish Rivers Winter Run	Moderate
	Pilchuck River Winter Run	Low
	North Fork Skykomish River Summer Run	Moderate
	Snoqualmie River Winter Run	Moderate
	Tolt River Summer Run	Moderate
Central and South Puget Sound	Cedar River Summer Run and Winter Run	Low
	North Lake Washington and Lake Sammamish Winter Run	Moderate
	Green River Winter Run	Low
	Puyallup River Winter Run	Low
	White River Winter Run	Low
	Nisqually River Winter Run	Low
	South Sound Tributaries Winter Run	Moderate
	East Kitsap Peninsula Tributaries Winter Run	Moderate
Hood Canal and Strait de Fuca	East Hood Canal Winter Run	Low
	South Hood Canal Tributaries Winter Run	Low
	Skokomish River Winter Run	Low
	West Hood Canal Tributaries Winter Run	Moderate
	Sequim/Discovery Bay Tributaries Winter Run	Low
	Dungeness River Summer Run and Winter Run	Moderate
	Strait of Juan de Fuca Tributaries Winter Run	Low
	Elwha River Summer Run and Winter Run	Low

In 2015, the PSSTRT concluded that the DPS is at “very low” viability; with most of the 32 DIPs and all three MPGs at “low” viability based on widespread diminished abundance, productivity, diversity, and spatial structure when compared with available historical evidence (Hard et al. 2015). Based on the PSSTRT viability criteria, the DPS would be considered viable when all three component MPG are considered viable. A given MPG would be considered viable when: 1) 40 percent or more of its component DIP are viable; 2) mean DIP viability within the MPG exceeds the threshold for viability; and 3) 40 percent or more of the historic life history strategies (i.e., summer runs and winter runs) within the MPG are viable. For a given DIP to be considered viable, its probability of persistence must exceed 85 percent, as calculated by Hard et al. (2015), based on abundance, productivity, diversity, and spatial structure within the DIP.

General Life History: PS steelhead exhibit two major life history strategies. Ocean-maturing, or winter-run fish typically enter freshwater from November to April at an advanced stage of maturation, and then spawn from February through June. Stream-maturing, or summer-run fish typically enter freshwater from May to October at an early stage of maturation, migrate to headwater areas, and hold for several months prior to spawning in the following spring. After hatching, juveniles rear in freshwater from one to three years prior to migrating to marine habitats (two years is typical). Smoltification and seaward migration typically occurs from April to mid-May. Smolt lengths vary between watersheds, but typically range from 4.3 to 9.2 inches (109 to 235 mm) (Myers et al. 2015). Juvenile steelhead are generally independent of shallow nearshore areas soon after entering marine water (Bax et al. 1978; Brennan et al. 2004; Schreiner et al. 1977), and are not commonly caught in beach seine surveys. Recent acoustic tagging studies (Moore et al. 2010) have shown that smolts migrate from rivers to the Strait of Juan de Fuca from one to three weeks. PS steelhead feed in the ocean waters for one to three years (two years is again typical), before returning to their natal streams to spawn. Unlike Chinook salmon, most female steelhead, and some males, return to marine waters following spawning (Myers et al. 2015).

Spatial Structure and Diversity: The PS steelhead DPS includes all naturally spawned anadromous steelhead populations in streams in the river basins of the Strait of Juan de Fuca, Puget Sound, and Hood Canal, Washington, bounded to the west by the Elwha River (inclusive) and to the north by the Nooksack River and Dakota Creek (inclusive). The DPS also includes six hatchery stocks that are considered no more than moderately diverged from their associated natural-origin counterparts (USDC 2014). PS steelhead are the anadromous form of *O. mykiss* that occur below natural barriers to migration in northwestern Washington State (NWFSC 2015). Non-anadromous ‘‘resident’’ *O. mykiss* (a.k.a. rainbow trout) occur within the range of PS steelhead but are not part of the DPS due to marked differences in physical, physiological, ecological, and behavioral characteristics (Hard et al. 2015). As stated above, the DPS consists of 32 DIP that are distributed among three geographically-based MPG. An individual DIP may consist of winter-run only, summer-run only, or a combination of both life history types. Winter-run is the predominant life history type in the DPS (Hard et al. 2015).

Abundance and Productivity: Available data on total abundance since the late 1970s and early 1980s indicate that abundance trends have fluctuated between positive and negative for individual DIPs. However, low productivity persists throughout the 32 DIPs, with most showing downward trends, a few DIPs showing slight increases, and a few showing sharply downward trends (Hard et al. 2015; Ford 2022). Since the mid-1980s, trends in natural spawning abundance have also been temporally variable for most DIPs but remain predominantly negative, and well below replacement for at least 10 of the DIPs (Ford 2022). Smoothed abundance trends since 2009 show modest increases for 11 DIPs. However, those trends are similar to variability seen across the DPS, where brief periods of increase are followed by decades of decline. Further, several of the upward trends are not statistically different from neutral, and most populations remain small. A comparison of the most recent two 5-year periods indicated positive percentage changes in spawner abundance for 14 of the DIPs (Ford 2022). For DIPs with recent 5-year abundance information, 6 out of 20 DIPs had achieved less than 10 percent of the recovery target abundance and all six populations were less than 250 fish (Ford 2022). Over the time series examined, the over-all abundance trends, especially for natural spawners, remain predominantly negative or flat across the DPS, and general steelhead abundance across the DPS remains well below the level needed to sustain natural production into the future (NWFSC 2015). The PSSTRT recently concluded that the PS steelhead DPS is currently not viable and the Recovery Plan was finalized in December 2019 (Hard et al. 2015; NMFS 2019).

Limiting Factors: Factors limiting recovery for PS steelhead include:

- The continued destruction and modification of steelhead habitat
- Widespread declines in adult abundance (total run size), despite significant reductions in harvest in recent years
- Threats to diversity posed by use of two hatchery steelhead stocks (Chambers Creek and Skamania)
- Declining diversity in the DPS, including the uncertain but weak status of summer run fish
- A reduction in spatial structure
- Reduced habitat quality through changes in river hydrology, temperature profile, downstream gravel recruitment, and reduced movement of large woody debris
- In the lower reaches of many rivers and their tributaries in Puget Sound where urban development has occurred, increased flood frequency and peak flows during storms and reduced groundwater-driven summer flows, with resultant gravel scour, bank erosion, and sediment deposition
- Dikes, hardening of banks with riprap, and channelization, which have reduced river braiding and sinuosity, increasing the likelihood of gravel scour and dislocation of rearing juveniles

Critical Habitat

This section describes the status of designated critical habitat that would be affected by the proposed action by examining the condition and trends of physical or biological features (PBFs) that are essential to the conservation of the listed species throughout the designated areas. The PBFs are essential because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging). The proposed project would affect critical habitat for PS Chinook salmon.

The NMFS designated critical habitat for PS Chinook salmon on September 2, 2005 (70 FR 52630). That critical habitat is located in 16 freshwater subbasins and watersheds between the Dungeness/Elwha Watershed and the Nooksack Subbasin, inclusively, as well as in nearshore marine waters of the Puget Sound that are south of the US-Canada border and east of the Elwha River, and out to a depth of 30 meters. Although offshore marine is an area type identified in the final rule, it was not designated as critical habitat for PS Chinook salmon.

The PBFs of salmonid critical habitat include: (1) Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development; (2) Freshwater rearing sites with: (i) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; (ii) Water quality and forage supporting juvenile development; and (iii) Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks; (3) Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival; (4) Estuarine areas free of obstruction and excessive predation with: (i) Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels; and (iii) Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation; (5) Nearshore marine areas free of obstruction and excessive predation with: (i) Water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and (6) Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation. The PBF for PS Chinook salmon CH are listed in Table 4.

Major tributary river basins in the Puget Sound basin include the Nooksack, Samish, Skagit, Sauk, Stillaguamish, Snohomish, Lake Washington, Cedar, Sammamish, Green, Duwamish, Puyallup, White, Carbon, Nisqually, Deschutes, Skokomish, Duckabush, Dosewallips, Big Quilcene, Elwha, and Dungeness rivers and Soos Creek. Critical habitat throughout the Puget Sound basin has been degraded by numerous activities, including hydropower development, loss of mature riparian forests, increased sediment inputs, removal of large wood from the waterways, intense urbanization, agriculture, alteration of floodplain and stream morphology (i.e., channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, dredging, armoring of shorelines, marina and port development, road and railroad construction and maintenance, logging, and mining. Changes in habitat quantity, availability, and diversity, and flow, temperature, sediment load and channel instability are common limiting factors of critical habitat throughout the basin.

Land use practices have likely accelerated the frequency of landslides delivering sediment to streams. Fine sediment from unpaved roads also contributes to stream sedimentation. Unpaved roads are widespread on forested lands in the Puget Sound basin, and to a lesser extent, in rural residential areas. Historical logging removed most of the riparian trees near stream channels. Subsequent agricultural and urban conversion permanently altered riparian vegetation in the river valleys, leaving either no trees, or a thin band of trees. The riparian zones along many agricultural areas are now dominated by alder, invasive canary grass and blackberries, and provide substantially reduced stream shade and large wood recruitment (SSPS 2007).

Table 4. Physical or biological features (PBFs) of designated critical habitat for PS Chinook salmon, and corresponding life history events. Although offshore marine areas were identified in the final rule, none were designated as critical habitat.

Site Type	Site Attribute	Life History Event
Freshwater spawning	Water quantity Water quality Substrate	Adult spawning Embryo incubation Alevin growth and development
Freshwater rearing	Water quantity and Floodplain connectivity Water quality and Forage Natural cover	Fry emergence from gravel Fry/parr/smolt growth and development
Freshwater migration	(Free of obstruction and excessive predation) Water quantity and quality Natural cover	Adult sexual maturation Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration
Estuarine	(Free of obstruction and excessive predation) Water quality, quantity, and salinity Natural cover Forage	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	(Free of obstruction and excessive predation) Water quality, quantity, and forage Natural cover	Adult growth and sexual maturation Adult spawning migration Nearshore juvenile rearing
Offshore marine	Water quality and forage	Adult growth and sexual maturation Adult spawning migration Subadult rearing

Diking, agriculture, revetments, railroads and roads in lower stream reaches have caused significant loss of secondary channels in major valley floodplains in this region. Confined main channels create high-energy peak flows that remove smaller substrate particles and large wood. The loss of side-channels, oxbow lakes, and backwater habitats has resulted in a significant loss of juvenile salmonid rearing and refuge habitat. When the water level of Lake Washington was lowered 9 feet in the 1910s, thousands of acres of wetlands along the shoreline of Lake Washington, Lake Sammamish and the Sammamish River corridor were drained and converted to agricultural and urban uses. Wetlands play an important role in hydrologic processes, as they store water which ameliorates high and low flows. The interchange of surface and groundwater in complex stream and wetland systems helps to moderate stream temperatures. Thousands of acres of lowland wetlands across the region have been drained and converted to agricultural and urban uses, and forest wetlands are estimated to have diminished by one-third in Washington State (FEMAT 1993; Spence et al. 1996; SSPS 2007).

Loss of riparian habitat, elevated water temperatures, elevated levels of nutrients, increased nitrogen and phosphorus, and higher levels of suspended sediment, presumably from urban and highway runoff, wastewater treatment, failing septic systems, and agriculture or livestock impacts, have been documented in many Puget Sound tributaries (SSPS 2007).

Peak stream flows have increased over time due to paving (roads and parking areas), reduced percolation through surface soils on residential and agricultural lands, simplified and extended drainage networks, loss of wetlands, and rain-on-snow events in higher elevation clear cuts (SSPS 2007). In urbanized Puget Sound, there is a strong association between land use and land cover attributes and rates of coho spawner mortality likely due to runoff containing contaminants emitted from motor vehicles (Feist et al. 2011; Tian et al. 2020).

Dams constructed for hydropower generation, irrigation, or flood control have substantially affected PS Chinook salmon populations in a number of river systems. The construction and operation of dams have blocked access to spawning and rearing habitat, changed flow patterns, resulted in elevated temperatures and stranding of juvenile migrants, and degraded downstream spawning and rearing habitat by reducing recruitment of spawning gravel and large wood to downstream areas (SSPS 2007). These actions tend to promote downstream channel incision and simplification (Kondolf 1997), limiting fish habitat. Water withdrawals reduce available fish habitat and alter sediment transport. Hydropower projects often change flow rates, stranding and killing fish, and reducing aquatic invertebrate (food source) productivity (Hunter 1992).

Juvenile mortality occurs in unscreened or inadequately screened diversions. Water diversion ditches resemble side channels in which juvenile salmonids normally find refuge. When diversion headgates are shut, access back to the main channel is cut off and the channel goes dry. Mortality can also occur with inadequately screened diversions from impingement on the screen, or mutilation in pumps where gaps or oversized screen openings allow juveniles to get into the system. Blockages by dams, water diversions, and shifts in flow regime due to hydroelectric development and flood control projects are major habitat problems in many Puget Sound tributary basins (SSPS 2007).

The nearshore marine habitat has been extensively altered and armored by industrial and residential development near the mouths of many of Puget Sound's tributaries. A railroad runs along large portions of the eastern shoreline of Puget Sound, eliminating natural cover along the shore and natural recruitment of beach sand (SSPS 2007).

Degradation of the near-shore environment has occurred in the southeastern areas of Hood Canal in recent years, resulting in late summer marine oxygen depletion and significant fish kills. Circulation of marine waters is naturally limited, and partially driven by freshwater runoff, which is often low in the late summer. However, human development has increased nutrient loads from failing septic systems along the shoreline, and from use of nitrate and phosphate fertilizers on lawns and farms. Shoreline residential development is widespread and dense in many places. The combination of highways and dense residential development has degraded certain physical and chemical characteristics of the near-shore environment (HCCC 2005; SSPS 2007).

2.3 Action Area

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

As described in Section 1.3, the project would occur in and adjacent to Allen Creek and an unnamed tributary to Allen Creek. For the proposed action, there are short-term effects of construction, long-term effects of the structures, and long term, intermittent operational effects, e.g. stormwater.

The action area would extend 100 feet upstream during block netting and fish exclusion. The downstream construction effects result from turbidity, which may occur up to 200 feet downstream of the project site within each stream reach. Allen Creek and an unnamed tributary drain much of the Eastern portion of suburban and rural Marysville within the Snohomish River Estuary. The creek empties into Ebey Slough. Based on the likely downstream transport of stormwater contaminants such as 6PPD/quinone, PAHs, and metals from 88th street, we draw the downstream extent of the direct stormwater effects beyond Ebey Slough to Puget Sound. Also, trophic connectivity between PS Chinook salmon and the SR killer whales that feed on them extends the action area to the marine waters of Puget Sound, as forage (salmon) is a feature of SR killer whale critical habitat. The described area overlaps with the geographic ranges of the ESA-listed species and the boundaries of designated critical habitats identified in Table 1. The action area also overlaps with areas that have been designated, under the MSA, as EFH for Pacific Coast salmon, Pacific Coast groundfish, and coastal pelagic species.

PS Chinook Salmon within the Action Area: The PS Chinook salmon that are likely to occur in the action area would be summer and fall-run Chinook salmon. Most of the Chinook salmon in the Snohomish River basin originate from the Snoqualmie and Skykomish rivers, and migrate from Puget Sound to reach spawning grounds in the upper reaches of those rivers and their tributaries, including Allen Creek (Snohomish Basin Salmon Recovery Forum 2005; WDFW 2021a). Both of these populations are below 10% of their historic levels, with a total of 6,119 adult Chinook returning to the Snohomish Basin in 2017 (Snohomish Basin Salmon Recovery Forum 2005; Snohomish Basin Salmon Recovery Forum 2019). Return timing of spawning adult summer Chinook salmon is generally from June through July, and adult fall Chinook salmon are documented to return between August and September (City of Everett 2001). Spawning could begin as early as late August, but the majority of spawning mainly occurs between September and October (WSDOT 2009; Haring 2002; City of Everett 2001). Allen Creek supports Chinook salmon rearing, migration, and spawning (WDFW 2021b). Adequate spawning habitat in the reach within the action area is lacking due to the presence of smaller gravel and high percentage of fine sediment, but Chinook salmon have been documented spawning in the upper reaches of Allen Creek (WDFW 2021b). Although spawning in the action area is unlikely, migrating adults could move through the action area during the in-water work window as fall Chinook can begin their migrations upstream to spawning areas in August. The unnamed tributary is not documented to support Chinook salmon use, and suitable spawning habitat is not present. The presence of rearing juveniles in the action area is unlikely due to the lack of suitable complex habitat, low flows, and outmigration is typically completed by June. However, there are no barriers to juvenile migration and their presence during in-water work cannot be discounted.

PS Steelhead within the Action Area: The Snohomish Basin has two summer runs and three winter runs of PS steelhead (Snohomish Basin Salmon Recovery Forum 2019). Since the early 2000s, both winter and summer-run steelhead populations have declined, with only 1,800 spawning adults in 2017. The PS steelhead that may occur in the action area includes all naturally spawned winter-run and summer-run steelhead populations, including those that inhabit the Snohomish River and nearby tributaries such as Quil Ceda Creek. PS steelhead have not been documented to occur in Allen Creek or its tributaries; however, since it is gradient accessible, there is presumed presence of steelhead (WDFW 2021c). Spawning steelhead are unlikely to spawn in Allen Creek or its tributaries due to the lack of suitable gravel and cobble substrate, and pool/riffle habitat complexity. Use of the action area by steelhead is likely limited to rearing and migratory use by juveniles that that may disperse up from Ebey Slough. Steelhead typically rear for several years in freshwater and therefore juveniles can be present year round. There are no passage barriers between the action area and the mouth of Allen Creek at Ebey Slough. Therefore, although steelhead presence is not documented and suitable habitat for spawning and rearing is limited, juvenile steelhead could potentially be present in Allen Creek and the unnamed tributary.

<u>Critical Habitat within the Action Area:</u> Critical habitat has been designated for PS Chinook salmon within Allen Creek as well as Quil Ceda Creek to the west of the action area. The critical habitat along the reach provides the Freshwater Rearing and Spawning PBFs for PS Chinook (WDFW 2021a).

2.4 Environmental Baseline

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

<u>Environmental conditions at the project sites and the surrounding area:</u> The project is located near Allen Creek, located north of the Snohomish River, and joins the Snohomish at Ebey Slough. The Allen Creek watershed drains approximately 11 square miles (Carroll 1999). The project reach on Allen Creek is within a low gradient, relatively shallow (less than 3 feet), meandering channel with steep, incised banks vegetated with native and invasive species. Stream substrate is dominated by sand and stilt throughout the reach, with occasional patches of gravel. Substrates in the action area contain embedded gravels and a large proportion of fine sediment. Temperatures in Allen Creek within the action area are considered impaired, and insufficient riparian vegetation and shade limits adult and juvenile salmon use. Allen Creek has been placed on Washington State's 303(d) list for fecal coliform (City of Marysville 2021; WDOE 2021). Reaches upstream of the project site in Allen Creek are listed for dissolved oxygen. Other pollutants of concern within the Allen Creek watershed include total suspended solids (TSS), fertilizers, hydrocarbons, heavy metals, roadway runoff, and organic wastes. Water quality indicators for Chinook salmon and steelhead are generally not properly functioning (NMFS 1996) due in large part to the urbanized developed setting. The narrow riparian corridors and

predominantly deciduous tree cover limits adequate large woody debris recruitment. Pool habitat is also lacking in the action area with few, relatively shallow small pools present.

The watershed is mostly urban except in the upper portion of Allen Creek and associated tributaries, which is dominated by agricultural lands. The watershed faces heavy development pressure, as it is on the expanding eastern edge of the City of Marysville (Haring 2002). Extensive ditching and channelization has occurred along much of the Allen Creek watershed, particularly in mainstem Allen Creek and tributaries in the north end of the watershed. Streambank and channel habitat integrity are negatively impacted by peak flows and disconnected floodplains. Streams have been rerouted to drain current and previous agriculture areas, with many channels routed in ditches along roads. Historically, these channels meandered through a very large wetland system (Carroll 1999). Due to extensive stream channel alteration, riparian condition is generally poor throughout the watershed, except where the creeks are located in ravines (Haring 2002). Streamside vegetation removal has occurred throughout the watershed to create lawns, stream access, and livestock grazing areas, resulting in bank erosion and loss of fish and aquatic habitat (Carroll 1999). Wetlands throughout the watershed have been extensively filled or modified, especially in the Munson Creek drainage, and are degraded from livestock grazing, human trampling, and garbage dumping (Carroll 1999). The associated reduction in infiltration of stormwater and loss of wetland function result in a significant reduction in summer base flows, adversely affecting local fish species that rear in freshwater for an extended period prior to outmigration (Haring 2002).

Natural hydrology has been altered in the Allen Creek watershed as a result of increased acreage of impervious surfaces from development which has resulted in increased stormwater runoff. Stormwater runoff occurs following heavy rainfall or snowmelt over impervious surfaces where post construction, vehicular, and industrial pollutants are picked up, carried, and deposited into aquatic environments (Dressing et al. 2016). First- flush rain events after long periods without rain that most typically occur in September in western Washington are expected to have extremely high levels of toxic pollutants (Peter et al. 2020). Higher concentrations are also expected to occur between March and October in any given year—as there would be more dry periods during rain events. However, the occurrence of these events would occur with less frequency. In Western Washington, most discharge would occur between October and March, concurrent with when the region receives the most rain.

Contaminants become entrained in stormwater from a variety of sources in the urban landscape. Roads generate a broad range and large load of pollutants that accumulate and run off impervious surfaces into stormwater drains and into streams, rivers, and lakes. Vehicle wear and emissions are primary sources of tire tread particles, metallic particles (particularly copper and chromium); persistent bio-accumulating toxicants (PBTs) from upholstery, plastic, and carpet; and polycyclic aromatic hydrocarbons (PAHs), nickel, and zinc from exhaust and leakage. Stormwater conveyances are also likely to include: common-use herbicides and pesticides, nutrients (nitrogen, phosphorus), silt and sediment, chlorides, metals, petroleum hydrocarbons, livestock fecal matter (bacteria), pharmaceuticals, surfactants (detergents, cleaners, pesticide adjuvants), along with several PBTs and their metabolites (Table 1). Other pollutants present in water and sediments throughout Washington state include mercury, copper, and other metals; chlorinated pesticides (DDT) and their degradates (DDD and DDE), polychlorinated dibenzo-pdioxins and furans, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), PAHs, and many others (Alvarez et al. 2014; Counihan et al. 2014; Hinck et al. 2006; Johnson et al. 2007; Johnson et al. 2013a; Seiders et al. 2007; WDOE 2006). Other parameters such as temperature, pH, hardness, and conductivity may also be pollutants or indicators that other pollutants are negatively impacting receiving waters.

Table 5. Pollutants commonly found in stormwater runoff in Washington State.

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

The past and ongoing anthropogenic impacts described above have reduced the action area's ability to support PS Chinook salmon and PS steelhead. However, the Allen Creek continues to provide migratory habitat for adults and juveniles of both species, and the area has also been designated as critical habitat for PS Chinook salmon.

In Ebey Slough, the baseline condition of habitat is degraded by historical work of settlers who drained and/or isolated ~3370 hectares of palustrine marsh in the Snohomish River floodplain upstream of Ebey Slough. Diking and bank armoring contributed to a 2-kilometer decrease in total length of side channels and a 55% reduction in the area of side channel sloughs on the Snohomish River. There has also been a 40% loss of beaver pond area (not including habitat loss in vast floodplain areas). Extensive historical floodplain wetlands at Marshland and lower French Creek have been diked and drained, and no longer provide salmonid habitat. Estimates of lost chinook and coho production capacity associated with the loss of floodplain habitat are 40-61% and 50%, respectively (Haas and Collins 2001). Restoration work in recent years incorporating a breach of the North Ebey Slough levee at Marysville has re-created approximately 400 acres of estuarine habitat, called Qwuloolt Estuary. By 2021, marine species had returned to the recovering habitat and 30 to 40 percent of the site was vegetated with marsh species (https://www.historylink.org/File/21379).

2.5 Effects of the Action

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

As described in Section 1.3, the FHWA's project would add a center turn lane to improve roadway operations, construct a sidewalk to provide safety and non-motorized access along 88th St NE. The project would also replace two undersized culverts, one on Allen Creek and the other on an unnamed tributary to Allen Creek. Work at the project site would include work area isolation with fish removal, as well as removal of and re-planting native riparian vegetation.

The effects of the proposed work can be characterized as temporary effects associated with construction, and long-term effects associated with the improved stream passage and stormwater runoff from roadway improvements and their use. The construction effects include water quality diminishment, construction-related noise and activity, fish salvage-related injury or mortality, migratory delay, and diminished prey base. Ephemeral effects are those that are likely to last for hours or days, short-term effects would likely last for weeks, and long-term effects are likely to last for months, years or decades. The FHWA's authorization of the construction extends the operational life of the roadway by several decades beyond its existing condition, and accommodates more traffic. Over that time, the roadway's presence and normal operations would cause long term effects on fish and habitat resources through stormwater runoff.

The action's work window avoids the peak emigration season for juvenile PS Chinook salmon, but does overlap with much of return timing for adult summer and some of the timing for fall-run PS Chinook salmon. As such, juvenile PS Chinook salmon are extremely unlikely to be present during the proposed in-water work, but low numbers of adults could be present during the spawning season. The work window also overlaps with the normal migration seasons for juvenile and adult PS steelhead, though use of the action area by steelhead is likely limited to rearing and migratory use by juveniles that may disperse up from Ebey Slough. Adult PS steelhead are unlikely to be present in the project area due to low population size within the watershed and lack of suitable spawning habitat, but cannot be discounted since there are no barriers to their presence in the creeks. Though juvenile PS steelhead from nearby streams may enter the project area year-round, they are unlikely to be exposed to the direct effects of construction due to the short period of construction and timing of work when conditions do not favor salmonids in the stream.

2.5.1 Effects on Listed Species

Fish Removal and Salvage and Site Isolation

The presence of rearing juvenile PS Chinook salmon in the action area is unlikely due to the lack of suitable complex habitat, low flows, and outmigration is typically completed by June. In order to minimize exposure if wetted conditions and fish are present at the time of the culvert replacements, Marysville will perform fish salvage measures to ensure no fish are present in the project site before work begins.

Fish salvage is intended as a measure to ensure individual fish from either species avoid exposure to detrimental project effects, or that exposure is minimized. However, fish handling and exclusion itself has direct consequences on fish. Fish removal would likely use a fine-mesh herding net to drive fish out from behind the isolation barrier before it is closed off. Herding is not considered capture or handling because fish remain in the water without interruption and is instead considered a short term displacement from preferred habitat, described later in this document. Small fish that remain within the isolation barrier after multiple passes with the herding net or that become trapped in standing pools will be collected with dip nets or traps, which is considered capture. Any fish not collected in this manner will be electrofished to capture. Electrofishing temporarily stuns the fish with a small percentage being injured or killed. Fish not successfully removed will die from dewatering. After being herded or otherwise removed from the area, a temporary stream bypass will be created adjacent to the project site to redirect stream flow around the dewatered project area and the work sites will be coffer dammed. This would encompass an area of approximately 4,500 square feet on Allen Creek including the culvert footprint, and approximately 2,000 square feet on the unnamed tributary that would be isolated and dewatered.

Fish exposed to electrofishing and capture would experience stress and may experience trauma and mortality. Electrofishing causes effects that range from increased respiratory action to mortality under certain conditions. Dalbey et al. (1996), Emery (1984), and Snyder (2003) describe responses that range from muscular contractions to mortality from exposure to electrofishing. Depending on the pulse train used, and the intensity and duration of exposure, muscular contractions may cause a lactic acid load and oxygen debt in muscle tissues (Emery 1984), it can cause internal hemorrhage and spinal fractures in 12 to 54% of the exposed fish, and acute mortality in about 2% (Dalbey et al. 1996). Severe interruption of motor function can stop respiration, and combinations of lactic acid load and oxygen debt may be irreversible, causing delayed mortality in apparently healthy fish. Obvious physical injuries often lead to reduced long-term growth and survival, whereas uninjured to slightly injured fish showed long-term growth and survival rates similar to unexposed fish of similar age (Dalbey et al. 1996). To reduce the effects of electrofishing, it would be used only after multiple net passes within the isolation area yield no fish. Further, the biologist and environmental staff would adhere to the guidelines for initial and maximum power settings for backpack electrofishing identified in the WSDOT Fish Removal Protocol and Standards (WSDOT 2016).

Fish can also experience physical trauma and physiological stress responses if care is not taken during the various handling and transfer processes (Moberg 2000; Shreck 2000). Contact with nets may cause scale and skin damage, and overcrowding in traps can cause stress and injury. The primary contributing factors to stress and mortality from handling are: (1) Difference in water temperatures between the river and the holding buckets; (2) dissolved oxygen levels; (3) the amount of time that fish are held out of the water; and (4) physical trauma. Stress from handling increases rapidly if water temperature exceeds 18 ºC (64 ºF), or if dissolved oxygen is below saturation. Debris buildup in traps can also injure or kill fish. The risk of entrainment or impingement during the de-watering of the isolation area is considered extremely unlikely because very few, if any, fish would remain in the affected area, and the pump intakes would be isolated and screened in compliance with the WSDOT Fish Removal Protocol and Standards (WSDOT 2016). However, any fish that remain in the isolation area following dewatering would likely die from dehydration and asphyxiation. However, given the small numbers of juvenile steelhead that could occur in the area, the numbers of fish that may be affected by these stressors would comprise such small subsets of their respective cohorts, that their loss would cause no detectable population-level effects.

Exclusion From Migration Habitat

Habitat in the project reach of Allen Creek observed during a field visit conducted by the action agency's consultant did not exhibit characteristics of suitable spawning habitat. The substrate composition was predominantly sand and silt with a few areas of small gravel, with low flow that likely does not proved adequate movement of fines nor dissolved oxygen for eggs. Spawning habitat is, however, reported in the watershed upstream of the project area (WDFW 2021b). Although spawning in the action area is unlikely, migrating adult fall Chinook salmon could exhibit return migration with attempt to move through the action area during the in-water work window (July 1- October 1). Because work timing overlaps with Chinook salmon returns the project site will prevent fish from using the area for migration or rearing purposes for a period up to 6 weeks. The unnamed tributary is not documented to support Chinook salmon use, and suitable spawning habitat is not present, so these effects will not occur there.

If pre-spawning adults are delayed below the cofferdam, they could experience higher summer water temperatures and lower stream flows downstream of the project reach, potentially causing pre-spawn mortality (Barnett et al. 2020; Bowerman et al. 2017). Juvenile salmon and steelhead upstream of the coffer dam that are prevented from continuing their downstream migration may be subjected to increased predation risk from the lack of adequate cover due to the removal of riparian vegetation in Allen's Creek (Quinn 2005).

Prey Base Diminishment

Short-term disturbance to the benthic macroinvertebrate because of dewatering and sediment disturbance or sediment deposition within Allen Creek and the unnamed tributary, temporarily reducing prey for rearing or migrating juvenile salmon and steelhead. Changes to the abundance and composition of the macroinvertebrate community abundance and richness within the action area typically recover within weeks to months post construction (Lawrence et al. 2014) as upstream prey communities re-seed the area. Removal of existing riparian vegetation and trees may also contribute to reduced prey for juvenile salmonids and this reduction will last for several years as newly planted vegetation matures. This suggests that diminished prey availability may negatively affect some fish from one cohort by increasing competition and decreasing growth, fitness, or survival in some individuals but that successive cohorts will experience less of this project effect as prey conditions ameliorate.

Dewatering the stream during in-water construction would contribute to macroinvertebrate mortality. Increased sedimentation downstream of the construction site may also lead to macroinvertebrate disturbance or mortality during and for a period of time following construction. Short-term changes to the composition of the macroinvertebrate community abundance and richness within the action area may occur following the replacement and completion of culvert construction. Additionally, removal of existing riparian vegetation and trees may also contribute to reduced prey for juvenile salmonids, both temporarily during construction and over the long term as newly planted vegetation matures. However, these changes are likely to be minimal over the long-term and return to baseline conditions in the years following construction (Lawrence et al. 2014). Since juvenile salmon and steelhead would have access to other in-tact habitat within the reach, and the effects of the action would be short-term, changes to the macroinvertebrate community is not likely to affect long-term fitness of juvenile salmon and steelhead that occupy Allen Creek and the unnamed tributary.

Construction Noise

Fish are excluded from the work site, so exposure to construction noise during demolition and removal of the old culverts, construction of the new culverts, wingwalls, and retaining walls at Allen Creek and the unnamed tributary is unlikely to expose PS Chinook salmon and PS steelhead at any lifestage. The best available information to describe the in-water noise levels that are likely to be caused by this project is a study that measured the in-water noise from excavator dredging of rocks (Reine et al. 2012). They report that the source level (sound level at 1 meter from the source; SL) for the excavator bucket scooping rocks was about 179 dB_{rms}. The area most likely to be affected by construction-related noise would be within 61 feet of the individual project sites, where the noise level drops to that which results in behavioral responses such as acoustic masking (Codarin et al. 2009), startle responses and altered swimming (Neo et al. 2014), abandonment or avoidance of the area of acoustic effect (Mueller 1980; Picciulin et al. 2010; Sebastianutto et al. 2011; Xie et al. 2008) and increased vulnerability to predators (Simpson et al. 2016). However, because of the use coffer dam to prevent access, work timing when habitat conditions are dry or any wet areas are warmer than suitable for rearing fish habitat (which leads to natural avoidance of the area) we anticipate very few fish of either species would be exposed to construction noise, or if exposed to exhibit any of these responses other than behavioral based on their distance from the construction.

Construction-Related Water Quality Diminishment

The streambed in Allen Creek is characterized by a high percentage of fines, and disturbance of the stream substrate during excavation, culvert removal, and post-construction cofferdam removal is likely to increase turbidity downstream of the work area during installation and removal of cofferdams and bypass pipes, during riparian vegetation clearing, and installation of the new culverts.

Removal of the existing culvert crossings on Allen Creek and the unnamed tributary would require excavation of the precast concrete culvert, timber arch structure, and corrugated metal pipe using heavy equipment. While the cofferdam and streamflow bypass system are in place, construction activities are not expected to degrade water quality in Allen Creek and the unnamed tributary because the work area will be dewatered and isolated from the flowing waters of the creek. Post-construction, NMFS anticipates rain on disturbed soils could briefly affect water quality in the action area in the form of small, and short-term increases in turbidity are likely during re-watering (e.g., following removal of the cofferdam and bypass pipes) and subsequent higher flow events during the first winter storms post-construction may also cause a pulse of suspended sediment. Since the proposed action occurs during summer flows lower than 100 cfs, the turbidity mixing zone would extend no further than 200 feet from the project site. Fish are excluded to areas 100 feet from the project site and fish remaining in the portion of the action area between 100 and 200 feet from the project site could be exposed to higher than background turbidity. Based on the best available information, work-related turbidity concentrations would be too low and short-lived to cause more than temporary, non-injurious behavioral effects such as avoidance of the plume and mild gill flaring in any PS Chinook salmon or PS steelhead that may be exposed to them. None of these potential responses, individually, or in combination would affect the fitness or meaningfully affect the normal behaviors of exposed fish.

<u>Dissolved Oxygen:</u> Mobilization of anaerobic sediments can decrease dissolved oxygen levels (Hicks et al., 1991; Morton 1976). The impact on dissolved oxygen is a function of the oxygen demand of the sediments, the amount of material suspended in the water, the duration of suspension, and the water temperature (Lunz and LaSalle 1986; Lunz et al. 1988). Reduced dissolved oxygen can affect salmonid swimming performance (Bjornn and Reiser 1991), as well as cause avoidance of water with low dissolved oxygen levels (Hicks 1999). However, the small amount of sediments that would be mobilized suggests that any dissolved oxygen reductions would be too small and short-lived to cause detectable effects in exposed fish. Additionally, all demolition and construction would be done within the dewatered project area which would reduce the potential for fish exposure to waters with reduced dissolved oxygen levels related to that work.

Reduced Riparian Vegetation

Removal of mature riparian vegetation and trees adjacent to Allen Creek and the unnamed tributary will increase solar input to the streams within the action area by reducing shade, will reduce natural cover, and decrease detrital prey inputs. Species will be exposed to these effects for several years, until replanted vegetation has attained sufficient height and canopy to cast shade. However, removal of non-native and invasive species may increase the quality of riparian habitat into the future. Due to the relatively small size of the area that would be affected, the continued input of terrestrial material upstream and downstream of the project reach, and the diluting effects of flowing water, the impacts on aquatic food webs attributable to the project would likely be too small to cause detectable effects on the fitness or normal behaviors for any life stage of Chinook salmon and steelhead in the action area. Further, some of the lost terrestrial input would return as the replanted vegetation grows to maturity.

Long-term Water Quality Diminishment (Stormwater)

The project increases pollution generating impervious surfaces (PGIS), adds some capture and treatment of road runoff equal to the new PGIS, and remediates additional PGIS areas without treatment. Stormwater runoff, despite treatment, often contains residual contaminants. Water quality would be affected by increased turbidity from roadway runoff and also be affected by the introduction of toxic materials from pollution generating impervious surfaces. Exposure to roadway-related degraded water quality is likely to adversely affect PS Chinook salmon and PS steelhead.

Stormwater effects to ESA-listed species will occur during and after each discharge of untreated runoff that will occur throughout the design life of the proposed project. Since the project would only treat the amount of stormwater produced by the proposed new PGIS, and not the replaced PGIS as well, it is highly likely that untreated stormwater will enter creeks within the action area, and that contaminants will move downstream, diluting concentration near the points of discharge, but introducing chronic low levels of contamination from the discharge points to Ebey Slough, ultimately reaching Puget Sound via the Snohomish River. The duration and severity of each effect will vary with site and event specific characteristics, such as average traffic volume in the project area (determining the amount of pollutant to be carried by stormwater), precipitation volume (determining the concentration of pollutant in the stormwater), and the volume of stream flow in Allen Creek and the unnamed tributary (determining the rate of dilution of the stormwater). Traffic-related contaminants include PAHs, heavy metals, and a growing list of contaminants that are just beginning to be identified, including tire wear particles (Peter et al. 2018; Tian et al. 2020). These pollutants will become more concentrated on impervious surfaces until they either degrade in place or are transported by wind, precipitation, or active site management. Stormwater contaminants that accumulate on roadway surfaces are prevalent in higher concentrations in urban creeks during the initial phase ("first flush") of rain events, but contaminants continue to be present throughout the duration of and immediately following such storms (Peter et al. 2020).

Zinc: A common component of road surface runoff (vehicle emissions, motor oils, lubricants, tires, and fuel oils), several species of zinc are highly mobile in aquatic environments, are often transported many miles downstream, and eventually load to sediments. Zinc interacts with many chemicals and aquatic conditions of reduced pH and dissolved oxygen, low DOC, and elevated temperatures increase zinc toxicity, causing altered patterns of accumulation, metabolism, and toxicity (Eisler 1993; Farag et al. 1998). Many aquatic invertebrates (prey) and some fish may be adversely affected from ingesting zinc-contaminated particulates (Farag et al. 1998). In freshwater fish, excess zinc affects the gill epithelium, which leads to internal tissue hypoxia, reduced immunity, and may acutely include osmoregulatory failure, acidosis, and low oxygen tensions in arterial blood (Eisler 1993). Toxicity of zinc mixtures with other metals is mostly additive; however, toxicity of zinc-copper mixtures is more than additive (or synergistic) for freshwater fish and amphipods (Skidmore 1964; de March 1988).

<u>Copper</u>: Copper from automobiles is one of the most common heavy metals contaminating stormwater, especially stormwater originating from parking lots. Copper is highly toxic to aquatic biota and ESA-listed salmon and steelhead can experience a variety of acute and chronic lethal and sub-lethal effects (NMFS 2014). Copper bio-accumulates in invertebrates and fish (Feist et al. 2005; Layshock et al. 2021), is redox-active, and interacts with or alters many compounds in mixtures (Gauthier et al. 2015). Copper-PAH mixtures, which synergistically interact are highly toxic through several exacerbating mechanisms: copper weakens cell membranes increasing absorption of PAHs, copper chelates or hastens and preserves the bio-accumulative toxicity of PAHs; and PAHs in turn increase the bio-accumulative and redox properties of Copper (Gauthier et al. 2015). Sub-lethal effects of copper include avoidance at very low concentrations (Hecht et al. 2007) and reduced chemosensory function at slightly higher concentrations, which in turn causes maladaptive behaviors, including inability to avoid copper or to detect chemical alarm signals (McIntyre et al. 2012). Sandahl et al. (2007) demonstrated that copper concentration as low as 2 micrograms/liter can significantly impair the olfactory system of salmonids and hinder their predator avoidance behavior. Thus any fish that are exposed to stormwater containing high concentrations of copper may experience diminishment of predator avoidance ability and would be at greater risk of predation. Appreciable adverse effects among fishes can be expected with increases as small as 0.6 µg/L above background concentrations (NMFS 2014).

<u>Polycyclic Aromatic Hydrocarbons (PAHs)</u>: Petroleum-based contaminants are usually in the form of two or more condensed aromatic carbon rings, include more than 100 different chemicals, and usually occur as complex mixtures in the environment. Major human-related sources released to the environment are from wood stoves, creosote treated wood, and vehicle emissions, plastics including tire wear particles, improper motor oil disposal, leaks, and asphalt sealants (WDOE 2021). PAHs are lipophilic, persistent, interact synergistically with bio-accumulative and redox-active metals and other contaminants, and may disperse long-distances in water (Arkoosh et al. 2011; Gauthier et al. 2014, 2015; WDOE 2021). Metabolites are commonly more toxic than the parent, some are carcinogenic, neurotoxic, and cause genetic damage. Although biotransformation of PAHs causes oxidative stress with subsequent cellular damage and increased energy is required at the cost of growth, many organisms (including salmon) can eliminate at least the lower density PAHs from their bodies as part of metabolism and excretion (Arkoosh et al. 2011). However, plants and some aquatic organisms, such as mussels and lamprey, have limited ability to metabolize or degrade PAHs, which may bioaccumulate over several years (Tian et al. 2019; Nilsen et al. 2015). The environmental fate of each type of PAH depends on its molecular weight. In surface water, PAHs can volatilize, photolyze, oxidize, biodegrade, bind to suspended particles or sediments, or accumulate in aquatic organisms, with bioconcentration factors often in the 10-10,000 range. In sediments, PAHs can biodegrade or accumulate in aquatic organisms or non-living organic matter. Some evaporate into the air from the surface but most do not easily dissolve in water, some evaporate into the air from surface waters, but most stick to solid particles and settle into sediments. Changes in pH and hardness may increase or decrease the toxicity of PAHs, and the variables of organic decay further complicate their environmental pathway (Santore et al. 2001).
Many of the pollutants that may enter the water column due to project activities can cause effects in exposed fish that range from avoidance of an affected area, to reduced growth, altered immune function, and immediate mortality in exposed individuals. The intensity of effects depends

largely on the pollutant, its concentration, and/or the duration of exposure (Brette et al. 2014; Feist et al. 2011; Gobel et al. 2007; Incardona et al. 2004, 2005, and 2006; Mcintyre et al. 2012; Meadore et al. 2006; Sandahl et al. 2007; Spromberg et al. 2016). PAHs and metabolites are acutely toxic to salmonids and may cause narcosis at low levels of exposure, can in some cases bioaccumulate through food webs (water, groundwater, soil, and plants; Bravo et al. 2011; Zhang et al. 2017), and can also cause chronic sub-lethal effects to aquatic organisms at very low levels (Neff 1985; Varanasi et al. 1985; Meador et al. 1995). PAHs can affect DNA within the nucleus of cells, cause genetic damage, and are classified as carcinogens (Collier et al. 2014).

<u>6PPD-quinone:</u> Chemicals in stormwater have been directly linked to pre-spawner die off in adult coho salmon, mortality in rearing juvenile coho salmon, as well as mortality in aquatic invertebrates that are important forage resources for juvenile salmonids (Chow et al. 2019; McIntyre et al. 2015; McIntyre et al. 2018; Spromberg et al. 2016). The primary effects of PAH exposure in salmonids are reduced growth, increased susceptibility to infection, and increased mortality (Meador et al. 2006; Varanasi et al. 1993). Tian et al. (2020) recently identified a degradation product in automobile tire rubber, 6PPD-quinone, which has been shown to be present in stormwater runoff that contributed to coho salmon pre-spawn mortality.
These ubiquitous pollutants are a source of potent adverse effects to salmon and steelhead, even at ambient levels (Johnson et al. 2007; Loge et al. 2006; Sandahl et al. 2007; Spromberg and Meador 2006). Published work has identified stormwater from roadways and streets as causing a high percentage of rapid mortality of adult coho salmon in the wild (Scholz et al. 2011) and laboratory settings (McIntyre et al. 2018). In an examination of effect on juvenile salmon, McIntyre et al. (2015) exposed sub-yearling coho salmon to urban stormwater. In these experiments, 100 percent of the coho juveniles exposed to untreated highway runoff died within 12 hours of exposure. McIntyre et al. (2018) later examined the pre-spawn mortality rate of adult coho salmon exposed to urban stormwater runoff. In these experiments 100 percent of adult coho salmon exposed to stormwater mixtures expressed abnormal behavior (e.g., lethargy, surface respiration, loss of equilibrium, and immobility) within 2 to 6 hours after exposure. Recent evaluations of exposures of these contaminants on juvenile steelhead and Chinook salmon resulted in mortality of up to 40 percent for steelhead and up to 10 percent for Chinook (J. McIntyre and N. Scholz, NMFS Northwest Fisheries Science Center, unpublished data). Repeated and chronic exposures, even of very low levels of toxins in stormwater, are still likely to injure or kill individual fish, by themselves and through synergistic interactions with other contaminants already present in the water (Baldwin et al. 2009; Feist et al. 2011; Hicken et al. 2011; Spromberg and Meador 2006; Spromberg and Scholz 2011). Santore et al. (2001) indicates that the presence of natural organic matter and changes in pH and hardness affect the potential for toxicity (both increase and decrease). Additionally, organics (living and dead) can adsorb and absorb other pollutants such as PAHs. The variables of organic decay further complicate the path and cycle of pollutants in the freshwater environment.

Many stormwater pollutants travel long distances in rivers either in solution, adsorbed to suspended particles, or else they are retained in sediments, particularly clay and silt, which can only be deposited in areas of reduced water velocity, such as behind dams or backwater and off-channel areas, until they are mobilized and transported by future sediment moving flows (Alpers et al. 2000a; Alpers et al. 2000b; Anderson et al. 1996). Wagner et al. (2018) reported that the fate and downstream transport of tire wear particles is dependent upon the density and composition of the mixture. Since tire wear particles are composed of lower density materials (rubber and carbon black) than those in asphalt or other particulate matter suspended in runoff (gravel, plastics, etc.), it is likely that tire wear particles remain in suspension and travel further downstream (Wagner et al. 2018). Further, the main components of tire wear particles are anticipated to resist biodegradation and persist in the environment, potentially contributing toxins over extended periods of time (Wagner et al. 2018). Recent studies indicated that the use of compost-amended bioswales was effective at removing a variety of contaminants from runoff, including PAHs and heavy metals (Fardel et al. 2020; McIntyre et al. 2015). Unlike traditional stormwater collection and conveyance practices, such as storm drain systems with direct outfalls to waterways, vegetated filter strips at the edges of paved surfaces or vegetated swales (i.e., bioswales) can collect and convey stormwater in ways that infiltrate into soils with large amounts of organic matter that bind or otherwise remove contaminants from the stormwater before it reaches a stream (McIntrye et al. 2015).

We cannot estimate the number of individuals that would experience adverse effects from exposure to stormwater with any meaningful level of accuracy. We cannot predict the number or duration of each pulse of discharge events, nor the number of individual fish that would be exposed during those events. However, it is very likely given the permanent and episodic nature of stormwater discharges and their ability to travel far downstream that most fish using Allen Creek and the unnamed tributary will be exposed to some level of contamination both as adult fish migrating to upstream natal sites, or as juveniles. Not all exposed individuals would experience immediate adverse effects, and latent health effects are difficult to discern and document. We expect that every year some individual PS Chinook (juvenile and adult) and PS steelhead (juvenile and adult), would experience sublethal effects such as stress and reduced prey consumption, some may respond with avoidance behaviors that disrupt feeding and migratory behavior, and some experience reduced growth, impairment of essential behaviors related to successful rearing and migration, cellular trauma, physiological trauma, reproductive failure, and mortality. These effects reduce fitness and likelihood of survival among some individuals in all exposed cohorts for the foreseeable future.

Stormwater-related Prey Base Diminishment

Short-term changes to the composition of the macroinvertebrate community abundance and richness within the action area may occur following the roadway improvements and increase in roadway runoff. Increased levels of contaminants from roadway-related runoff will expose prey to pollutants including metals, PAHs, and other toxins (Spromberg et al. 2016) which is expected to diminish the number, size, and species diversity of prey types available to foraging juvenile salmonids. Salmonid prey would be reduced in quantity and quality by and rearing or migrating juvenile salmon and steelhead will be exposed to this reduction. Also, amphipods and copepods can uptake PAHs from contaminated sediments (Landrum and Scavia 1983; Landrum et al. 1984; Neff 1982), and pass them to juvenile Chinook salmon and other small fish through the food web. When juvenile fish encounter areas of diminished prey, competition for those limited resources increases, and less competitive individuals are forced into suboptimal foraging areas (Auer et al. 2020). Further, individuals with an inherently higher metabolism tend to be bolder and competitively dominant, and may outcompete other individuals for resources within a microhabitat, potentially increasing interspecific mortality (Biro and Stamps 2010).

It is uncertain and impossible to predict the amount of contaminated prey that any individual fish may consume, the number of fish that would be undernourished or outcompeted for available prey, nor the intensity of any response that an exposed individual may experience. Based on the best available information, the NMFS expects that over the decades-long life of the repaired roadway, some individual juvenile Chinook salmon and juvenile steelhead from all future cohorts are likely to be exposed to reduced forage or contaminated forage, with likely effects including some combination of reduced growth, increased susceptibility to infection, and increased mortality. However, due to the latent quality of these effects on individual health, the numbers of juvenile Chinook salmon and juvenile PS steelhead annually exposed will be difficult to discern as reductions in abundance and productivity when the cohorts return as adult fish.

2.5.2 Effects on Critical Habitat

This assessment considers the intensity of expected effects in terms of the change they would cause in affected Primary Biological Features (PBFs) from their baseline conditions, and the severity of each effect, considered in terms of the time required to recover from the effect. Ephemeral effects are those that are likely to last for hours or days, short-term effects would likely last for weeks, and long-term effects are likely to last for months, years or decades.

The proposed action is likely to adversely affect features of critical habitat in freshwater areas that within the designation for PS Chinook salmon. The project site on Allen Creek provides freshwater spawning, rearing and migration habitat for PS Chinook salmon. The essential PBFs of critical habitat for PS Chinook salmon are listed below. The expected effects on those PBFs from completion of the planned project, including full application of the conservation measures and BMPs, would be limited to the impacts on freshwater PBFs as described below.

The PBFs for PS Chinook salmon in the action area are those for migration habitat, specifically, migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks that support juvenile and adult mobility and survival. The baseline condition is a general lack of natural cover due to extensive clearing of streamside vegetation throughout the watershed for lawns, development, and livestock. Water quantity and side channels are features not relevant to this consultation. We present here the effects listed above for their influence on the affected PBFs.

Migration Areas free from obstruction and excessive predation – This PBF will be diminished by short-term adverse impacts to up and downstream migration, but create long-term positive impacts by reducing barriers to upstream migration of adult salmon and steelhead and downstream migration of juveniles. No changes are expected to predation. This feature of critical habitat is maintained at a slightly less degraded level.

Freshwater Spawning Sites – The proposed action would cause long-term minor adverse effects on substrate at potential spawning sites. The construction of the two culverts would disturb potential spawning habitat up and downstream of the each of the culvert construction sites, and potentially bury eggs that have already been deposited. Creation of the retaining walls could introduce sediment into the stream, covering spawning gravels. This feature of critical habitat is maintained at a degraded level.

Floodplain connectivity – The proposed action would cause short-term adverse impacts on this attribute during culvert construction but long-term positive impacts to floodplain connectivity once the undersized culverts are replaced. Larger culverts would reduce flooding risk, improve access to upstream habitat, reduce scour downstream during high flows, and increase mobility of natural substrate and wood downstream. This feature of critical habitat is maintained at a slightly less degraded level.

Forage – The proposed action would cause short- and long-term minor adverse effects on forage. Removal of riparian vegetation at the sites would decrease input of terrestrial insects and leaf litter that support aquatic food webs. However, the action would replace vegetation along the stream corridors, but it would take years for vegetation to contribute forage to near baseline levels. Short-term disturbance to the benthic macroinvertebrate community may occur during removal of old and construction of new culverts within the project area. Stormwater runoff would increase contaminant load in invertebrate prey for salmonids. Detectable effects would likely be minor and limited to the area immediately adjacent to the project sites, but the effects would persist for months to years. This feature of critical habitat is maintained at a degraded level.

Water quality – The proposed action would cause both short- and long-term adverse effects on this attribute. Culvert replacement would temporarily reduce water quality downstream during construction, increasing turbidity from mobilizing sediments within and adjacent to the streams. Detectable effects of turbidity are expected to be ephemeral and limited to the area within about 200 feet of either project site. Impacts on riparian vegetation are likely to slightly increase water temperatures for years. Roadway improvements would cause long-term adverse effects to water quality in Allen Creek and the unnamed tributary from stormwater runoff. Untreated stormwater would impact the health and potentially survival of juvenile and adult salmonids that migrate or rear in the action area. This feature of critical habitat is maintained at a degraded level.

Stormwater runoff is certain to continue to deliver toxic and potentially lethal contaminants from urban and rural areas if left untreated, degrading water quality, a feature of designated critical habitat for all ESA listed species, serving multiple conservation values depending on location (e.g., for salmonids - spawning in upstream reaches; rearing and migration lower in the riverine system; growth and maturation in estuarine and nearshore areas). Exposure to untreated, and to insufficiently treated, stormwater causes adverse effects to ESA-listed salmonids. Similarly, prey communities in fresh and estuarine waters are an additional feature of designated critical habitat that can be impaired by stormwater; prey communities exposed to the various contaminants in stormwater may be reduced in quantity, composition, and in quality if they accumulate toxins. This creates a second, indirect pathway of exposure among ESA-listed species.

The incremental addition of small amounts of these pollutants over time are a source of adverse effects on critical habitat, and to salmon and steelhead that utilize those critical habitats. Adverse effects occur even when the source load cannot be distinguished from ambient levels because many pollutants bioaccumulate in the tissues of aquatic organisms and in benthic sediments. Contaminants accumulate in both the tissues and prey of salmon and steelhead and can cause a variety of lethal and sublethal effects (Hecht et al. 2007). Repeated and chronic exposures, even at very low levels, are likely to injure or kill individual fish, by themselves and through synergistic interactions with other contaminants already present in the water (Baldwin et al. 2009; Feist et al. 2011; Hicken et al. 2011; Spromberg and Meador 2006; Spromberg and Scholz 2011).

Water quantity – No changes to this attribute are expected.

Natural Cover – Construction related removal of riparian vegetation would cause minor effects to PS Chinook salmon and PS steelhead. Construction would cause the removal of approximately 0.5 acres of trees and riparian vegetation at the Allen Creek project site and 0.35 acres at the unnamed tributary site. Following construction, the affected areas would be replanted with native trees and shrubs. However, it will take several years to decades before the replacement vegetation would provide ecological functions equitable to pre-construction levels in areas where mature vegetation must be removed. Reduced riparian vegetation can alter in-stream chemical and biological functions. Biological processes include aquatic and riparian plant and animal growth, and community development and succession, which establish the biodiversity and influence the life histories of aquatic and riparian organisms (Harman et al. 2012). Reduced shade can cause increased water temperatures, which affects chemical processes as well as linkages to terrestrial food webs, retention and export of nutrients and nutrient cycling in the aquatic food web, and decline in dissolved oxygen (Beechie et al. 2010). Increased stream temperatures, especially during summer low flows, may also contribute to pre-spawn mortality of PS Chinook and steelhead, which may become a more frequent occurrence as summer air temperatures increase due to climate change (Bowerman et al. 2017; FitzGerald et al. 2021).

Many terrestrial insects are forage for salmonids, and terrestrial vegetative matter often provides cover. Terrestrial organic matter is also important to nutrient cycling in aquatic food webs that support aquatic algae and invertebrates that are important resources for juvenile salmonids.

Because the project includes removal of vegetation, including vegetation adjacent to the streams, the proposed action would cause long-term adverse effects on natural cover, shade, evapotranspirative cooling, and detrital prey inputs. Despite replacement plantings, these impacts on riparian vegetation would persist for years to decades, until the new plants have established height and canopy. This feature of critical habitat, already degraded, will be further diminished.

2.6 Cumulative Effects

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

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.4). Regardless, listed salmonids are expected to be adversely affected by changes in stream flows, water quantity, elevated temperatures, frequency of storms, and severity of storms. Climate change is also expected to alter ocean conditions including reducing prey abundance, increasing water temperature, and increasing habitat for predators on salmonids.

The current conditions of ESA-listed species and designated critical habitat within the action area are described in the Rangewide Status of the Species and Critical Habitat and Environmental Baseline sections above. The non-federal activities in and upstream of the action area that have contributed to those conditions include past and on-going bankside development, upland urbanization, upstream forest management, agriculture, road construction, water development, subsistence and recreational fishing, and restoration activities. Those actions were, and continue to be, driven by a combination of economic conditions that characterized traditional natural resource-based industries, general resource demands associated with settlement of local and regional population centers, and the efforts of conservation groups dedicated to restoration and use of natural amenities, such as cultural inspiration and recreational experiences.

Human population density in the city of Marysville and surrounding areas is reasonably certain to increase in future years and contribute to cumulative effects. This anticipated growth will increase contaminant loading from wastewater treatment plants, traffic, stormwater runoff, and sediments that recruit into the action area's waters from agricultural and non-point sources. Impacts from population growth in the watershed are reasonably likely to have cumulative adverse effects on salmonid critical habitat through two primary mechanisms: First, we anticipate increased residential and commercial development and associated road construction in the foreseeable future for this watershed. This growth-induced development is anticipated to increase the use and application of pesticides, fertilizers, and herbicides, which will increase the delivery of contaminants into the waters of the action area. Secondly, increased demand on water resources from the basin from growth (e.g. for agriculture, residential and/or municipal use) will further limit the use of those water resources to support salmonid critical habitat. As stream flows are reduced from diversion, contaminants can also become more concentrated in these systems, exacerbating contamination issues.

The NMFS is unaware of any specific future non-federal activities that are reasonably certain to affect the action area. However, the NMFS is reasonably certain that future non-federal actions such as the previously mentioned activities are all likely to continue and increase in the future as the human population continues to grow across the region. The intensity of these influences depends on many social and economic factors, and therefore is difficult to predict. Further, the adoption of more environmentally acceptable practices and standards may gradually reduce some negative environmental impacts over time. Interest in restoration activities has increased as environmental awareness rises among the public. State, tribal, and local governments have developed plans and initiatives to benefit ESA-listed PS Chinook salmon and PS steelhead within many of the watersheds that flow into the action area. However, the implementation of plans, initiatives, and specific restoration projects are often subject to political, legislative, and fiscal challenges that increase the uncertainty of their success. Therefore, NMFS finds it likely that the cumulative effects of these activities will have adverse effects on population abundance and productivity for Chinook salmon, coho salmon, chum salmon, and steelhead and critical habitats for these salmonid species.

2.7 Integration and Synthesis

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

2.7.1 ESA-listed Species

PS Chinook salmon and PS steelhead are both listed as threatened, based on declines from historic levels of abundance and productivity, loss of spatial structure and diversity, and an array of limiting factors in habitat rangewide as well as at a baseline habitat condition. All Puget Sound Chinook salmon populations continue to remain well below the TRT planning ranges for recovery escapement levels. Most populations also remain consistently below the spawner–recruit levels identified by the TRT as necessary for recovery. Across the ESU, most populations have increased somewhat in abundance since the last status review in 2016, but have small negative trends over the past 15 years (Ford, 2022). The viability of the Puget Sound steelhead DPS has improved somewhat since the PSTRT concluded that the DPS was at very low viability, as were all three of its constituent MPGs, and many of its 32 DIPs (Hard et al. 2015). Improvements in abundance were not as widely observed in the Northern Cascades MPG. Foremost among the declines were summer- and winter-run populations in the Snohomish River basin (Ford 2022).

To this context we add the project effects, which will affect individuals from two populations of PS Chinook Salmon and 1 population of PS steelhead. All three populations are performing poorly with a 29% decline in natural spawners of steelhead in the 2015-2019 reporting period and less than 1% increase in the two Chinook populations in the same period (see Figure 91 in Ford 2022).

Both species will be affected over time by cumulative effects, some positive – as recovery plan implementation and regulatory revisions increase habitat protections and restoration, and some negative – as climate change and unregulated or difficult to regulate sources of environmental degradation persist or increase. Overall, to the degree that habitat trends are negative, the effects on viability parameters of each species are also likely to be negative. In this context we consider how the proposed action's impacts on individuals would affect the listed species at the population and ESU/DPS scales.

Project effects include possible death, injury, and sublethal responses in a small number of fish from construction work in one cohort of the Chinook populations, and among many individuals of all forseeable future cohorts, chronic exposure and (most likely) latent health effects decreasing fitness and survival from both Chinook and the steelhead populations.

The annual number of juveniles that are likely to be injured or killed by action-related stressors is unknown. However, the fraction of any annual cohort affected by latent health effects (reduced fitness) is not documentable as an effect on any of the characteristics of a viable salmon population (abundance, productivity, distribution, or genetic diversity) because of the delayed nature of its consequences (death, failure in homing, reproductive failure).

When we consider cumulative effects associated with increasing human population growth and resource demands (including increasing urban runoff) and climate change effects that will overlap with the project effects over coming decades, population declines are likely, though it will be impossible to attribute any portion of the decline directly to the proposed action.

2.7.2 Critical Habitat

Critical habitat was designated for PS Chinook salmon to ensure that specific areas with PBFs that are essential to the conservation of that listed species are appropriately managed or protected. The critical habitat for PS Chinook salmon will be affected over time by cumulative effects, some positive – as restoration efforts and regulatory revisions increase habitat protections and restoration, and some negative – as climate change and unregulated or difficult to regulate sources of environmental degradation persist or increase. Overall, to the degree that trends are negative, the effects on the PBFs of critical habitat for PS Chinook salmon are also likely to be negative. In this context we consider how the proposed action's impacts on the attributes of the action area's PBFs would affect the designated critical habitat's ability to support the conservation of PS Chinook salmon as a whole.

Past and ongoing land and water use practices have degraded salmonid critical habitat throughout the Puget Sound basin. Hydropower and water management activities have reduced or eliminated access to significant portions of historic spawning habitat. Timber harvests, agriculture, industry, urbanization, and shoreline development have adversely altered floodplain and stream morphology in many watersheds, diminished the availability and quality of estuarine and nearshore marine habitats, and reduced water quality across the region.

Global climate change is expected to increase in-stream water temperatures and alter stream flows, possibly exacerbating impacts on baseline conditions in freshwater habitats across the region. Rising sea levels are expected to increase coastal erosion and alter the composition of nearshore habitats, which could further reduce the availability and quality of estuarine habitats. Increased ocean acidification may also reduce the quality of estuarine habitats.

In the future, non-federal land and water use practices and climate change are likely to increase. The intensity of those influences on salmonid critical habitat is uncertain, as is the degree to which those impacts may be tempered by adoption of more environmentally acceptable land use practices, by the implementation of non-federal plans that are intended to benefit salmonids, and by efforts to address the effects of climate change.

The PBFs of salmonid critical habitat that would be affected by the proposed action are freshwater spawning sites, rearing sites, and migration corridors free of obstruction and excessive predation. As described above, the proposed action would cause short term low level adverse effects on water quality, substrate, forage, natural cover, and freedom from obstruction and excessive predation within about 200 feet of the culverts and long term chronic low-level degradation of water quality degrading rearing and migration habitats.

Based on the best available information, the scale of the proposed action's effects, when considered in combination with the degraded baseline, cumulative effects, and the impacts of climate change, habitat degradation will reduce the potential for the habitat to support recovery, but the project effects themselves would be too small to attribute in that reduction. Therefore, the overall effect of the project on critical habitat, while adverse, and chronic, cannot be considered to reduce the conservation role of migration and rearing in the action area, nor reduce conservation potential for critical habitat overall.

2.8 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is the NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of PS Chinook salmon and PS steelhead, nor is it likely to destroy or adversely modify designated critical habitat for PS Chinook salmon.

2.9 Incidental Take Statement

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

2.9.1 Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take is reasonably certain to occur as follows:

Harm of PS Chinook salmon from exposure to:

- Construction-related habitat exclusion, disrupted migration, and turbidity (adults),
- Water quality reductions (adults and juveniles)
- Prey reductions (juveniles)
- Capture, injury or death from fish exclusion activities (juveniles)

Harm of juvenile PS steelhead from exposure to:

- Construction-related fish salvage,
- Construction-related migratory delay,
- Water quality reduction and prey reductions (juveniles)

The NMFS cannot predict with meaningful accuracy the number of PS Chinook salmon and PS steelhead that are reasonably certain to be injured or killed annually by exposure to any of these stressors. The distribution and abundance of the fish that occur within an action area are affected by habitat quality, competition, predation, and the interaction of processes that influence genetic, population, and environmental characteristics. These biotic and environmental processes interact in ways that may be random or directional, and may operate across far broader temporal and spatial scales than are affected by the proposed action. Thus, the distribution and abundance of fish within the action area cannot be attributed entirely to habitat conditions, nor can the NMFS precisely predict the number of fish that are reasonably certain to be injured or killed if their habitat is modified or degraded by the proposed action. Additionally, the NMFS knows of no device or practicable technique that would yield reliable counts of individuals that may experience these impacts. In such circumstances, the NMFS uses the causal link established between the activity and the likely extent and duration of changes in habitat conditions to describe the extent of take as a numerical level of habitat disturbance. The most appropriate surrogates for take are action-related parameters that are directly related to the magnitude of the expected take.

For this action, the physical area of disturbance, the timing and the duration of work are the best available surrogates for the extent of take of juvenile and adult PS Chinook salmon from exposure to construction-related effects. Timing and duration of work are appropriate surrogates because the planned work window was selected to reduce the potential for juvenile and adult Chinook salmon and juvenile steelhead presence at the project site. Therefore, working outside of the planned work window and/or working for longer than planned would increase the number of fish likely to be exposed to these construction-related impacts.

The extent of PS Chinook salmon and PS steelhead take in the form of harm from construction effects is defined as:

- Six weeks of in-water work at the project site to be completed between July 1 and October 1; and

Take in the form of harm from long term water quality degradation is the area of new and replaced impervious surfaces and the capacity of the stormwater treatment system. These are the best available surrogates for the extent of take of PS Chinook salmon and PS steelhead from exposure to roadway-related contaminated water because, as the size of the impervious surface area of the road increases, the volume of vehicle-contaminated stormwater runoff from the road would increase. Conversely, as the capacity of the stormwater treatment system is reduced, the earlier and more frequently untreated stormwater would bypass the system. As the volume of untreated stormwater from the road increases, the concentration of contaminants reaching streams would increase, and the likelihood of PS Chinook salmon and PS steelhead being exposed to the contaminants would increase.

- The extent of take is 4.67 acres of new and replaced PGIS during roadway improvement and stormwater treatment of 0.73 acre of new PGIS in TDA1 and 0.71 acre in TDA2.

Take in the form of injury or death and harm from fish salvage activities during channel re-alignment and project site dewatering for the duration of the in-water work window (July 1 through October 1) is no more than 5% of the total number handled when isolating the in-water work areas.

Some of these take surrogates could be construed as partially coextensive with the proposed action. However, they nevertheless function as effective re-initiation triggers. The construction-related take surrogates will likely be monitored on a near-daily basis; thus any exceedance of the surrogates will be apparent in real-time and well before the project is completed. Further, if the size of the culverts or if roadway improvements exceed the proposal, it could still meaningfully trigger re-initiation because the FHWA has authority to conduct compliance inspections and to take actions to address non-compliance, including post-construction (33 CFR 326.4).

2.9.2 Effect of the Take

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

2.9.3 Reasonable and Prudent Measures

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

The FHWA shall require the City of Marysville to:

1. Minimize incidental take of PS Chinook salmon and PS steelhead associated with operational effects (stormwater).
2. Minimize incidental take of PS Chinook salmon and PS steelhead associated with construction effects.
3. Ensure completion of a monitoring and reporting program to confirm this Opinion is meeting its objective of limiting the extent of take and minimizing take from permitted activities. Please electronically send these reports to: projectreports.wcr@noaa.gov and refer to NMFS number WCRO-2020-01439.

2.9.4 Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the Federal action agency must comply (or must ensure that any applicant complies) with the following terms and conditions. The FHWA and/or the local recipient of FHWA funds has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. The following terms and conditions implement reasonable and prudent measure 1 on stormwater:
    a. Ensure the project does not exceed the design specifications and creates no more than 4.67 acres of new and replaced PGIS;
    b. Construct and maintain treatment facilities to maximize removal of stormwater pollutants;
        i. Comply with the conditions of use described in Ecology's General Use Designation for Basic (TSS), Enhanced, and Phosphorous treatment for The BioPod ™ Biofilter, which includes installing, maintaining, and monitoring per the Ecology guidance.
        ii. Monitor discharge pursuant to Ecology guidance, and provide copy to NMFS when exceedances are documented.

2. The following terms and conditions implement reasonable and prudent measure 2 on construction effects:
    a. Evaluate fish presence prior to starting work. If spawning fish or redds are present in the project area contact NMFS to discuss delay of the in-water work window.
    b. If rearing or migrating fish are present, conduct fish exclusion using methods with the least handling first, eg. herd out of the project site fish using block nets, and pace the block net 200 feet downstream of each project site to minimize fish within the sediment mixing zone;
    c. Retain block nets up and downstream of the bypass pipes during construction to prevent fish entrainment and impingement on dewatering pumps;

d. If capture and handling are required to remove fish from the worksite, take all appropriate steps to minimize the amount and duration of handling during capture and release operations, including the following:
    i. Corps or applicant fish biologists, their subordinate staff, or certified contractors must conduct all fish capture, handling, and electrofishing operations, unless otherwise approved in writing by NMFS.
    ii. ESA-listed fish must be handled with extreme care, keeping fish in water to the maximum extent possible during seining and transfer procedures to prevent the added stress of out-of-water handling.
    iii. Water quality conditions must be adequate in tanks, buckets, or in sanctuary nets that hold water to transport fish by providing circulation of clean, cold water, using aerators to provide DO, and minimizing holding times. DO and temperature should be periodically monitored in transport containers.
    iv. Fish must be released into a safe location as quickly as possible, and as near as possible to capture sites; and
    v. Do not electrofish.
e. Use native tree species in replanting and check annually to ensure plantings survive, for 5 years. Replace dead or failing tree plantings in that time period.

3. The following terms and conditions implement reasonable and prudent measure 3:
    a. Provide an as-built report that identifies
        i. if sediment entered Allen Creek and the unnamed tributary and how far downstream the pulse or plume was visible.
        ii. the net increase in PGIS;
        iii. the total amount of riparian vegetation removed in acres at both project sites and the total amount of riparian vegetation replanted at each project site and list of native species planted;
    b. Report to NMFS within 30 days post project, the total number of PS Chinook salmon and PS steelhead encountered, captured, and relocated, injured, and/or killed. This notification should be sent to projectreports.wcr@noaa.gov and should also include:
        i. Dates and methods of fish exclusion.
        ii. Disposition of fish at release (i.e. alive with no apparent injuries, alive with apparent minor/serious injuries, dead with/without apparent injuries).
    c. Submit electronically reports annually to NMFS within six months of the close of the work window. Send the reports to: projectreports.wcr@noaa.gov. Be sure to include the NMFS number for this project in the subject line: Attn: WCRO-2020-01439.

2.10 Conservation Recommendations

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

1. Construct stormwater treatment facilities sufficient to provide treatment of runoff from all existing, new and replaced PGIS in the project area.
2. Conduct in-water work in Allen Creek as late in the work window as possible to allow spawning PS Chinook salmon to reach upstream spawning habitat.
3. Ensure replanted vegetation is a variety of native plants that will create a shade canopy.
4. Submit juvenile salmonids killed during fish capture/handling for genetic analysis to determine stock origin and include the results in fish monitoring reports.

2.11 Reinitiation of Consultation

This concludes formal consultation for the FHWA City of Marysville 88th Street Corridor Improvements Project in Snohomish County, Washington. Under 50 CFR 402.16(a): "Reinitiation of consultation is required and shall be requested by the Federal agency or by the Service where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and: (1) If the amount or extent of taking specified in the incidental take statement is exceeded; (2) If new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion or written concurrence; or (4) If a new species is listed or critical habitat designated that may be affected by the identified action."

2.12 "Not Likely to Adversely Affect" Determinations

This assessment was prepared pursuant to section 7(a)(2) of the ESA, implementing regulations at 50 CFR 402 and agency guidance for preparation of letters of concurrence.

As described in Section 1.2 and below, the NMFS has concluded that the proposed action is not likely to adversely affect adversely affect southern resident (SR) killer whales and their designated critical habitat. Detailed information about the biology, habitat, and conservation status and trends of SR killer whales can be found in the listing regulations and critical habitat designations published in the Federal Register, as well as in the recovery plans and other sources at: https://www.fisheries.noaa.gov/species-directory/threatened-endangered, and are incorporated here by reference.

The applicable standard to find that a proposed action is not likely to adversely affect listed species or critical habitat is that all of the effects of the action are expected to be discountable, insignificant, or completely beneficial. Beneficial effects are contemporaneous positive effects without any adverse effects to the species or critical habitat. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur. The effects analysis in this section relies heavily on the descriptions of the proposed action and project site conditions discussed in Sections 1.3 and 2.4, and on the effects analyses presented in Section 2.5.

Species

SR killer whales are limited to marine water habitats, and would not be directly exposed to any construction-related or stormwater effects, but they could possibly be exposed indirectly through the trophic web. Direct exposure to stormwater is expected to be insignificant because the contaminants will be very dilute upon reaching Puget Sound, and while SR killer whales enter locations near the area where the Snohomish River enters Puget Sound, their duration of presence is unlikely to create prolonged or intense exposure; exposure to reduction in prey availability is also expected to be insignificant because the likelihood that the small number of juveniles potentially affected by the project would grow to adulthood and be available as SR killer whale forage is exceedingly low. As described in Section 2.1 the PS Chinook populations that would be affected by the proposed action are very small. Further, as described in Section 2.5, the proposed action would annually affect too few individuals to cause detectable population-level effects on the affected Chinook salmon populations. Therefore, any project-related reduction in Chinook salmon availability for SR killer whales would be undetectable. Although some PS Chinook salmon could be exposed to adverse effects from fish salvage activities, reduced forage will affect only one cohort, and is insufficient to impair the abundance of adult fish which SR killer whales prey upon; stormwater runoff downstream of the project site, their individual levels of harm as well as the total numbers of annually exposed individuals would be too low to cause any detectable trophic link between the effects of the action and SR killer whales. Therefore, the action's effects on SR killer whales is expected to be insignificant.

Critical Habitat

This assessment considers the intensity of expected effects in terms of the change they would cause in affected physical or biological features (PBFs) from their baseline conditions, and the severity of each effect, considered in terms of the time required to recover from the effect. Ephemeral effects are those that are likely to last for hours or days, short-term effects would likely to last for weeks, and long-term effects are likely to last for months, years or decades.

<u>SR killer whale Critical Habitat:</u> Designated critical habitat for SR killer whales includes marine waters of the Puget Sound that are at least 20 feet deep. The expected effects on SR killer whale critical habitat from completion of the proposed action, including full application of the conservation measures and BMP, would be limited to the impacts on the PBFs as described below.

1. <u>Water quality to support growth and development:</u> The proposed roadway repair and culvert replacements would cause no detectable effects on marine water quality since the project area is confined to freshwater. Project-related turbidity is unlikely to travel as far downstream as Puget Sound, and is therefore a discountable exposure for this critical habitat feature.

2. <u>Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth:</u> The proposed action would cause long-term, but insignificant effects on prey availability and quality. Action-related impacts would annually injure or kill extremely low numbers of individual adult and juvenile Chinook salmon (primary prey). However, their numbers and levels of

contamination would be too small to cause detectable effects on prey availability, or to create any detectable trophic link between project-related contaminants and SR killer whales. Therefore, it would an insignificant reduction in prey availability and quality.

3. Passage conditions to allow for migration, resting, and foraging: The proposed roadway repair and culvert replacements would cause no detectable effects on this attribute.

As described above, all potential effects are discountable, insignificant, or entirely beneficial; therefore, the project is not likely to adversely affect SRKW or their designated critical habitat.

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

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

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

3.1 Essential Fish Habitat Affected By the Project

The project site is located in Marysville, Washington (Figure 1). The waters and substrate of Allen Creek and the unnamed tributary are designated as freshwater EFH for various life-history stages of Pacific Coast Salmon, which within the Snohomish River watershed include Chinook and coho salmon. Due to trophic links between PS Chinook salmon and SR killer whales, the project's action area also overlaps with marine waters that have been designated, under the MSA, as EFH for Pacific Coast Salmon, Pacific Coast Groundfish, and Coastal Pelagic Species. However, the action would cause no detectable effects on any components of marine EFH. Therefore, the action's effects on EFH would be limited to impacts on freshwater EFH for

Pacific Coast Salmon, and it would not adversely affect marine EFH for Pacific Coast Salmon, or EFH for Pacific Coast groundfish and coastal pelagic species.

Freshwater EFH for Pacific salmon is identified and described in Appendix A to the Pacific Coast salmon fishery management plan, and consists of four major components: (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors and holding habitat. The action area may provide migration and spawning habitat for adult Chinook salmon, juvenile rearing and migration corridors, and may provide spawning and migration habitat for adult and rearing habitat for juvenile coho salmon.

Those components of freshwater EFH for Pacific Coast Salmon depend on habitat conditions for spawning, rearing, and migration that include: (1) water quality (e.g., dissolved oxygen, nutrients, temperature, etc.); (2) water quantity, depth, and velocity; (3) riparian-stream-marine energy exchanges; (4) channel gradient and stability; (5) prey availability; (6) cover and habitat complexity (e.g., large woody debris, pools, aquatic and terrestrial vegetation, etc.); (7) space; (8) habitat connectivity from headwaters to the ocean (e.g., dispersal corridors); (9) groundwater-stream interactions; and (10) substrate composition.

As part of Pacific Coast Salmon EFH, five Habitat Areas of Particular Concern (HAPCs) have been defined: 1) complex channels and floodplain habitats; 2) thermal refugia; 3) spawning habitat; 4) estuaries; and 5) marine and estuarine submerged aquatic vegetation. The action area may provide spawning for PS Chinook salmon, an important HAPC habitat feature.

3.2 Adverse Effects on Essential Fish Habitat

The ESA portion of this document (Sections 1 and 2) describes the proposed action and its adverse effects on ESA-listed species and critical habitat, and is relevant to the effects on EFH for Pacific Coast Salmon. Based on the analysis of effects presented in Section 2.5 the proposed action will cause minor short- and long-term adverse effects on EFH for Pacific Coast Salmon as summarized below.

1. <u>Water quality:</u> – The proposed action would cause short- and long-term incremental adverse effects on this attribute. Over the life of the improved roadway, untreated stormwater would discharge residual levels of petroleum-based pollutants, metals, and other contaminants into Allen Creek and the unnamed tributary. Construction to replace the culverts on Allen Creek and the unnamed tributary would disturb stream sediment and riparian vegetation, creating temporary turbidity plumes downstream of the action area. The action would cause no measurable changes in water temperature or salinity.

2. <u>Water quantity, depth, and velocity:</u> No changes expected.

3. <u>Riparian-stream-marine energy exchanges:</u> No changes expected.

4. <u>Channel gradient and stability:</u> No changes expected.

5. Prey availability: The proposed action would cause short- and long-term low level but chronic adverse effects on this attribute. Over the life of the repaired roadway, untreated stormwater would provide a persistent source of contaminants that could be taken up by benthic invertebrates that are forage resources for juvenile Chinook salmon. Prey communities exposed to the various contaminants in stormwater may be reduced in quantity, composition and quality if they accumulate toxins. Benthic invertebrates would also be displaced or killed during demolition of old and construction of new culverts.

6. Cover and habitat complexity: The proposed action would cause short and long-term minor adverse effects on this attribute. Construction would cause the removal of approximately 0.5 acres of trees and riparian vegetation at the Allen Creek project site and 0.35 acres at the unnamed tributary site. The area of affect would be limited to the riparian areas around the culverts. It will take several years to decades before the replacement vegetation would provide ecological functions equitable to pre-construction levels in areas where mature vegetation must be removed.

7. Space: No changes expected.

8. Habitat connectivity from headwaters to the ocean: The proposed action would cause short-term adverse and long-term beneficial effects on this attribute. During stream realignment and dewatering, habitat connectivity may be reduced, temporarily blocking fish access to upstream habitats. However, the replacement of undersized and ineffective culverts would increase connectivity of up- and downstream freshwater spawning and rearing habitats.

9. Groundwater-stream interactions: No changes expected.

10. Connectivity with terrestrial ecosystems: No changes expected.

11. Substrate composition: No changes expected.

3.3 Essential Fish Habitat Conservation Recommendations

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

To reduce adverse impacts from construction-related effects and roadway stormwater, the FHWA should:

1. Size the stormwater treatment system to accommodate the runoff from the total area of existing, new, and replaced roadway and any other existing PGIS that would deliver runoff to the system;
2. Use a turbidity curtain at all times during all activities where implementation would minimize suspended sediments in Allen Creek and the unnamed tributary; and
3. Remove only the amount of riparian vegetation necessary to complete the project and replace removed trees with native tree plantings.

3.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, the FHWA must provide a detailed written response in to the 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 the NMFS' EFH Conservation Recommendations unless the 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 the 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, the 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 FHWA must reinitiate EFH consultation with the NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH Conservation Recommendations (50 CFR 600.920(l)).

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended user of this opinion is the FHWA. Other interested users could include the applicant, WDFW, the governments and citizens of Snohomish County and the City of Marysville, and Native American tribes. Individual copies of this opinion were provided to the FHWA. The document will be available within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adheres to conventional standards for style.

4.2 Integrity

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

4.3 Objectivity

Information Product Category: Natural Resource Plan

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

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

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

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

5. REFERENCES

Abatzoglou, J.T., Rupp, D.E. and Mote, P.W. 2014. Seasonal climate variability and change in the Pacific Northwest of the United States. *Journal of Climate* 27(5): 2125-2142.

Alpers, C.N., R.C. Antweiler, H.E. Taylor, P.D. Dileanis, and J.L. Domagalski (editors). 2000a. Volume 2: Interpretation of metal loads: Metals transport in the Sacramento River, California, 1996-1997, Water-Resources Investigations Report 00-4002. U.S. Geological Survey. Sacramento, California.

Alpers, C.N., R.C. Antweiler, H.E. Taylor, P.D. Dileanis, and J.L. Domagalski (editors). 2000b. Volume 1: Methods and Data.In: Metals transport in the Sacramento River, California, 1996-1997, Water-Resources Investigations Report 99-4286. U.S. Geological Survey. Sacramento, California.

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

Anderson, C.W., F.A. Rinella, and S.A. Rounds. 1996. Occurrence of selected trace elements and organic compounds and their relation to land use in the Willamette River Basin, Oregon, 1992–94. U.S. Geological Survey. Water-Resources Investigations Report 96-4234. Portland, Oregon.

Anderson, J.J., E. Gurarie, and R.W. Zabel. 2005. Mean free-path length theory of predator-prey interactions: Application to juvenile salmon migration. *Ecological Modelling*. 186:196-211.

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

Barnett, H.K., T.P. Quinn, M. Bhuthimethee, J.R. Winton. 2020. Increased prespawning mortality threatens an integrated natural- and hatchery-origin sockeye salmon population in the Lake Washington Basin. Fisheries Research, 227 (2020): 105527

Bax, N. J., E. O. Salo, B. P. Snyder, C. A. Simenstad, and W. J. Kinney. 1978. Salmonid outmigration studies in Hood Canal. Final Report, Phase III. January - July 1977, to U.S. Navy, Wash. Dep. Fish., and Wash. Sea Grant. Fish. Res. Inst., Univ. Wash., Seattle, WA. FRI-UW-7819. 128 pp.

Beechie, T.J., D.A. Sear, J.D. Olden, G.R. Pess, J.M. Buffington, H. Moir, P. Roni, and M.M. Pollock. 2010. Process-based Principles for Restoring River Ecosystems. BioScience 60(3): 209-222.

Berg, L. and T.G. Northcote. 1985. Changes in Territorial, Gill-Flaring, and Feeding Behavior in Juvenile Coho Salmon (*Oncorhynchus kisutch*) Following Short-Term Pulses of Suspended Sediment. Canadian Journal of Fisheries and Aquatic Sciences 42: 1410-1417.

Biro, P. A., and J. A. Stamps. 2010. Do consistent individual differences in metabolic rate promote consistent individual differences in behavior? Trends in Ecology and Evolution 25: 653– 659.

Bjornn, T. C., and D. W. Reiser. 1991. Habitat requirements of salmonids in streams. American Fisheries Society Special Publication 19:83-139.

Bowerman, T., A. Roumasset, M. L. Keefer, C. S. Sharpe and C. C. Caudill. 2017. Prespawn Mortality of Female Chinook Salmon Increases with Water Temperature and Percent Hatchery Origin, Transactions of the American Fisheries Society, September 21, 2017. DOI: 10.1080/00028487.2017.1377110

Brennan, J. S., K. F. Higgins, J. R. Cordell, and V. A. Stamatiou. 2004. Juvenile Salmon Composition, Timing, Distribution, and Diet in Marine Nearshore Waters of Central Puget Sound, 2001-2002. Prepared for the King County Department of Natural Resources and Parks, Seattle, WA. August 2004. 164 pp.

Brette, F., B. Machado, C. Cros, J.P. Incardona, N.L. Scholz, and B.A. Block. 2014. Crude Oil Impairs Cardiac Excitation-Contraction Coupling in Fish. Science Vol 343. February 14, 2014. 10.1126/science.1242747. 5 pp.

Campbell Scientific, Inc. 2008. Comparison of Suspended Solids Concentration (SSC) and Turbidity. Application Note Code: 2Q-AA. April 2008. 5 pp.

Chow, M.I., J.I. Lundin, C.J. Mitchell, J.W. Davis, G. Young, N.L. Scholz, and J.K. McIntyre. 2019. An urban stormwater runoff mortality syndrome in juvenile coho salmon. Aquatic Toxicology, 214:105231.

City of Everett. 2001. Snohomish Estuary Wetland Integration Plan.

City of Marysville. 2021. Stormwater Management Program Plan 2021.

Codarin, A., L.E. Wysocki, F. Ladich, and M. Picciulin. 2009. Effects of ambient and boat noise n hearing and communication in three fish species living in a marine protected area (Miramare, Italy). Marine Pollution Bulletin 58 (2009): 1880-1887.

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

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

Crozier, L.G., Hendry, A.P., Lawson, P.W., Quinn, T.P., Mantua, N.J., Battin, J., Shaw, R.G. and Huey, R.B., 2008. Potential responses to climate change in organisms with complex life histories: evolution and plasticity in Pacific salmon. *Evolutionary Applications* 1(2): 252-270.

Crozier, L. G., M. D. Scheuerell, and E. W. Zabel. 2011. Using Time Series Analysis to Characterize Evolutionary and Plastic Responses to Environmental Change: A Case Study of a Shift Toward Earlier Migration Date in Sockeye Salmon. *The American Naturalist* 178(6): 755-773.

de March, B.G.E. 1988. Acute toxicity of binary mixtures of five cations (Cu^{2+}, Cd^{2+}, Zn^{2+}, Mg^{2+}, and K^{+}) to the freshwater amphipod *Gammarus lacustris* (Sars): alternative descriptive models. Canadian Journal of Fisheries and Aquatic Sciences 45: 625-633.

Dominguez, F., E. Rivera, D. P. Lettenmaier, and C. L. Castro. 2012. Changes in Winter Precipitation Extremes for the Western United States under a Warmer Climate as Simulated by Regional Climate Models. *Geophysical Research Letters* 39(5).

Doney, S. C., M. Ruckelshaus, J. E. Duffy, J. P. Barry, F. Chan, C. A. English, H. M. Galindo, J. M. Grebmeier, A. B. Hollowed, N. Knowlton, J. Polovina, N. N. Rabalais, W. J. Sydeman, and L. D. Talley. 2012. Climate Change Impacts on Marine Ecosystems. *Annual Review of Marine Science* 4: 11-37.

Dressing, S. A., D. W. Meals, J.B. Harcum, and J. Spooner, J.B. Stribling, R.P. Richards, C.J. Millard, S.A. Lanberg, and J.G. O'Donnell. 2016. Monitoring and evaluating nonpoint source watershed projects. Prepared for the U.S. Environmental Protection Agency, Office of Water Nonpoint Source Control Branch, Washington, DC. EPA 841-R-16-010. May 2016. https://www.epa.gov/sites/production/files/2016-06/documents/nps_monitoring_guide_may_2016-combined_plain.pdf

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

Ellison, C.A., R.L. Kiesling, and J.D. Fallon. 2010. Correlating Streamflow, Turbidity, and Suspended-Sediment Concentration in Minnesota's Wild Rice River. 2nd Joint Federal Interagency Conference, Las Vegas, NV, June 27 - July 1, 2010. 10 pp.

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

Fardel, A., P. Peyneau, B. Béchet, A. Lakel, and F. Rodriguez. 2020. Performance of two contrasting pilot swale designs for treating zinc, polycyclic aromatic hydrocarbons and glyphosate from stormwater runoff. Science of the Total Environment, 743: 140503

Federal Highway Administration (FHWA). 2017. On-line Construction Noise Handbook – Section 9.0 Construction Equipment Noise Levels and Ranges. Updated: August 24, 2017. Accessed November 13, 2020 at: https://www.fhwa.dot.gov/environment/noise/construction_noise/handbook/handbook09.cfm

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

Feist, B.E., E.R. Buhle, P. Arnold, J.W. Davis, and N.L. Scholz. 2011. Landscape ecotoxicology of coho salmon spawner mortality in urban streams. Plos One 6(8):e23424.

FitzGerald, A.M., S.N. John, T.M. Apgar, N.J. Mantua, and B.T. Martin. 2021. Quantifying thermal exposure for migratory riverine species: Phenology of Chinook salmon populations predicts thermal stress. Global Change Biology, 27: 536-549.

Ford, M. J., editor. 2022. Biological Viability Assessment Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Pacific Northwest. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-171.

Forest Ecosystem Management Assessment Team (FEMAT). 1993. Forest ecosystem management: An ecological, economic, and social assessment. Report of the Forest Ecosystem Management Assessment Team. 1993-793-071. U.S. Gov. Printing Office.

Furniss, M.J., T.D. Roelofs, and C.S. Lee. 1991. Road construction and maintenance. Pages 297- 323 in W. R. Meehan, editor. Influences of Forest and Rangeland Management on Salmonid Fishes and their Habitats. American Fisheries Society Special Publication 19. 622 pages.

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

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

Gobel, P., C. Dierkes, and W.C. Coldewey. 2007. Storm water runoff concentration matrix for urban areas. Journal of Contaminant Hydrology, 91: 26–42.

Goode, J.R., J.M. Buffington, D. Tonina, D.J. Isaak, R.F. Thurow, S. Wenger, D. Nagel, C. Luce, D. Tetzlaff, and C. Soulsby. 2013. Potential effects of climate change on streambed scour and risks to salmonid survival in snow-dominated mountain basins. *Hydrological Processes* 27(5): 750-765.

Graham, A.L. and S.J. Cooke. 2008. The effects of noise disturbance from various recreational boating activities common to inland waters on the cardiac physiology of a freshwater fish, the largemouth bass (*Micropterus salmoides*). Aquatic Conservation: Marine and Freshwater Ecosystems, 18: 1315-1324.

Hard, J.J., J.M. Myers, E.J. Connor, R.A. Hayman, R.G. Kope, G. Lucchetti, A.R. Marshall, G.R. Pess, and B.E. Thompson. 2015. Viability criteria for steelhead within the Puget Sound distinct population segment. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-NWFSC-129. May 2015. 367 pp

Harman, W., R. Starr, M. Carter, K. Tweedy, M. Clemmons, K. Suggs, and C. Miller. 2012. A function-based framework for stream assessment and restoration projects. U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, EPA 843-K-12-006, Washington, D.C., 2012.

Haring, D. 2002. Salmonid habitat limiting factors analysis, Snohomish River Watershed, Water Resource Inventory Area (WRIA) 7; Final Report of the Washington State Conservation Commission, Olympia, Washington. December 2002. 316p

HDR. Biological Assessment, 88th St. Corridor Improvement Project. Prepared for City of Marysville. May 21, 2020.

HDR 2021a. Supplemental information for the 88th Street NE Corridor Improvement Project Biological Assessment. Memo to City of Marysville. Submitted October 25, 2021.

HDR 2021b. Attachment 3- Vegetation removal and planting plan. Sent as attachment to WSDOT 2021a.

HDR 2021c. Attachment 1- Culverts 60% plans. Sent as attachment to WSDOT 2021a.

HDR 2021d. Attachment 4- Stormwater Treatment Areas for Water Quality. Sent as attachment to WSDOT 2021a.

Hecht, S.A., D.H. Baldwin, C.A. Mebane, T. Hawkes, S.J. Gross, and N.L. Scholz. 2007. An overview of sensory effects on juvenile salmonids exposed to dissolved copper: Applying a benchmark concentration approach to evaluate sublethal neurobehavioral toxicity. *In* U.S. Dept. Commer., NOAA Technical White Paper. March 2007. 45 pp.

Hicks, B. J., J. D. Hall, P. A. Bisson, and J. R. Sedell. 1991. Responses of salmonids to habitat change. American Fisheries Society Special Publication 19: 483-519.

Hicks, M. 1999. Evaluating criteria for the protection of aquatic life in Washington's surface water quality standards (preliminary review draft). Washington State Department of Ecology. Lacey, Washington. 48p.

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

Hood Canal Coordinating Council (HCCC). 2005. Hood Canal & Eastern Strait of Juan de Fuca summer chum salmon recovery plan. November 15.

Hunter, M.A. 1992. Hydropower flow fluctuations and salmonids: A review of the biological effects, mechanical causes, and options for mitigation. Washington Department of Fisheries. Technical Report No. 119. Olympia, Washington

Incardona, J.P., T.K. Collier, and N.L. Scholz. 2004. Defects in cardiac function precede morphological abnormalities in fish embryos exposed to polycyclic aromatic hydrocarbons. Toxicology and Applied Pharmacology 196: 191-205.

Incardona, J.P., M.G. Carls, H. Teraoka, C.A. Sloan, T.K. Collier, and N.L. Scholz. 2005. Aryl hydrocarbon receptor-independent toxicity of weathered crude oil during fish development. Environmental Health Perspectives 113: 1755-1762.

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

Isaak, D.J., Wollrab, S., Horan, D. and Chandler, G., 2012. Climate change effects on stream and river temperatures across the northwest US from 1980–2009 and implications for salmonid fishes. *Climatic Change* 113(2): 499-524.

Johnson, L.L., G.M. Ylitalo, M.R. Arkoosh, A.N. Kagley, C.L. Stafford, J.L. Bolton, J. Buzitis, B.F. Anulacion, and T.K. Collier. 2007. Contaminant exposure in outmigrant juvenile salmon from Pacific Northwest estuaries. Environmental Monitoring and Assessment 124: 167-194.

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

Karrow, N., H.J. Boermans, D.G. Dixon, A. Hontella, K.R. Soloman, J.J. White, and N.C. Bols. 1999. Characterizing the immunotoxicity of creosote to rainbow trout (*Oncorhynchus mykiss*): a microcosm study. Aquatic Toxicology. 45 (1999): 223–239.

Kunkel, K. E., L. E. Stevens, S. E. Stevens, L. Sun, E. Janssen, D. Wuebbles, K. T. Redmond, and J. G. Dobson. 2013. Regional Climate Trends and Scenarios for the U.S. National Climate Assessment: Part 6. *Climate of the Northwest U.S. NOAA Technical Report NESDIS 142-6.* 83 pp. National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service, Washington, D.C.

Lawrence, J.E., Cover, M.R., May, C.L., and V.H. Resh. 2014. Replacement of culvert styles has minimal impact on benthic macroinvertebrates in forested, mountainous streams of Northern California. Limnologica. 4, 7-20.

Lawson, P. W., Logerwell, E. A., Mantua, N. J., Francis, R. C., & Agostini, V. N. 2004. Environmental factors influencing freshwater survival and smolt production in Pacific Northwest coho salmon (*Oncorhynchus kisutch*). *Canadian Journal of Fisheries and Aquatic Sciences* 61(3): 360-373

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

Lee, R. and G. Dobbs. 1972. Uptake, Metabolism and Discharge of Polycyclic Aromatic Hydrocarbons by Marine Fish. Marine Biology. 17, 201-208.

Loge, F., M.R. Arkoosh, T.R. Ginn, L.L. Johnson, and T.K. Collier. 2006. Impact of environmental stressors on the dynamics of disease transmission. Environmental Science and Technology 39(18): 7329-7336

Lunz, J.D. and M.W. LaSalle. 1986. Physiochemical alterations of the environment associated with hydraulic cutterhead dredging. Am. Malacol. Bull. Spec. Ed. No. 3: 31-36.

Lunz, J.D., M.W. LaSalle, and L. Houston. 1988. Predicting dredging impacts on dissolved oxygen. Pp.331-336. In Proceedings First Annual Meeting Puget Sound Research, Puget Sound Water Quality Authority, Seattle, WA. oxygen. Pp.331-336. In Proceedings First Annual Meeting Puget Sound Research, Puget Sound Water Quality Authority, Seattle, WA.

Mantua, N., I. Tohver, and A. Hamlet. 2009. Impacts of Climate Change on Key Aspects of Freshwater Salmon Habitat in Washington State. *In* The Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate, edited by

Mantua, N., I. Tohver, and A. Hamlet. 2010. Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State. *Climatic Change* 102(1): 187-223.

Mauger, G.S., J.H. Casola, H.A. Morgan, R.L. Strauch, B. Jones, B. Curry, T.M. Busch Isaksen, L. Whitely Binder, M.B. Krosby, and A.K. Snover, 2015. State of Knowledge: Climate Change in Puget Sound. Report prepared for the Puget Sound Partnership and the National Oceanic and Atmospheric Administration. Climate Impacts Group, University of Washington, Seattle. doi: 10.7915/CIG93777D

McCain, B., D.C. Malins, M.M. Krahn, D.W. Brown, W.D. Gronlund, L.K. Moore, and S-L. Chan. 1990. Uptake of Aromatic and Chlorinated Hydrocarbons by Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in an Urban Estuary. Arch. Environ. Contam. Toxicol. 19, 10-16 (1990).

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42. June 2000. 156 pp.

McIntyre, J.K, D.H. Baldwin, D.A. Beauchamp, and N.L. Scholz. 2012. Low-level copper exposures increase visibility and vulnerability of juvenile coho salmon to cutthroat trout predators. Ecological Applications, 22(5), 2012, pp. 1460–1471.

McMahon, T.E., and G.F. Hartman. 1989. Influence of cover complexity and current velocity on winter habitat use by juvenile coho salmon (*Oncorhynchus kisutch*). *Canadian Journal of Fisheries and Aquatic Sciences* 46: 1551–1557.

Meadore, J.P., F.C. Sommers, G.M. Ylitalo, and C.A. Sloan. 2006. Altered growth and related physiological responses in juvenile Chinook salmon (*Oncorhynchus tshwaytscha*) from dietary exposure to polycyclic aromatic hydrocarbons (PAHs). Canadian Journal of fisheries and Aquatic Sciences. 63: 2364-2376.

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

Meyer, J.L., M.J. Sale, P.J. Mulholland, and N.L. Poff. 1999. Impacts of climate change on aquatic ecosystem functioning and health. *JAWRA Journal of the American Water Resources Association* 35(6): 1373-1386.

Moberg, G.P. 2000. Biological response to stress: Implications for animal welfare. Pages 1-21. In: The biology of animal stress - basic principles and implications for animal welfare. G.P. Moberg, and J.A. Mench (editors). CABI Publishing. Cambridge, Massachusetts.

Moore, M. E., F. A. Goetz, D. M. Van Doornik, E. P. Tezak, T. P. Quinn, J. J. Reyes-Tomassini, and B. A. Berejikian. 2010. Early marine migration patterns of wild coastal cutthroat trout (*Oncorhynchus clarki clarki*), steelhead trout (*Oncorhynchus mykiss*), and their hybrids. PLoS ONE 5(9):e12881. Doi:10.1371/journal.pone.0012881. 10 pp.

Moore, M.E., B.A. Berejikian, and E.P. Tezak. 2013. A Floating Bridge Disrupts Seaward Migration and Increases Mortality of Steelhead Smolts in Hood Canal, Washington State. PloS one. September 2013. Vol 8. Issue 9. E73427. 10 pp.

Morton, J. W. 1976. Ecological effects of dredging and dredge spoil disposal: a literature review. Technical Paper 94. U.S. Fish and Wildlife Service. Washington D.C. 33 pp.

Mote, P.W., J.T. Abatzglou, and K.E. Kunkel. 2013. Climate: Variability and Change in the Past and the Future. In Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities, edited by M.M. Dalton, P.W. Mote, and A.K. Snover, 41-58. Island Press, Washington, DC.

Mote, P.W, A. K. Snover, S. Capalbo, S.D. Eigenbrode, P. Glick, J. Littell, R.R. Raymondi, and W.S. Reeder. 2014. Ch. 21: Northwest. *In* Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, T.C. Richmond, and G.W. Yohe, Eds., U.S. Global Change Research Program, 487-513.

Mueller, G. 1980. Effects of Recreational River Traffic on Nest Defense by Longear Sunfish. Transactions of the American Fisheries Society. 109: 248-251.

Myers, J.M., J.J. Hard, E.J. Connor, R.A. Hayman, R.G. Kope, G. Lucchetti, A.R. Marshall, G.R. Pess, and B.E. Thompson. 2015. Identifying historical populations of steelhead within the Puget Sound distinct population segment U.S. Department of Commerce. NOAA Technical Memorandum NMFS-NWFSC-128. 149 pp.

National Marine Fisheries Service (NMFS). 2006. Final Supplement to the Shared Strategy's Puget Sound Salmon Recovery Plan. Prepared by NMFS Northwest Region. November 17, 2006. 47 pp.

NMFS. 2013. Programmatic Restoration Opinion for Joint Ecosystem Conservation by the Services (PROJECTS) by the U.S. Fish and Wildlife Service Using the Partners for Fish and Wildlife, Fisheries, Coastal, and Recovery Programs and NOAA Restoration Center Using the Damage Assessment, Remediation and Restoration Program (DARRP), and Community-Based Restoration Program (CRP) in the States of Oregon, Washington, and Idaho. NWR-2013-10221. December 3, 2013. 228 pp.

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

NMFS. 2017. 2016 5-Year Review: Summary and Evaluation of Puget Sound Chinook Salmon, Hood Canal Summer-run Chum Salmon, and Puget Sound Steelhead. NMFS West Coast Region, Portland, Oregon. April 6, 2017. 98 pp.

NMFS. 2019. ESA Recovery Plan for the Puget Sound Steelhead Distinct Population Segment (*Oncorhynchus mykiss*). National Marine Fisheries Service. Seattle, WA. 174p.

Neff, J.M. 1982. Accumulation and release of polycyclic aromatic hydrocarbons from water, food, and sediment by marine animals. Pages 282-320 in N.L. Richards and B.L. Jackson (eds.). Symposium: carcinogenic polynuclear aromatic hydrocarbons n the marine environment. U.S. Environ. Protection Agency Rep. 600/9-82-013.

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

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

Neo, Y.Y., J. Seitz, R.A. Kastelein, H.V. Winter, C. Cate, H. Slabbekoorn. 2014. Temporal structure of sound affects behavioural recovery from noise impact in European seabass. Biological Conservation 178 (2014): 65-73.

Northwest Fisheries Science Center (NWFSC). 2015. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. December 21, 2015. 356 pp.

Pacific Fishery Management Council (PFMC). 2014. Appendix A to the Pacific Coast salmon fishery management plan, as modified by amendment 18 to the pacific coast salmon plan: identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon. PFMC, Portland, OR. September 2014. 196 p. + appendices.

Quinn, T.P. 2005. The Behavior and Ecology of Pacific Salmon and Trout. University of British Columbia Press.

Peter, K.T., Z. Tian, C. Wu, P. Lin, S. White, B. Du, J.K. McIntyre, N.L. Scholz, and E.P. Kolodziej. 2018. Using High-Resolution Mass Spectrometry to Identify Organic Contaminants Linked to Urban Stormwater Mortality Syndrome in Coho Salmon. Environ. Sci. Technol. 2018, 52, 10317−10327.

Peter, K.T., F. Hou, Z. Tian, C. Wu, M. Goehring, F. Liu, and E.P. Kolodziej. 2020. More than a first flush: urban creek storm hydrographs demonstrate broad contaminant pollutographs. Environmental Science and Technology, 54: 6152-6165.

Picciulin, M., L. Sebastianutto, A. Codarin, A. Farina, and E.A. Ferrero. 2010. In situ behavioural responses to boat noise exposure of *Gobius cruentatus* (Gmelin, 1789; fam. Gobiidae) and *Chromis chromis* (Linnaeus, 1758; fam. Pomacentridae) living in a Marine Protected Area. Journal of Experimental Marine Biology and Ecology 386 (2010): 125–132.

Raymondi, R.R., J.E. Cuhaciyan, P. Glick, S.M. Capalbo, L.L. Houston, S.L. Shafer, and O. Grah. 2013. Water Resources: Implications of Changes in Temperature and Precipitation. *In* Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities, edited by M.M. Dalton, P.W. Mote, and A.K. Snover, 41-58. Island Press, Washington, DC.

Reeves, G.H., J.D. Hall, T.D. Roelofs, T.L. Hickman, and C.O. Baker. 1991. Rehabilitating and modifying stream habitats. Pages 519-557 in W.R. Meehan, editor. Influences of Forest and Rangeland Management on Salmonid Fishes and their Habitats. American Fisheries Society Special Publication 19. 751 pages.

Robertson, M.J., D.A. Scruton, R.S. Gregory, and K.D. Clarke. 2006. Effect of suspended sediment on freshwater fish and fish habitat. Canadian Technical Report of Fisheries and Aquatic Sciences 2644, 37 pp.

Ruckelshaus, M., K. Currens, W. Graeber, R. Fuerstenberg, K. Rawson, N. Sands, and J. Scott. 2002. Planning ranges and preliminary guidelines for the delisting and recovery of the Puget Sound Chinook salmon evolutionarily significant unit. Puget Sound Technical Recovery Team. April 30, 2002. 19 pp.

Sandahl, J.F., D. Baldwin, J.J. Jenkins, and N.L. Scholz. 2007. A Sensory System at the Interface between Urban Stormwater Runoff and Salmon Survival. Environmental Science and Technology. 2007(41): 2998-3004.

Santore, R.C., D.M. Di Toro, P.R. Paquin, H.E. Allen, and J.S. Meyer. 2001. Biotic ligand model of the acute toxicity of metals. 2. Application to acute copper toxicity in freshwater fish and Daphnia. Environmental Toxicology and Chemistry 20(10): 2397-2402.

Scholik, A.R., and H.Y. Yan. 2002. Effects of boat engine noise on the auditory sensitivity of the fathead minnow, *Pimephales promelas*. Environmental Biology of Fishes. 63:203-209.

Schreiner, J. U., E. O. Salo, B. P. Snyder, and C. A. Simenstad. 1977. Salmonid outmigration studies in Hood Canal. Final Report, Phase II, to U.S. Navy, Fish. Res. Inst., Univ. Wash., Seattle, WA. FRI-UW-7715. 64 pp.

Sebastianutto, L., M. Picciulin, M. Costantini, and E.A. Ferrero. 2011. How boat noise affects an studies in Hood Canal. Final Report, Phase II, to U.S. Navy, Fish. Res. Inst., Univ. Wash., Seattle, WA. FRI-UW-7715. 64 pp.

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

Shared Strategy for Puget Sound (SSPS). 2007. Puget Sound Salmon Recovery Plan – Volume 1. Shared Strategy for Puget Sound, 1411 4th Ave., Ste. 1015, Seattle, WA 98101. Adopted by NMFS January 19, 2007. 503 pp.

Simpson, S.D., A.N. Radford, S.L. Nedelec, M.C.O. Ferrari, D.P. Chivers, M.I. McCormick, and M.G. Meekan. 2016. Anthropogenic noise increases fish mortality by predation. Nature Communications 7:10544 DOI: 10.1038/ncomms10544 www.nature.com/naturecommunications February 5, 2016. 7 pp.

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

Snohomish Basin Salmon Recovery Forum. 2005. Snohomish River Basin Salmon Conservation Plan. Snohomish County Department of Public Works, Surface Water Management Division. Everett, WA. June 2005.

Snohomish Basin Salmon Recovery Forum. 2019. Snohomish River Basin Salmon Conservation Plan- Status and Trends. Snohomish County Department of Public Works, Surface Water Management Division. Everett, WA. December 2019

Sommers, F., E. Mudrock, J. Labenia, and D. Baldwin. 2016. Effects of salinity on olfactory toxicity and behavioral responses of juvenile salmonids from copper. *Aquatic Toxicology*. 175:260-268.

Spence, B.C., G.A. Lomnicky, R.M. Hughes, and R.P. Novitzki. 1996. An ecosystem approach to salmonid conservation. ManTech Environmental Research Services, Inc. Corvallis, Oregon. National Marine Fisheries Service, Portland, Oregon.

Spromberg, J.A, D.H. Baldwin, S.E. Damm, J.K. McIntyre, M. Huff, C.A. Sloan, B.F. Anulacion, J.W. Davis, and N.L. Scholz. 2016. Coho salmon spawner mortality in western US urban watersheds: bioinfiltration prevents lethal storm water impacts. Journal of Applied Ecology. DOI: 10.1111/1365-2264.12534.

Spromberg, J.A., and J.P. Meador. 2006. Relating chronic toxicity responses to population-level effects: A comparison of population-level parameters for three salmon species as a function of low-level toxicity. Ecological Modeling 199: 240-252.

Spromberg, J.A., and N.L. Scholz. 2011. Estimating future decline of wild coho salmon populations resulting from early spawner die-offs in urbanizing watersheds of the Pacific Northwest, USA. Integrated Environmental Assessment and Management 7(4): 648-656.

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

Tian, Z., H. Zhao, K.T. Peter, M. Gonzalez, J. Wetzel, C. Wu, X. Hu, J. Prat, E. Mudrock, R. Hettinger, A.E. Cortina, R.G. Biswas, F.V.C. Kock, R.Soong, A. Jenne, B. Du, F. Hou, H. He, R. Lundeen, A. Gilbreath, R. Sutton, N.L. Scholz, J.W. Davis, M.C. Dodd, A. Simpson, J.K. McIntyre, and E.P. Kolodziej. 2020. A ubiquitous tire rubber–derived chemical induces acute mortality in coho salmon. Science, 371: 185–189. 10.1126/science.abd6951.

Toft, J.D., J.R. Cordell, C.A. Simenstad, and L.A. Stamatiou. 2007. Fish Distribution, Abundance, and Behavior along City Shoreline Types in Puget Sound. *North American Journal of Fisheries Management*. 27: 465-480.

Tillmann, P. and D. Siemann. 2011. Climate Change Effects and Adaptation Approaches in Marine and Coastal Ecosystems of the North Pacific Landscape Conservation Cooperative Region. National Wildlife Federation.

U.S. Department of Commerce (USDC). 2014. Endangered and threatened wildlife; Final rule to revise the Code of Federal Regulations for species under the jurisdiction of the National Marine Fisheries Service. U.S Department of Commerce. Federal Register 79(71): 20802-20817.

U.S. Global Change Research Program (USGCRP). 2018. Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II D. R. Reidmiller, C. W. Avery, D. R. Easterling, K. E. Kunkel, K. L. M. Lewis, T. K. Maycock, and B. C. Stewart, editors. USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018. U.S. Global Change Research Program,Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018., Washington, DC, USA.

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

Varanasi, U., E. Casillas, M.R. Arkoosh, T. Hom, D.A. Misitano, D.W. Brown, S.L. Chan, T.K. Collier, B.B. McCain, and J.E. Stein. 1993. Contaminant Exposure and Associated Biological Effects in Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) from Urban and Nonurban Estuaries of Puget Sound. NOAA Technical Memorandum NMFS-NWFSC-8. NMFS NFSC Seattle, WA. April 1993. 69 pp.

Wagner, S., T. Huffer, P. Klockner, M. Wehrhahn, T. Hofmann, and T. Reemtsma. 2018. Tire wear particles in the aquatic environment- A review on generation, analysis, occurrence, fate and effects. Water Research, 139: 83-100.

Wainwright, T. C., and L. A. Weitkamp. 2013. Effects of climate change on Oregon Coast coho salmon: habitat and life-cycle interactions. *Northwest Science* 87(3): 219-242.

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

WDOE. 2018. General use level designation for basic (TSS), dissolved metals (enhanced) and phosphorus treatment for Oldcastle Infrastructure, Inc.'s The BioPod ™ Biofilter (formerly the TreePod Biofilter).

WDOE. 2021. Washington State Water Quality Atlas. Accessed on December 16, 2021 at: https://fortress.wa.gov/ecy/waterqualityatlas/StartPage.aspx.

Washington State Department of Fish and Wildlife (WDFW). 2021a. SalmonScape. Accessed on December 16, 2021 at: http://apps.wdfw.wa.gov/salmonscape/map.html.

WDFW. 2021b. WDFW Conservation Website – Species – Salmon in Washington – Chinook. Accessed on December 16, 2021 at: https://fortress.wa.gov/dfw/score/score/species/chinook.jsp?species=Chinook

WDFW. 2021c. WDFW Conservation Website – Species – Salmon in Washington – Steelhead. Accessed on December 16, 2021 at: https://fortress.wa.gov/dfw/score/score/species/steelhead.jsp?species=Steelhead

Winder, M. and D. E. Schindler. 2004. Climate change uncouples trophic interactions in an aquatic ecosystem. *Ecology* 85: 2100–2106.

Xie, Y.B., C.G.J. Michielsens, A.P. Gray, F.J. Martens, and J.L. Boffey. 2008. Observations of avoidance reactions of migrating salmon to a mobile survey vessel in a riverine environment. Canadian Journal of Fisheries and Aquatic Sciences. 65: 2178-2190.